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EASTERN NILE POWER TRADE PROGRAM STUDY

AfDB

PRE-FEASIBILITY STUDY OF BORDER HYDROPOWER PROJECT, ETHIOPIA

FINAL
INITIAL ENVIRONMENTAL IMPACT ASSESSMENT

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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 Border 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 1200 MW Border project (6,011 GWh/year), and the uplift in energy at hydropower facilities in Sudan (1,658 GWh/year), resulting from Border'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 160 million and USD 40 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 Border 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. Although parallel power trading studies are currently indicating that the Border project will be required after development of the Mandaya and Karadobi projects further upstream on the Abbay river, this environmental assessment has been produced on the basis that the Border project may be required earlier.

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 Border and other hydropower projects on the Abbay river.

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

The Border 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 Border 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 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 Border project encroaches 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 Border 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 region 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 – and opportunistic gold panning. 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 13,905 persons (2,781 households) live in the dam site and reservoir area of the three project-affected woredas (Guba, Wonbera and Sirba Abay) and will require compensation and resettlement. 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.

Preliminary social and archaeological assessment of the project-affected area in Benishangul Gumuz region 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 Border project is expected to take six 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, Border reservoir itself (574 km^2) 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, alluvial gold found in the river bed and banks near Border, where gold panning is an important dry season activity, will be permanently lost because of 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 reduced flood flows and greatly increased dry season flows (Figure E.2).

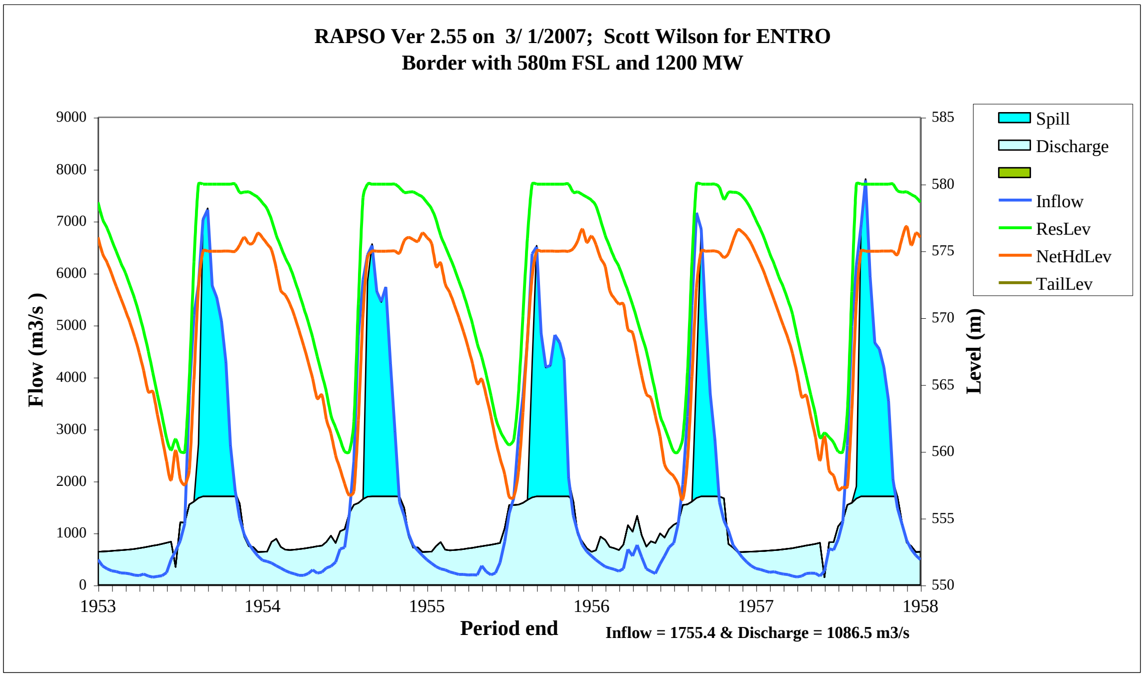


Figure E.2: Border hydropower project simulation, 1954 – 1958

E1.4.5 Construction and Operational Impacts in Sudan

Impacts of the Border project in Sudan are expected to be 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 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 (1,658 GWh/year) resulting directly from Border holding back silt and regulating flows, without any capital expenditure at these projects. This uplift is equivalent to some 85% of 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 per installed MW and per GWh/year are six times and five times greater than for Border, respectively. 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 Border releases its first spillway discharges (no longer charged with high concentrations of suspended sediment, and with no bed load) and on subsequent spill occasions. According to 50 years of reservoir and power generation simulation, these spillway discharges will occur every year but arrive downstream without the river experiencing the normal build up of flood flows in the several weeks preceding spillway discharges – the latter period being when the reservoir is refilling. The dry season regulated flows will also be virtually sediment-free. 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.

The Border reservoir will refill every year because its capacity is not large in relation to the river's annual flows. In about as many years as not, it will release the peak of floods more or less unchanged. In these years, the project will not assist flood relief downstream. In the other years, about half of those in the 50 year period studied, peak flows will be reduced. The degree of flood reduction is very little on many of these occasions and will have no significant benefit for flood relief downstream. In some years, the degree of flood reduction will be greater and in some of these years will contribute positively to reducing the magnitude and duration of major floods which cause damage to urban properties, livelihoods, flood defences and other infrastructure and public services. Border will therefore make a contribution to flood relief in some years, which will be beneficial, but the project does not have a large enough storage capacity to make a significant difference to major floods on a regular basis.

Owing to Border's impacts on flood flows, recession agriculture along the Blue Nile and Main Nile's alluvial strip will be adversely affected in some years but not in others. In all years, the build up of Nile flood levels in June, July and early August will be reduced and delayed as Border reservoir refills; some build up in flood levels will occur as normal because of the tributary rising floods of Dinder, Rahad and Atbara rivers. Apart from this change, recession agriculture along the Blue Nile and Main Nile will be unaffected for about half of the years when peak flows are not reduced, and overbank flooding will continue to occur at the normally experienced levels. In these years, crop production following the flood should be as usual. However, the deposition of silt on farmlands, for millennia regarded as a free and natural fertilizer, will be greatly reduced.

In those other years when flood discharges are slightly or heavily reduced, the floodplain areas reached by flooding, and the depth and duration of flooding will be correspondingly less. As inferred, in some of these years the impacts are expected to be small but in others a significant reduction in crop production could result and groundwater resources would not be replenished as under normal conditions. These conditions 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, even if this occurs in only a few years.

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. Meanwhile, farmers with pumps continue to cultivate. With Border 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.

Thus, the proposed mitigation measures for Border'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. 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 Border's first filling.

E1.4.6 Construction and Operational Impacts in Egypt

There are several impact areas of the Border 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 Border 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 Border. A fall in level of some 2 m appears probable but 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. However, throughout the first filling period, Lake Nasser’s regulated outflows downstream are expected to be maintained.

With regard to sedimentation, the holding of most of Abbay’s suspended sediment load and all of its bed load in Border 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 Border’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 Border 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 Border, 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 Border’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 the reservoir storage, with low evaporation losses, and power generation at Border 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 Border's principal impacts

Table E.1 : Summary of principal impacts of Border project

Positive Impacts	Principal Benefits	Negative Impacts	Mitigation measures
Ethiopia			
Border project	Border power generation, a major national energy benefit and increase in foreign exchange earnings	Involuntary resettlement	Resettlement and development program
Border project	Construction employment, new skills for the future	Loss of wildlife habitat and wildlife	New reservoir wetland and management of environmental offset(s)
Border project	New roads, Abbay bridge, promoting regional development	Loss of natural resources	Development of reservoir fisheries
Border 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		
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	Reduction in flooding	Conversion of flood recession agriculture to irrigation, and two crops per year

Positive Impacts	Principal Benefits	Negative Impacts	Mitigation measures
	flooding, and infrastructure maintenance		
		Reduction in sediment	Application of artificial fertilizers
Egypt			
Reduced sediment	Extension in life of High Aswan Dam	Reduction in Lake Nasser level Less energy at Aswan and Socio-economic (fisheries, agriculture, navigation) around lake	Compensation, or negotiate tariff for importing Border energy to compensate for foregone energy at Aswan Various, to be determined, and/or compensation
Regional			
Border project	Carbon emissions savings of some 210 million tonnes compared with equivalent thermal generation		

E1.5 ALTERNATIVES

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

There is some but not much 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. The report has pursued this need vigorously in its draft Environmental Management Plan.

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 Border 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 Border 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 region. 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 Benishangul Gumuz regional Environmental Protection Authority 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 Border 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 the existing gauging station downstream of Border dam site.

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, these 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 Border 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 125.4 million has been included for environmental costs and a further USD 25.8 million for reservoir basin clearance. Together, these represent some 10% of the estimated overall project cost.

E1.9 CONCLUSIONS

Initial environmental examination of the Border 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 Border 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 Border 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 Border, 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 Border 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 (Border and Mandaya 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 Border project, consistent with prefeasibility 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.

Border dam and reservoir site is located in Benishangul-Gumuz Region in north-western Ethiopia, some 20 km upstream of the Ethiopia-Sudan border.

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 but limited to 1:250,000 and ortho-photo maps at 1:50,000 in the Border dam site 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 Border dam site and accessible surrounding areas, including lower Beles, and to the uppermost area of the potential Border reservoir, in close proximity to Mandaya dam site. 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 in Asosa and 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 Border project and outlining mitigation measures in Ethiopia.

- Downstream Impacts. Fieldwork was conducted along 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 Border using 50 years river flow data with a 10-day time step..

- Workshops. Preliminary results of scoping investigations at Border (and Mandaya 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 Border 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 574 km^2 for the Full Supply Level of 580 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 Sudan extend along the river channels and related adjacent floodplain and wetland areas of the Blue Nile and Main Nile, from the border 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, Border's impacts relate principally to Lake Nasser/Nubia with regard to reduced lake levels expected from first filling in the construction period and to the reduction in sedimentation in Lake Nasser/Nubia during and following first filling of Border.

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 Border project, through interconnection, would bring to the economies of the three countries from its 1,200 MW installed capacity, typically generating 6,000 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 Border project's medium-term and long-term viability. This is the large catchment area to the Border 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 large catchment area, including additional consumptive use for irrigation schemes and any water transfers from the basin, would impact upon the Border 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 Border 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.
- Chapter 5 presents the existing environmental and social conditions and key issues downstream of Border dam - 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 Border project's principal potential impacts and mitigations during construction over a period of six years. It anticipates management and monitoring plans for these and considers aspects of cofferdam impoundment and then full reservoir impoundment before presenting principal impacts on the physical, biological and socio-economic environments in the Border region respectively – the direct impact zone. The final section considers construction and impoundment impacts in Sudan and Egypt – the secondary impact zone.
- Chapter 7 describes the Border 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 Border 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 Border area at the beginning of the operations phase before considering principal impacts on the bio-physical and socio-economic environments in the Border region – the direct impact zone. The final section considers operational impacts and mitigation measures in Sudan and Egypt – the secondary impact zone.
- Chapter 8 considers project alternatives.

- Chapters 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
- 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
- Border Hydropower project – CO_2 Emissions
- Settlements impacted by Border project
- Note on compensation procedures in Sudan and Egypt.

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 Border 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 Border project.

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

Safeguard policies on Indigenous Peoples, Pest Management and Disputed Areas are considered not applicable to the Border 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 Border 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 Border project. The Border 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 Border 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 Border 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 Border 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 Border 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 Border 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 Border 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 Border 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 Border 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 Border'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 Border 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 Border 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 Border project site is located on the Abbay river (Blue Nile) some 30 km downstream of its confluence with the Beles river and 20 km upstream of the Ethiopia – Sudan border. (Figure 3.1, and Drawing No. B1, at end of report). The catchment area to the Border dam site comprises some 176,918 km^2 of the Abbay river basin.

The headwaters of the Abbay river are in the mountains surrounding Lake Tana, the largest tributary of which is the Gilgel Abay. Lake Tana, at an elevation of approximately EL. 1785 m provides significant regulation of the natural river flow in the upper reaches of the Abbay. The Didessa, Dabus and Beles rivers are the main tributaries which join the Abbay in the reach between Lake Tana and the Border dam site.

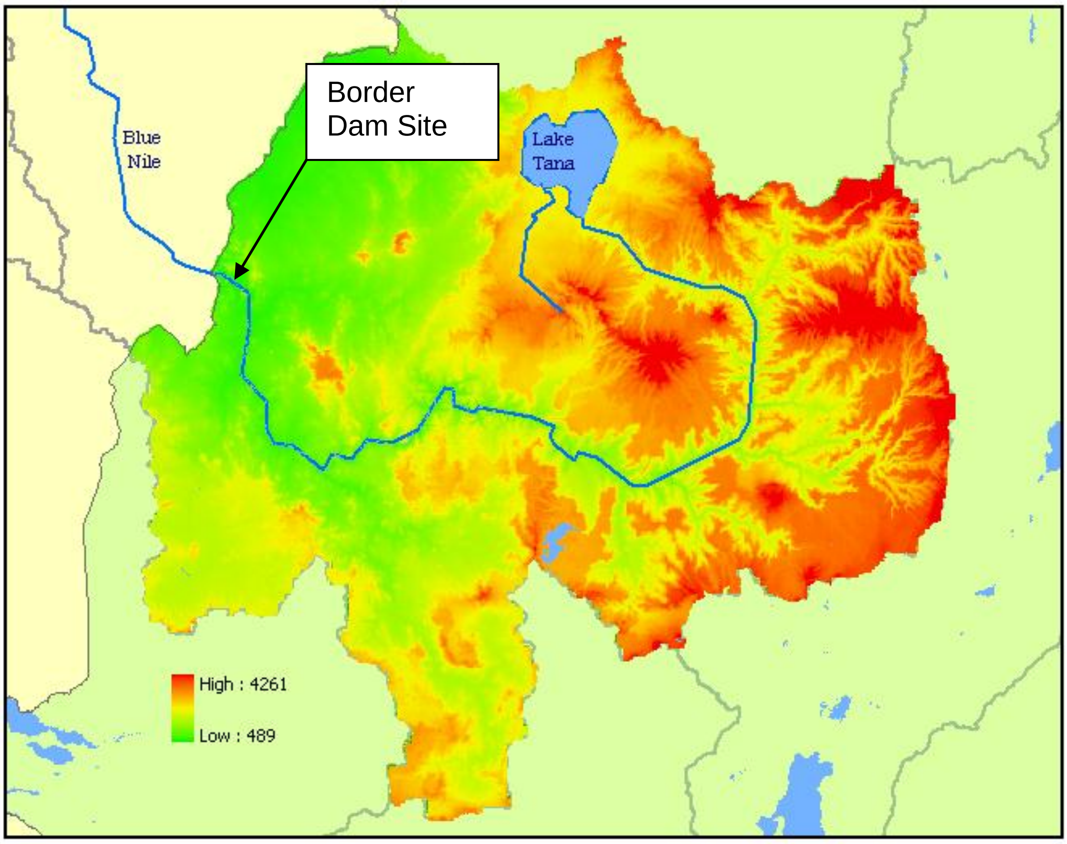


Figure 3.1 : Abbay River Basin

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. Mountain peaks rise to over 4000 m in the north. The Abbay flows generally within a deeply incised gorge which has a relatively gentle gradient falling some 545 m over 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 Blue Nile (Abbay) river basin in Ethiopia over the period 1960-1964. The study identified major hydropower development sites on the main stream of the Blue Nile 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 : Features 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 Border project concluded that the site was suitable for development of a dam up to 90 m in height, with a full supply level of up to El. 580 m. A reconnaissance overflight revealed that a number of villages were located within the potential reservoir area. Almost no roads or tracks were observed in the reservoir area except in the immediate vicinity of the dam site. In general, the reservoir area (Drawing No. B2) was found to be covered with partially disturbed open savannah vegetation.

For this study a full supply level of Border reservoir of El. 580 m has been adopted, as summarised in Table 3.2, below:

Table 3.2 : Characteristics of Proposed Hydropower Projects on Abay

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	14,470	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 records for hydrological analysis for the Border project comprise those for:

- Abbay River at Kessie (Station No. 2001)
- Abbay River at Border (Station No. 6002)
- Blue Nile at Deim, Sudan.

Mean annual flow at Border over the 50-year period 1954-2003 has been estimated as 1547 m^3/s. Mean annual flows at various key locations on the Abbay river are shown in Table 3.3.

Table 3.3 : 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 Border site for purposes of spillway design as shown in Table 3.4 below. A flood magnitude of 30,000 m^3/s has been adopted for spillway design.

Table 3.4 : Maximum Daily Discharge Estimates for Border Site

Return Period (years)	Estimates for Border based on analysis of:		
	Kessie (m^3/s)	Border (m^3/s)	El Deim (m^3/s)
10,000	39,267	18,824	10,240
1,000	31,235	16,138	9,655
100	21,425	13,323	8,782
50	19,491	12,434	8,441
20	16,796	11,213	7,916
10	14,580	10,238	

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 3.5 and this has been used to derive an estimate for the Border site (Table 3.6).

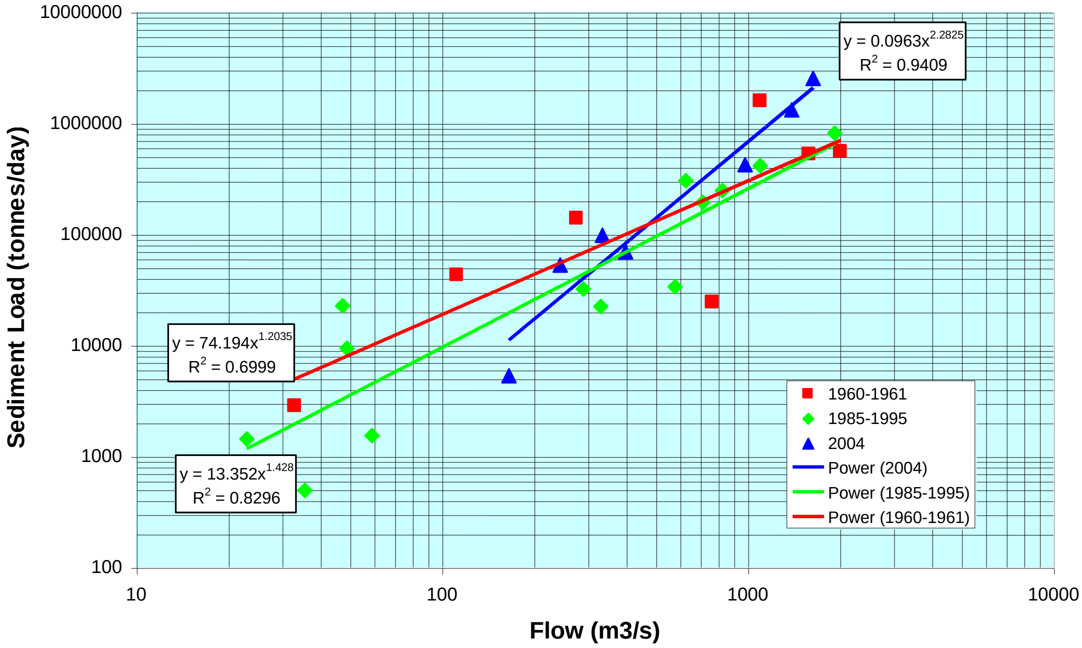


Figure 3.2 : Sediment Ratings for Abbay River at Kessie

Table 3.5 : 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 3.6 : Estimated Sediment Discharges at Border

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 Border	108,844	900	98
Border	176,918		318

*based on data for Year 2004 including bedload

3.6 RESERVOIR AND POWER SIMULATION

Energy outputs of the Border 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 Border project development with full supply level of El. 580m is presented in Table 3.7, below:

Table 3.7 : Energy Output of Border 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 Border project as simulated by RAPSO is illustrated in Figure 3.3, below.

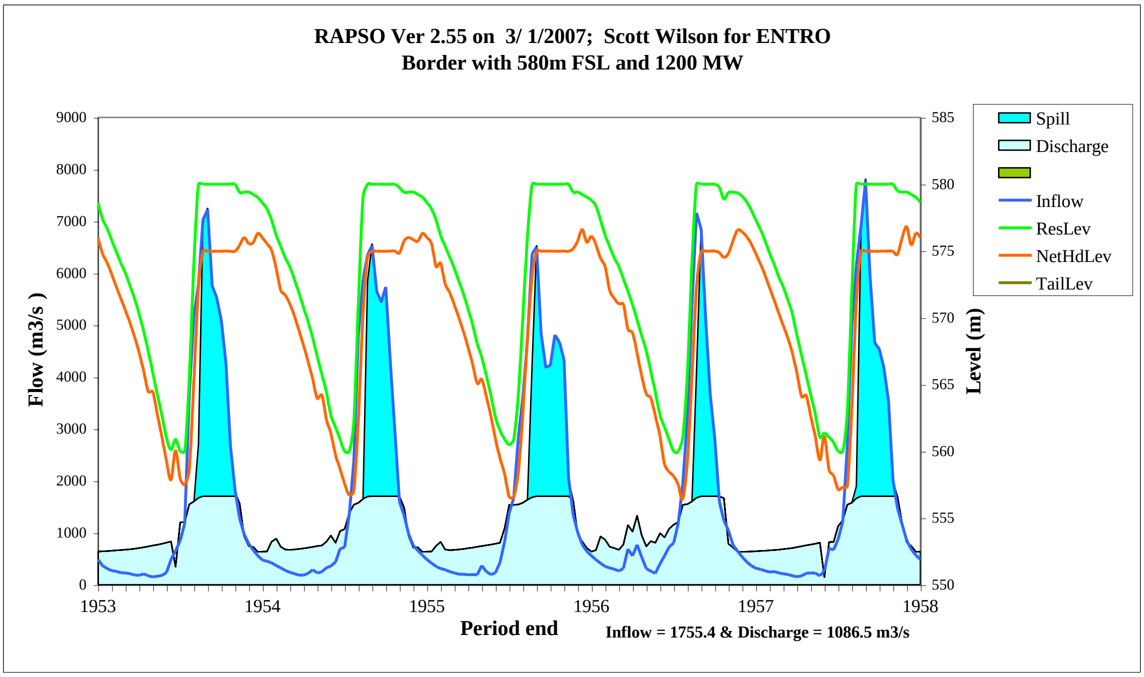


Figure 3.3 : Typical 5-year period operation of Border

3.7 EFFECTS OF BORDER ON ENERGY GENERATION IN SUDAN

The effects of the Border project on generation at existing hydropower projects in Sudan have been estimated by comparing the regulated downstream flows of the Mandaya and Border projects of approximately 840 m^3/s and 630 m^3/s respectively. It is estimated that the uplift due to Border project would be some 75% of the uplift associated with the Mandaya project, as indicated in Table 3.8.

Table 3.8 : Uplift in Generation at Sudan Hydropower Projects due to Border

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 Border, with Roseires flushing operation	1966	443	6173	8582	942
With Border, without Roseires flushing operation	2087	466	6745	9298	1658
Roseires MOL raised to El. 471 and 3 x 45 MW extension	2421	466	6745	9632	1992

3.8 EFFECTS OF BORDER ON HIGH ASWAN IN EGYPT

The filling of the Border reservoir will result in only a slight reduction of water level in Lake Nasser / Nubia of some 2 metres. This will have a marginal effect on the generating head at High Aswan power station.

3.9 GEOLOGY OF BORDER SITE

At the Border dam site the Abbay river traverses an area of mountainous terrain with peaks rising from river level at 490m up to elevation 1850m. These mountains are the topographic expression of a complex intrusion of granite, granitic gneiss, and granodiorite gneiss. Typically the mountains are dome shaped with concave slopes extending down to the river. The mountain summits and upper slopes are often formed by large exfoliated domes of granite or gneiss. Where the Abbay river crosses these granitic rocks the valley becomes quite narrow and incised with a rocky river bed and frequent rapids, indicative of relatively fast flow and only shallow accumulation of alluvium. Immediately upstream of the dam centre line the river valley opens up dramatically into a wide open plain.

This contrast in morphology between the two differing rock formations ensures a relatively narrow valley for the dam on granitic foundation, with a wide-open valley upstream of the dam, ensuring high storage potential. This combination of morphological factors determines the favourable characteristics of Border dam site.

Geological mapping at the site confirmed the existence of the two broad geological formations divisions; namely the Granite /Granite Gneiss Formation and the Biotite Schist / Marble Formations. The latter formation presents a significantly weaker rock mass than the former, and needs to be avoided as a foundation rock for the dam.

The Border 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 Border dam site is 300km away from the nearest epicentre.

3.10 PROPOSED DESIGN OF BORDER DAM AND POWER STATION

Having regard to the site topography and geology at the Border 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. B8.

The Border dam with full supply level of El. 580 m will have an RCC volume of some 3 million cubic metres. Table 3.9, below 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 Border of 150,000 m^3/month appears to be easily achievable.

Table 3.9 : 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 at the start of the flood season. In practise 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 left bank, downstream of the dam site, at a distance of approximately 500 m from the powerhouse.

3.11 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 150 MW assuming a design net head of 78.4 m. The synchronous speed of the unit has been selected at 136.4 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 176.5 MVA. Voltage will be in the range11–18 kV. The speed of each generator will be 136.4 rpm which corresponds to a 22 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.

3.12 TRANSMISSION SYSTEM

It is envisaged that the transmission system would connect the Border 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 Border to Debre Markos (Length approximately 380 km), or
- 400 kV double circuit transmission line from Border to Bahir Dar (Length approx. 340 km),

The connection to the Sudan grid would comprise:

- 500 kV double circuit transmission line from Border to Hasaheisa/Rabak following a route to the east side of the Roseires reservoir (Length approximately 440 km),

3.13 ACCESS ROADS AND BRIDGES

A new access road will be required from the existing Kosso Ber to Mankush (Guba) road to the Border site. Improvement of the existing road from Kosso Ber to Chagni and Mankush (Guba) will be required to accommodate construction traffic and heavy loads.

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

3.14 COST ESTIMATE

The cost of the Border project has been estimated as USD 1481 million inclusive of environmental mitigation measures. A breakdown of the project cost is given in Table 3.10.

Table 3.10 : Border Project Cost Estimate

Item	Cost (Million USD)
Environmental Mitigation	125.4
Access Roads and Infrastructure	107.7
Reservoir Clearance	25.8
Civil Works	
Diversion works	23.2
RCC Dam and spillway	458.2
Powerhouse and tailrace	122.6
Switchyard and Buildings	5.8
Civil contingencies	91.5
Mechanical and Electrical Plant	322.5
Sub-total	1039.8
Engineering and Construction Management	129.9
Owners Administration	51.9
OVERAL TOTAL	1480.6

3.15 CONSTRUCTION PROGRAMME

The Border project will take some 6 years to commencement of generation of the first units. Final installation and commissioning of all 8 turbine-generator is anticipated to require 7.5 years from commencement of construction. The project construction schedule is given in Drawing No. B14.

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 2018.

3.16 CO_2 EMISSION SAVINGS

The Border project will provide carbon emission savings of some 210 million tonnes of CO_2 compared to equivalent thermal generation based on a 50/50 gas-fired CCGT / coal fired thermal generation mix.

3.17 GENERATION PLANNING AND ECONOMIC APPRAISAL

The Border hydropower project has been selected as part of the least cost development plan within the generation planning analysis for commissioning following the Mandaya and Karadobi 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 3.11.

Table 3.11 : 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

3.18 KEY PROJECT CHARACTERISTICS

Power and Energy			
	Installed Capacity	1200 MW	
	Annual energy generation	Firm	3,966 GWh/yr
		Average	6,011 GWh/yr
	Plant factor	57%	
Hydrological data			
	Catchment area	176,918 km^2	
	Mean annual flow	1547 m^3/s	
Reservoir data			
	Full supply level	580 m	
	Minimum operating level	560 m	
	Operating range	20 m	
	Gross storage	14.5×10^9 m^3	
	Live storage	8.5×10^9 m^3	
	Surface area at FSL	574 km^2	
	Length of reservoir at FSL	150 km	
Dam			
	Type	Roller compacted concrete (RCC) gravity	
	Maximum height	90 m	
	Crest elevation	583 m	
	Crest length	1500 m	
	Dam volume	3,000,000 m^3	
Spillway			
	Type	Gated overfall with chute	
	Design capacity	30,000 m^3/s	
	Elevation of spillway crest	562 m	
	No.of gate bays	12	
	Size of gates (W x H)	16 m x 18 m	
Power Intake			
	Sill elevation	544 m	
	No. of intakes	8	
	Gate size (W x H)	3 m x 5.4 m, 2 per unit	
Penstocks			
	Number	8	
	Diameter	6.0 m	
	Length	120 m	
Powerhouse			
	Type	Surface	
	Overall length	245 m	
	Overall width	25 m	
	Generator floor level	501.5 m	
	Access / loading bay level	520 m	

Turbines		
	Type	Francis, vertical axis
	No.	8
	Speed	136.4 rpm
	Design net head	78.4 m
	Setting	490.13 m
Generator		
	Type	Vertical synchronous
	Size	173 MVA
Transmission within Ethiopia		
	Route	Border to Debre Markos
	Length	380 km
	Voltage	400 kV ac
	Type	Double circuit
Transmission to Sudan		
	Route	Border to Hasaheisa/Rabak
	Length	440 km
	Voltage	500 kV ac
	Type	Double circuit

4. EXISTING ENVIRONMENT OF PROJECT AREA

4.1 PHYSICAL ENVIRONMENT

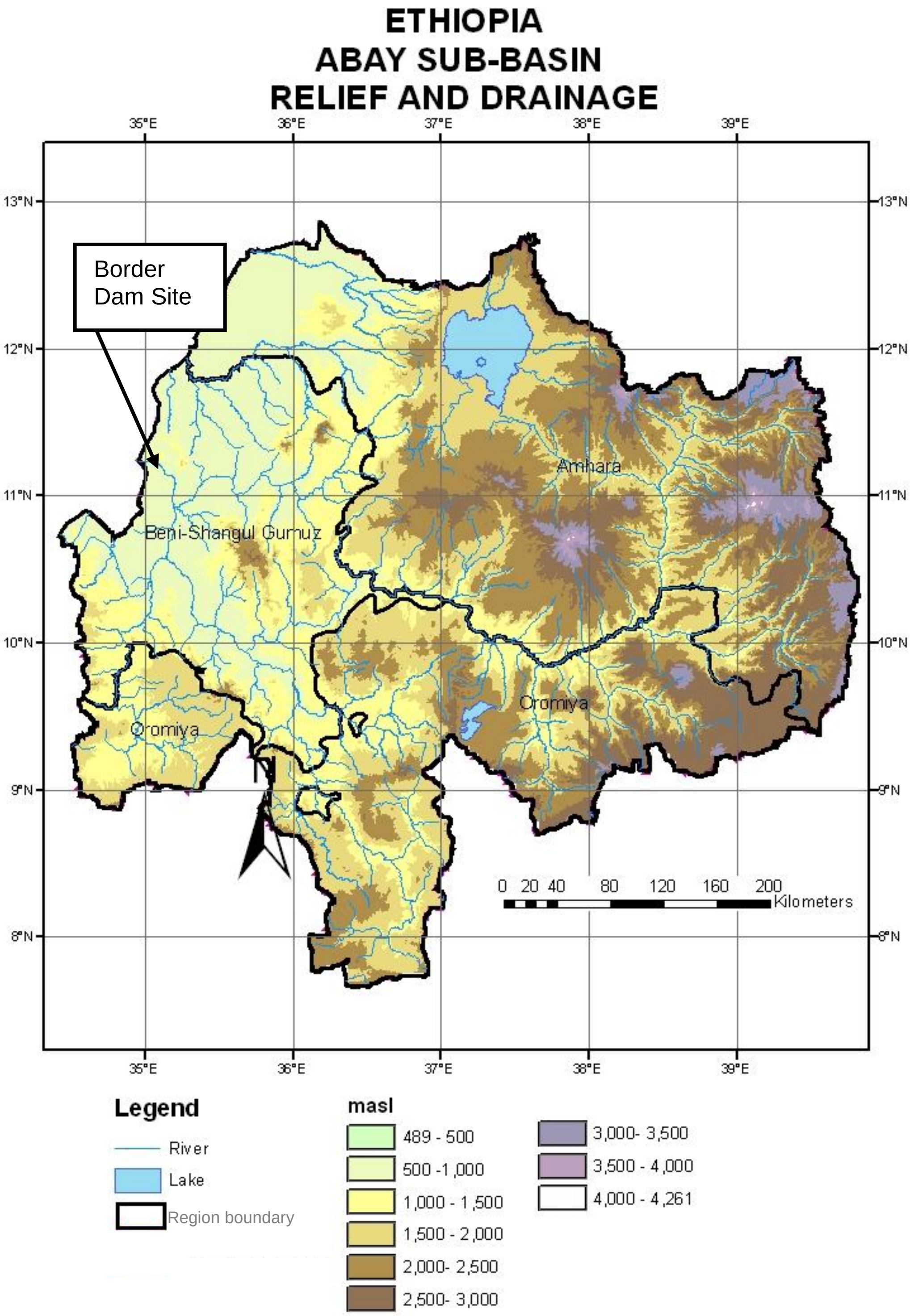
4.1.1 Topographic and drainage features

The land around the Border dam site is mountainous, having elevations ranging from 490 metres above sea level (masl) in the river bed at the dam site to a local peak of 1,255 masl in hills on the right bank and 1,241 masl in hills on the left bank. Upstream of the Border dam site, the valley opens into a basin with low relief, typically surrounding land lying between 500 and 600 masl with a number of areas of high ground greater than 1,000 masl.

The Abbay has confluences with two principal and perennial tributaries in this potential reservoir area, Beles on the right bank and Dabus on the left bank. Beles river joins Abbay 30 km upstream of the dam site. Other tributaries are shorter in length and are seasonal.

There are a series of rapids at the dam site, similar to cataracts on the Main Nile in Sudan, but no natural waterfall. The dam itself creates the head of the project for power generation.

The relief and principal drainage network of the Abbay's upstream catchment area to the Border dam site are presented in Figure 4.1.



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

Figure 4.1 : Abbay Sub-basin: Relief and Drainage

4.1.2 Geology, minerals and soils

Geology

Border dam site is situated some 30 km downstream of the Abbay/Beles confluence. After the Beles confluence, the Abbay flows due north for 15 km before turning sharply towards the west, from this turn the river traverses an area of mountainous terrain. These mountains are the topographic expression of a complex intrusion of granite, granitic gneiss, and granodiorite gneiss. Typically the mountains are dome-shaped with concave slopes extending down to the river. Large exfoliated domes of granite or gneiss often form the summits and upper slopes. Where the Abbay river crosses these granitic rocks the valley becomes quite narrow and incised with a rocky river bed and frequent rapids, indicative of relatively fast flow and only shallow accumulation of alluvium.

The flat, central, river section is 600m wide at the dam centreline. In February 2007, the river water surface was 90m wide and occupied a 10 to 15m deep rocky trench with outcrops on either bank with scattered small rock islands. The estimated river level at this time was approximately 490 masl. All the exposed rocks along the river section at and adjacent to the centreline consist of unweathered, or slightly weathered, very hard gneissic granite. This selected dam centre line is considered optimal as it avoids the dam being built at or close to soluble marble rock masses. The entire dam will be founded on gneissic granite.

Immediately upstream of the dam centre line the river valley opens up dramatically into a wide open plain, with average slopes of 1 in 25 to 1 in 50. This pediment slope is underlain by relatively weaker basement rocks comprising marble, schist, meta-volcanic greenstone, and biotite gneiss.

There is a huge, bare dome of massive granite 2 km east of the dam which is likely to be one of the preferred sources of aggregates for construction. Natural gravel deposits in the Abbay river and adjacent alluvial terraces are also likely to be required. Sirba Abbay marbles have been noted as a possible local source of cement for construction. Sources of pozzolanic materials for use in the RCC dam construction have not yet been identified.

Examination of topographic maps and orthophoto-maps indicate that the entire dam basin occupies a rather flat and level area, with rather shallow submerged side slopes generally in the range of 1 in 20 or less. Furthermore the available geological map confirms that the entire basin is underlain by basement crystalline rocks, with granite types far 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. Some regional faults and shear zones are present in the basin but they coincide with very flat terrain.

Our geological report notes that there is a low neck encroaching on the Border reservoir boundary at a point 9 km southwest of the dam site. Regional geological mapping shows a major fault passing through the neck, and this would exacerbate the depth of weathering in granitic bedrock.

The Border dam project area appears to be located in a relatively low seismic hazard zone. It is 250 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 Border dam site falls outside of these active zones. (See Figures 6.2 and 6.3 in the Border 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 January and February 2007, the geologist noted only one location in the Border area where gold was being extracted; this was just downstream of the dam site.

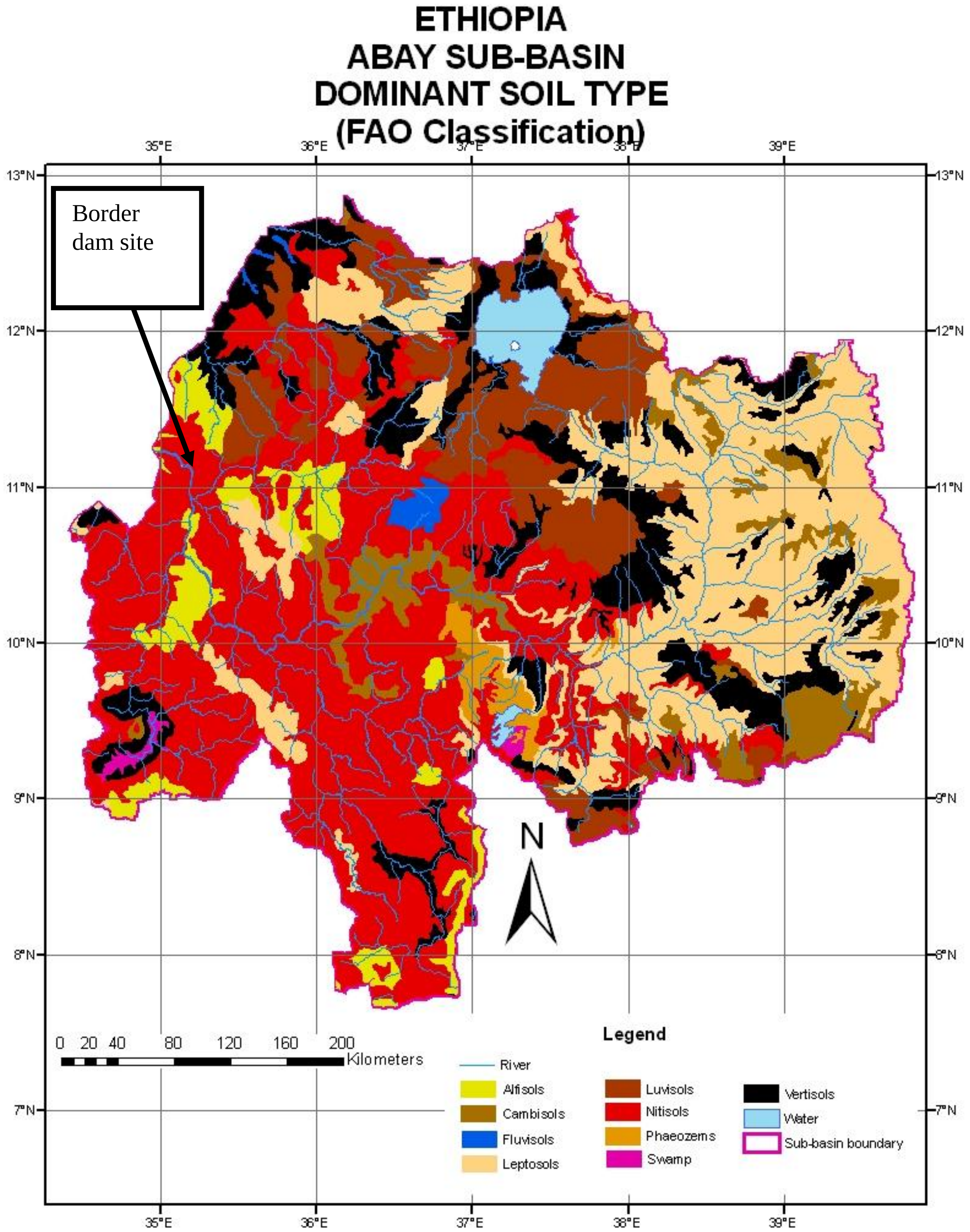
Minor outcrops of marble have been mapped in the reservoir area, but they are too small to be commercially viable. Significant resources of high quality marble are found in the Koncho area near the uppermost limit the Border reservoir basin but the quarry working areas are confined to elevated koppies which are all well above the proposed full supply level of 580 masl.

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

Soils

Soils in the Border area are broadly classified as Nitosols and Alfisols, two of the nine major soil groups covering the Abbay basin (Figure 4.2). These units are capable of cultivation but their acidity reduces the availability of nutrients like phosphorus, calcium and magnesium.

Major Soil Group	**Soil Depth**	**Soil Unit**
Nitosols	Deep to very deep	Haplic Nitisols Rhodic Nitosols
Alfisols	Deep to very deep	Haplic Alfisols



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

Figure 4.2 : Dominant Soil Types in Abbay Basin

4.1.3 Climate and Hydrology

Climate

There are no climatological stations in or close to Border dam site and reservoir location. Descriptions of climate are therefore based on regionally mapped data by the former Ethiopian Meteorological Service provided in the National Atlas of Ethiopia. Border lies in the Tropical Climate II type of the nine types of the Koppen classification system occurring in Ethiopia. Areas with Tropical Climate II are mostly found in the west of Ethiopia and are characterized by dry winter months, the mean temperature of the coldest month being greater than 18°C and mean annual rainfall between 680 and 2000 mm.

Rainfall

According to mapping of the former Ethiopian Meteorological Service (National Atlas of Ethiopia, 1988), mean annual rainfall at the Border reservoir site is expected to be in the order of 1,000 mm. From more recent mapping, it may be assessed at between 1,000 and 1,250 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 Abay basin and elsewhere is not distinct in the Border area. Rainfall quantities in the Belg season are low and variable and frequently have no significant impact on tributary rivers of Abay in the Border 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 Border area into October, as experienced during our surveys October 2006. Normally, there is very little rainfall between October and January.

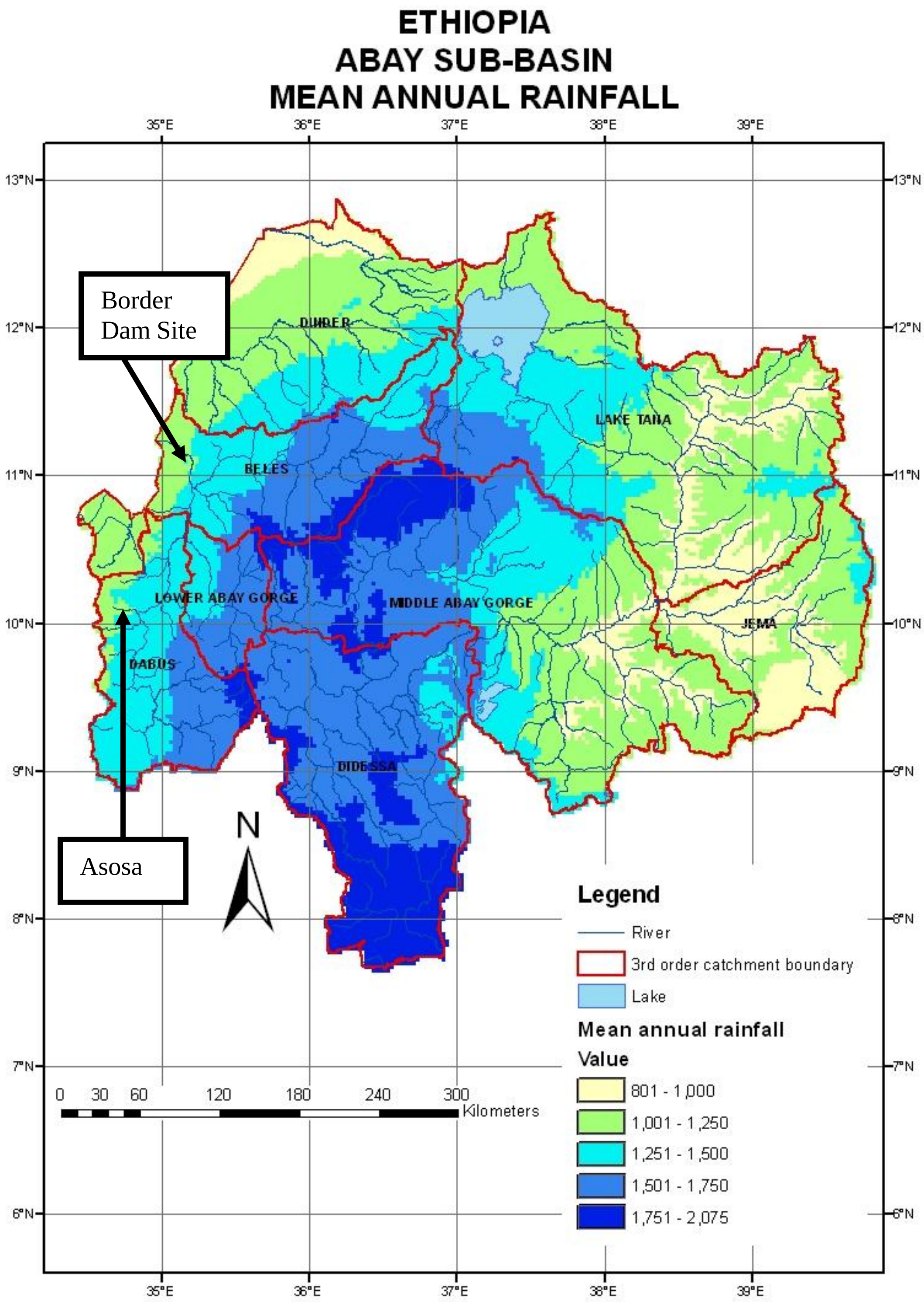
The nearest representative station with climatological records in this region is at Asosa town, located some 140 km SSW of Border dam site. Climatological statistics for Asosa are published on the National Meteorological Agency's website. Monthly mean rainfall is shown in Table 4.1.

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

According to mapping of the former Ethiopian Meteorological Service (National Atlas of Ethiopia, 1988), mean annual temperature in the Border project area is between 25 and 30°C. Quarterly temperature ranges are indicated as follows:

- January and April, between 25 and 30°C
- July and October, between 20 and 25°C

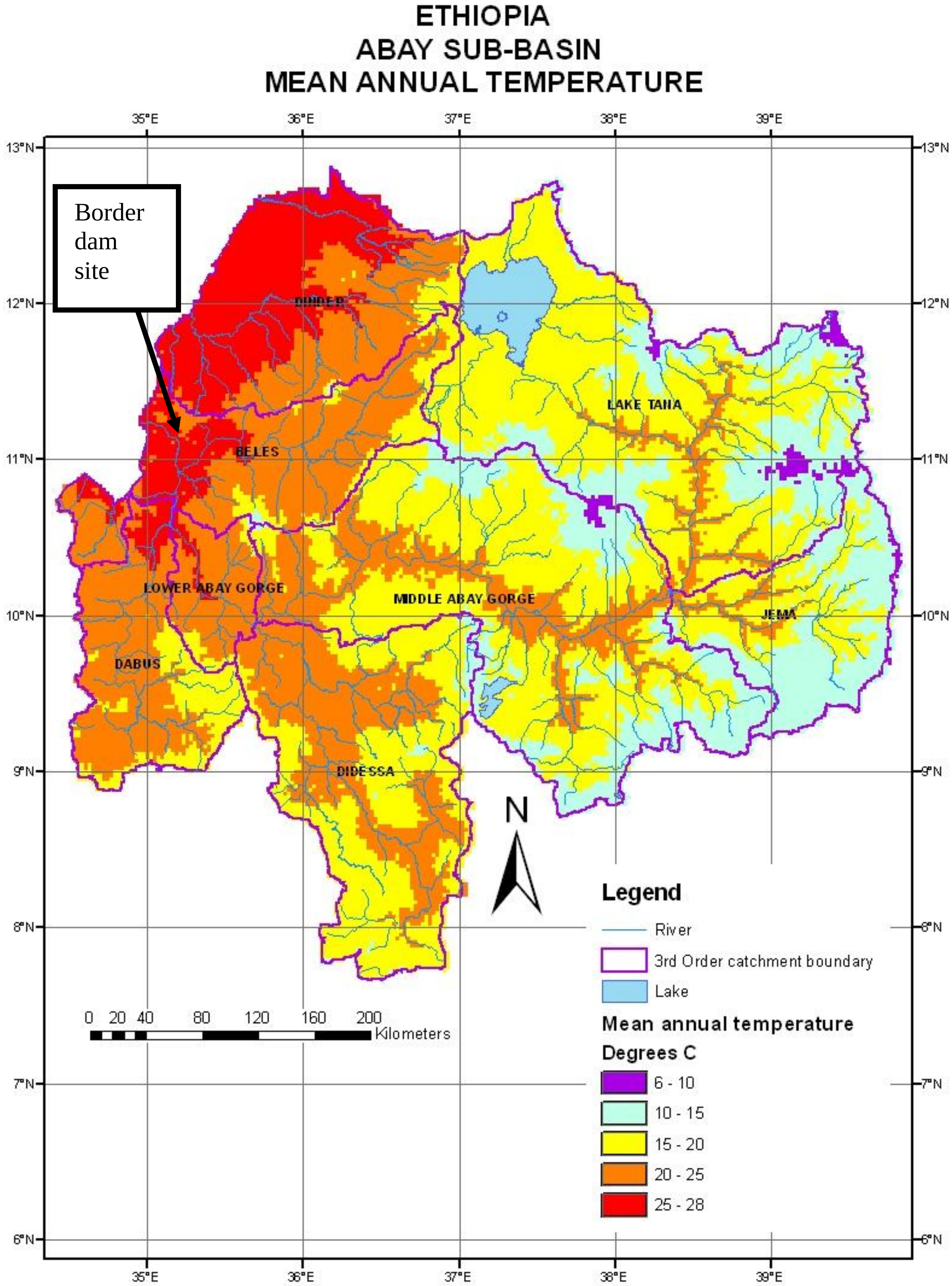
Recent mapping (Figure 4.4) indicates that Border dam site is located in the hottest part of the Abbay basin, with a mean annual temperature between 25 and 28°C.

In the days around the spring equinox in March 2007, when field surveys were conducted near Boka, some 27 km upstream of the uppermost end of the potential Border reservoir, 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 (approximately 1,000 m higher and a little cooler than at the full supply level of Border reservoir and Boka (580 and 600 masl respectively) show that March and April are the hottest months in the region, supporting the high temperatures experienced at Boka 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 Border. These are shown in Table 4.3.

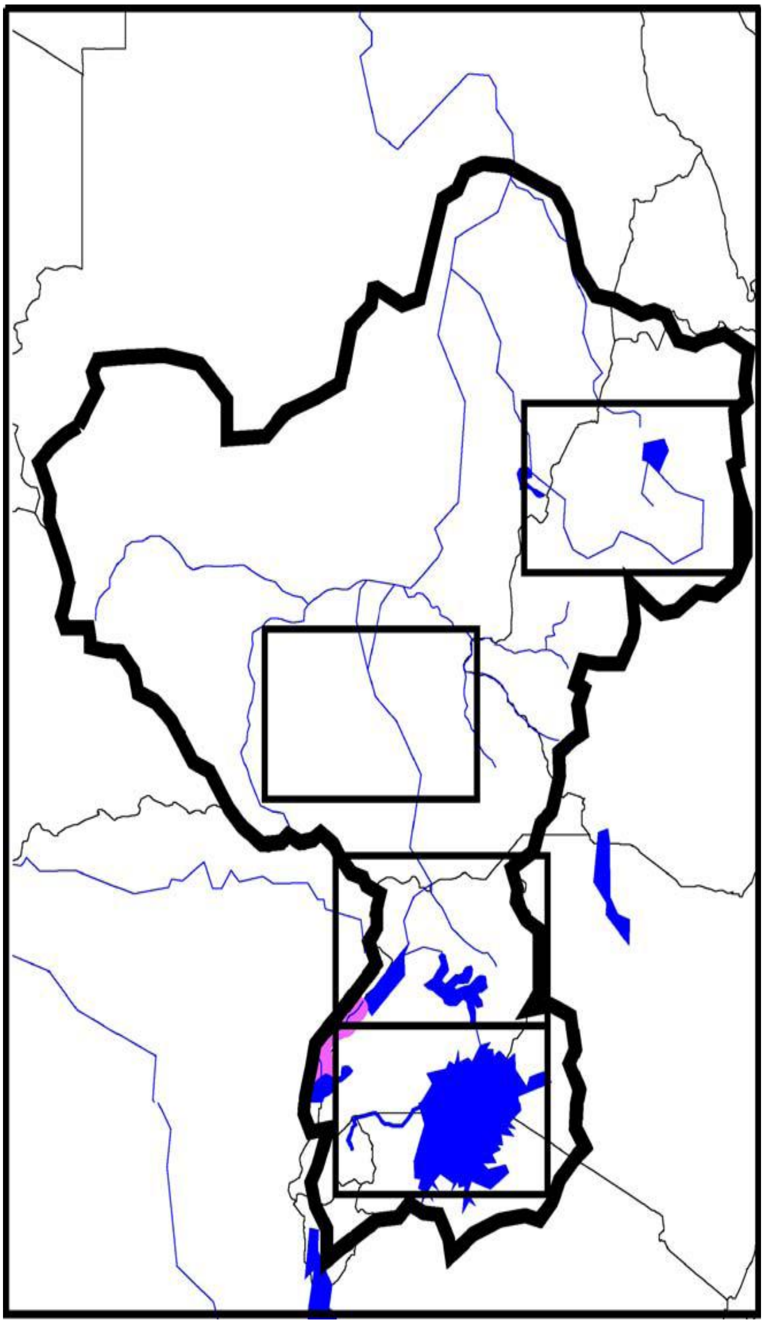
Table 4.3 : Monthly mean net evaporation rates adopted for Border reservoir

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
201	192	159	148	117	-8	-188	-122	31	127	155	187	999

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

Two river gauging stations have been operational for many years downstream of Border dam site, one in Ethiopia and the other in Sudan at El Deim, a site upstream of Roseires reservoir. Staff of respective Ministries reported in each case that their stations have exhibited stable stage/discharge relationships since their installations and first calibrations in the early 1960s. Nevertheless, when monthly data for these stations are directly compared, the relationship exhibits some scatter. This may be due to inaccuracies in one or both of the stage/discharge relationships but more likely to poor quality stage data in some periods of record and/or to completely missing stage records for which flow records may only be derived synthetically. At feasibility study level, there will be merit in detailed cooperative studies of stage and flow records at the two stations in order to proceed with planning in future using an agreed record. This may be a hybrid of the two records.

For the river simulation modeling in this study, the 50 year flow record for the El Deim station in Sudan has been adopted (Table 4.4). The mean flow at Border dam site has been assessed from this at 1,548 m^3/s, equivalent to approximately 49,000 Mm^3 (49 billion m^3 or 49 km^3). This average flow is less than 1,556 m^3/s given in the Cooperative Regional Assessment (CRA) watershed management report for the Blue Nile (Table 4.5) but is closely similar, in spite of different record periods being adopted.

Table 4.4 : Blue Nile Flows at El Deim (m^3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Mean
1954	316.5	242.5	196.2	179.8	198.1	665.5	3403.0	6696.7	5459.2	2893.6	1016.8	565.7	1832.3
1955	416.4	284.5	197.4	248.4	316.4	620.6	2911.1	6262.1	5612.6	2896.2	1024.1	570.2	1791.2
1956	361.0	258.9	201.7	254.3	230.0	883.0	2747.2	5884.1	4420.6	4598.7	1471.5	657.2	1845.1
1957	416.6	301.3	523.1	541.2	301.7	699.3	2157.1	6479.3	3863.9	1288.1	650.7	374.9	1476.3
1958	272.0	234.3	175.9	208.1	225.7	749.5	3026.1	6977.9	5046.5	3219.3	1165.6	580.1	1836.8
1959	399.0	294.9	212.1	179.0	295.3	476.7	2188.8	6122.7	5956.1	3181.3	1331.2	683.9	1786.6
1960	447.7	300.2	229.1	194.5	272.4	541.6	2853.1	6337.1	5013.5	2376.4	847.1	480.6	1669.8
1961	324.5	258.6	205.2	255.9	206.6	588.7	3399.2	6501.2	6143.4	3812.9	1252.4	827.4	1994.6
1962	430.1	277.9	215.8	162.2	277.8	685.7	2060.3	5582.5	5093.3	2923.3	848.7	506.1	1598.2
1963	350.2	249.3	223.0	241.9	541.5	629.2	2506.9	6695.4	4723.5	1694.6	969.1	799.8	1646.7
1964	363.8	261.9	160.0	211.4	233.9	681.0	3647.7	6417.7	5478.2	3517.3	1277.5	688.5	1925.9
1965	430.2	291.1	215.1	271.2	181.5	506.8	1824.8	5455.0	3433.4	2490.2	1105.7	613.6	1411.5
1966	353.7	278.1	233.3	217.4	274.3	758.0	2361.9	5263.9	4432.9	1387.4	819.5	505.7	1414.8
1967	300.8	222.1	210.2	220.9	290.5	571.9	2647.4	5827.4	4888.4	3397.7	1087.1	706.1	1709.7
1968	349.8	265.7	187.7	183.5	197.4	682.0	3307.5	5988.5	3811.1	2039.6	709.4	437.5	1526.1
1969	284.1	241.4	386.1	207.7	327.6	710.2	2788.8	7072.1	4023.8	1421.0	618.7	360.3	1549.1
1970	258.2	208.7	209.8	183.8	184.0	454.2	2298.3	6415.9	4549.7	2267.4	835.8	393.7	1532.6
1971	287.7	220.9	169.3	155.0	237.3	702.6	2564.6	6172.2	4238.1	1973.8	943.5	442.3	1519.5
1972	308.3	231.9	180.5	206.0	260.9	536.7	1964.9	4186.7	2516.5	1174.4	663.8	383.1	1059.3
1973	260.0	180.3	149.0	157.7	333.8	706.4	2140.7	6572.7	4459.7	2213.7	869.3	451.6	1552.4
1974	321.1	239.5	209.6	179.1	361.3	824.7	3396.3	6085.1	4376.2	1883.8	755.2	453.5	1602.2
1975	266.2	246.6	183.3	161.9	198.4	603.8	2878.0	6416.5	6298.3	2456.1	922.0	534.2	1773.7
1976	368.2	245.6	226.7	190.4	301.3	606.3	2160.8	5602.8	3552.3	1209.6	827.2	444.5	1320.9
1977	284.0	239.7	202.1	180.4	250.3	695.2	3668.7	5747.9	4489.4	2089.5	1338.4	494.7	1651.1
1978	303.1	220.1	185.2	173.5	251.3	629.1	2857.3	4901.1	4083.5	2655.2	860.3	468.3	1476.2
1979	334.7	269.1	186.4	175.7	347.3	678.9	2174.7	4897.8	3145.1	1498.5	659.7	370.2	1236.7
1980	256.0	205.7	175.6	209.4	251.1	554.6	2838.7	5757.9	3564.2	1646.6	657.0	377.5	1386.1
1981	256.0	239.4	366.4	217.8	263.2	466.4	2504.5	5415.6	4397.8	1811.1	656.7	358.6	1422.2
1982	271.9	213.5	193.7	172.3	204.8	457.3	1701.7	4566.4	2930.3	1753.6	660.5	358.9	1132.0
1983	241.2	199.0	171.0	187.4	258.2	491.1	1575.1	5697.8	3838.5	1953.1	775.0	399.0	1324.6
1984	262.9	197.1	157.7	143.6	198.3	764.1	2428.5	3961.5	2716.5	959.9	457.2	291.2	1052.7
1985	200.4	151.8	140.5	183.2	345.6	586.5	2328.2	5928.0	4855.1	1568.6	619.8	360.8	1448.3
1986	245.1	200.1	187.1	208.3	608.6	591.1	2655.7	4189.5	3389.1	1306.7	499.1	285.4	1205.6
1987	205.0	174.3	220.8	212.3	382.5	970.1	1778.3	4348.2	2481.1	1432.4	695.7	368.8	1113.6
1988	241.0	211.6	213.8	170.4	185.8	813.3	4594.9	7353.0	5381.5	3415.4	1147.5	621.9	2046.3
1989	329.0	244.4	214.1	252.3	238.1	494.4	2389.3	4827.0	3947.2	1601.0	586.4	398.4	1301.8
1990	346.8	252.2	206.3	192.1	192.1	368.7	1863.9	5119.0	3690.9	1717.0	611.7	350.2	1251.0
1991	246.5	191.6	180.7	217.9	312.3	640.7	3239.6	5450.4	4106.5	1552.5	697.1	423.4	1448.8
1992	284.3	241.3	193.5	180.2	304.1	586.4	1690.8	4672.6	3902.0	2592.4	1126.2	586.8	1372.3
1993	365.9	274.2	200.7	380.5	509.7	1135.2	3191.5	5845.6	4631.3	2583.8	1134.9	553.0	1744.9
1994	354.4	260.4	199.3	183.9	333.5	778.9	3334.0	6861.6	4964.3	1578.8	746.2	393.1	1677.2
1995	270.3	208.4	189.6	233.1	285.9	601.6	2132.7	5071.8	3495.3	1399.2	614.0	381.8	1248.8
1996	285.6	198.5	220.5	276.2	619.4	1591.0	4154.5	6439.5	4242.5	1975.3	789.5	493.1	1787.8
1997	353.9	210.3	268.9	235.9	390.5	1057.9	3156.9	4818.1	2629.4	1623.2	1448.0	631.2	1412.5
1998	360.9	324.5	267.4	297.7	349.8	697.3	3377.0	7511.3	5707.3	3888.6	1338.0	663.8	2080.2
1999	418.1	279.4	210.6	163.4	369.0	842.8	3484.3	6342.6	4575.4	3950.3	1352.3	671.6	1903.2
2000	399.4	339.7	170.4	255.4	369.1	900.8	2943.6	6717.9	4075.9	3049.3	1406.5	655.7	1787.6
2001	375.1	221.4	298.2	307.7	375.5	1014.3	3952.3	6844.7	4627.8	1891.7	894.1	483.4	1787.3
2002	486.5	209.6	280.3	266.7	216.4	752.7	2467.9	4872.3	3141.7	1336.7	642.5	375.6	1263.2
2003	269.5	217.3	257.0	234.5	198.3	749.9	3338.5	5522.9	4090.2	1808.3	656.2	356.2	1485.7
Mean	322.7	240.6	217.2	218.5	297.2	695.9	2741.2	5813.9	4289.8	2219.1	901.6	492.7	1548.5
Max	486.5	339.7	523.1	541.2	619.4	1591.0	4594.9	7511.3	6298.3	4598.7	1471.5	827.4	
Min	200.4	151.8	140.5	143.6	181.5	368.7	1575.1	3961.5	2481.1	959.9	457.2	285.4	

Source: River simulation model

Table 4.5 : Monthly discharge (m^3/s) of Abbay River at the Ethiopian/Sudan border

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year
Mean	345	229	162	141	240	722	2,841	5,634	4,340	2468	1,019	526	1,556
Max	527	434	306	194	470	1453	6,018	6,988	5,919	3,708	1,551	755	6,988
Min	212	137	93	81	99	472	1,930	3,693	2,813	1,305	681	324	81

Source: CRA Country Paper. Length of record, 1961 – 1979.

Groundwater

There has been no systematic survey of springs and groundwater in the Border project area and so documented quantitative information about groundwater availability has not been found. Generally, although the geology of the area is not conducive to having major aquifers, survey work in future may highlight the importance of shallow groundwater and some springs for supporting some niche vegetation types and local domestic water supplies.

4.1.4 Water Quality

Historical records of water quality at the Border river gauging station, downstream of the dam site, are not available. Water quality records for Sudan’s El Deim gauging station (near the border) and for Roseires reservoir (where water quality may be expected to be closely similar to water quality at Border dam site) were not collected as part of this study. However, as part of the fieldwork, single water quality samples were obtained from Abbay river at the proposed Border dam site and at the Bure-Nekemte bridge (at the upper end of the potential Mandaya reservoir). A sample was also taken at Beles river bridge (23 km from Mankush); this location is near the upstream end of the Beles arm of the potential Border reservoir. Physical and chemical parameters are shown in Table 4.6 along with a sample 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 Border is required in future to cover all seasons, whilst water quality records of the Upper Blue Nile in Sudan, including records for Roseires reservoir, will be required to assist assessment and interpretation of the probable water quality of Border reservoir and its downstream releases. Laboratory analysis of future water samples will be required to cover a much broader range of parameters including, for example, mercury. The results of any prescribed reservoir water quality modeling 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 nearBorder 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

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: 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 of the bulk of Abbay’s sediment loads at Border dam site is the eastern part of the catchment area.

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 to Border. The only clear water seen was in a few small tributaries downstream of the Abbay/Didessa confluence.

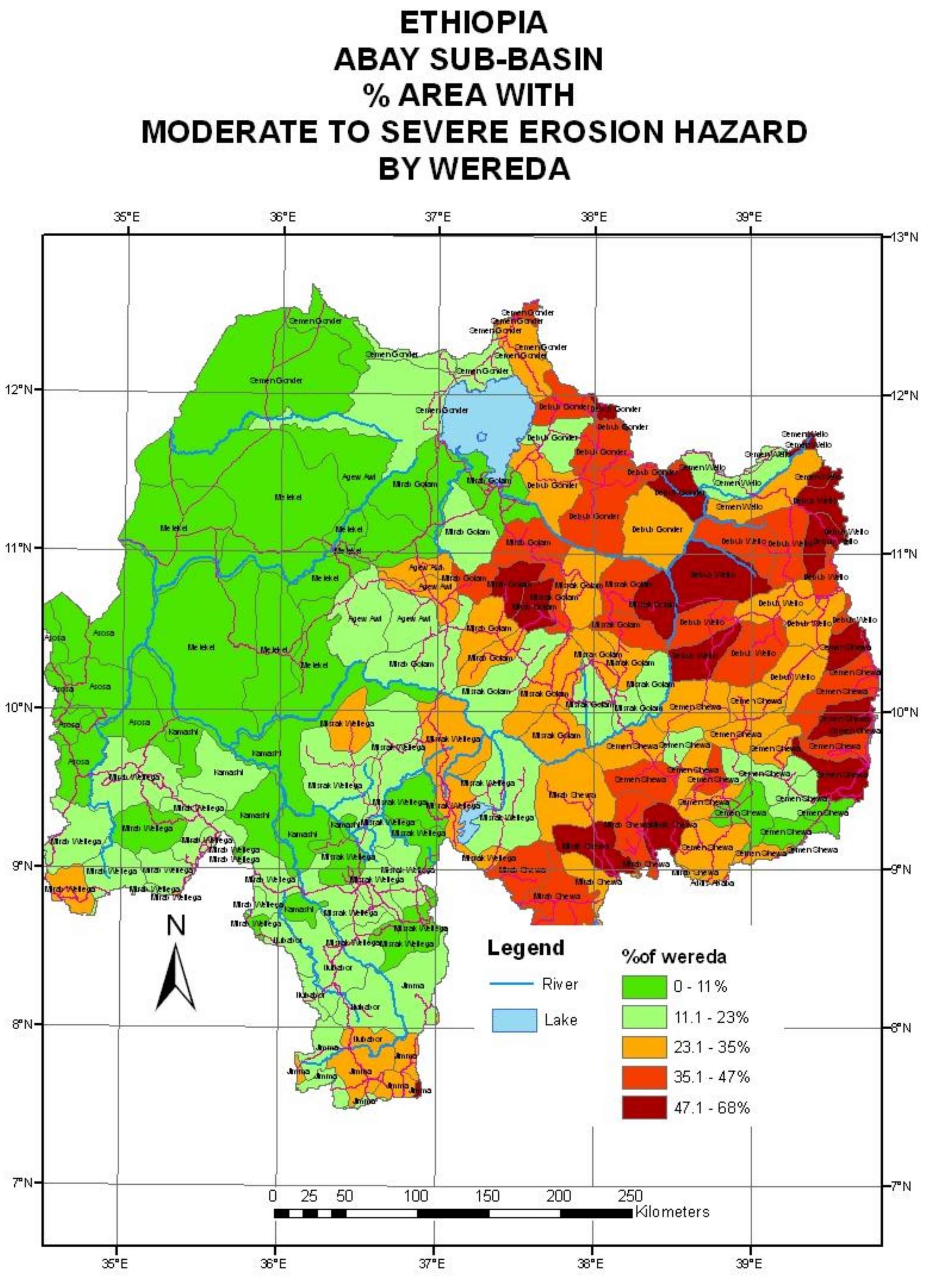
Our foot surveys of the Border dam site and potential reservoir area in January 2007 confirmed that soil erosion features are few, generally confirming that the project area itself is in the “low sediment” hazard zone described in the Abbay Master Plan Study. This is due to very low population density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

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 (within which the Border project is located), 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).



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

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 123M tons. They estimated bed load to be 15% giving a total mean annual sediment inflow of 140M tons". These figures give a mean annual suspended sediment yield for the Abbay basin of approximately 700t/km2/yr, and approximately 800t/km2/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 4.7).

Table 4.7: 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 123M tons mean annual suspended sediment load and 140M 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 140M 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 168M 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 140M 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 273M 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 4.8), 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 (140M 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 4.8: 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)

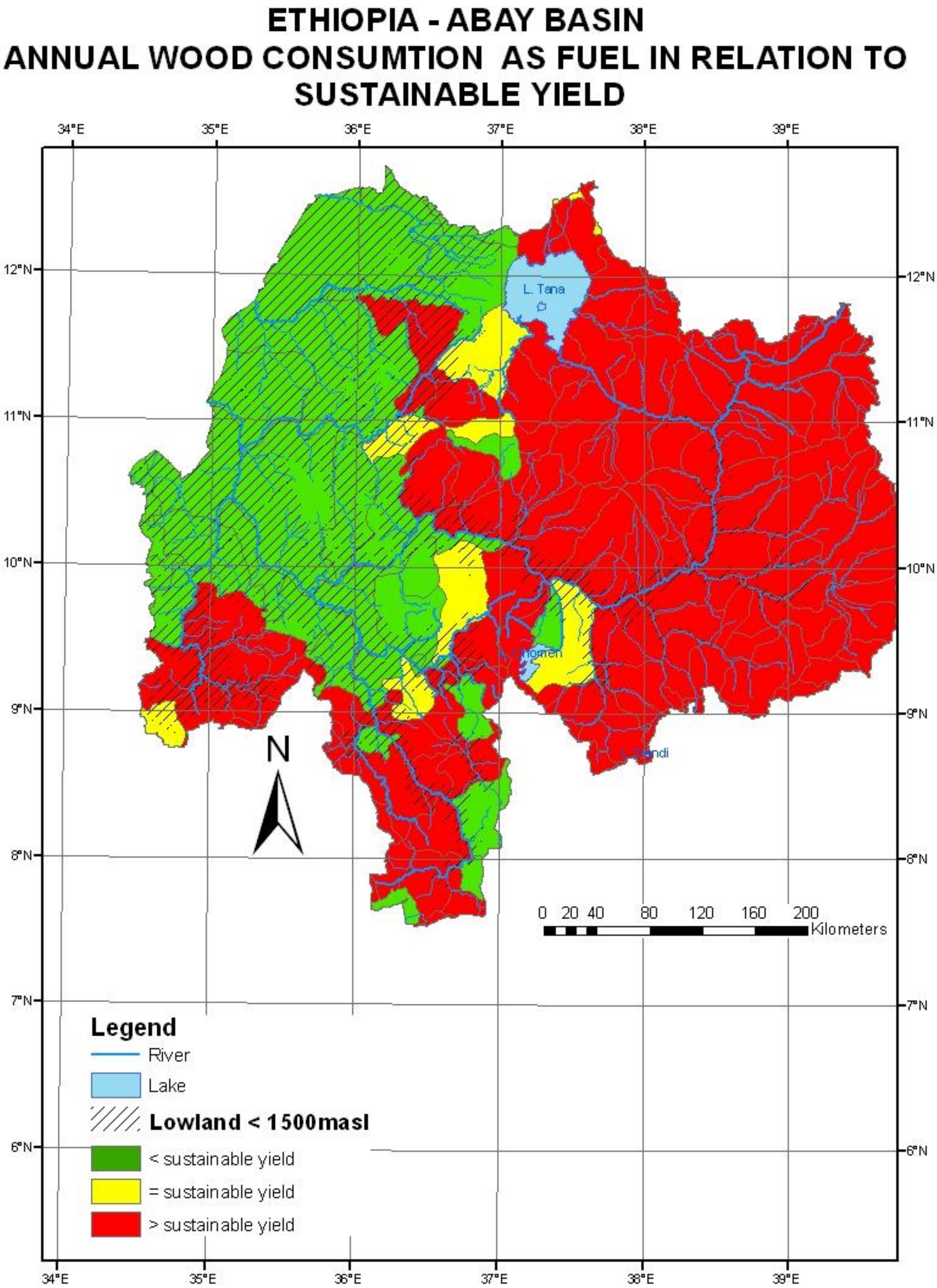
In the Abbay Master Plan report itself, we note that sediment transport is presented for potential dam sites including Mandaya and Border. For Border dam site, sediment transport annual yield is given as 168M tons (and for Mandaya 124M tons). (Phase 2, Data Collection – Site Investigation Survey and Analysis. Section III, Volume 2: Dam Project Profiles). This 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 scheme 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.

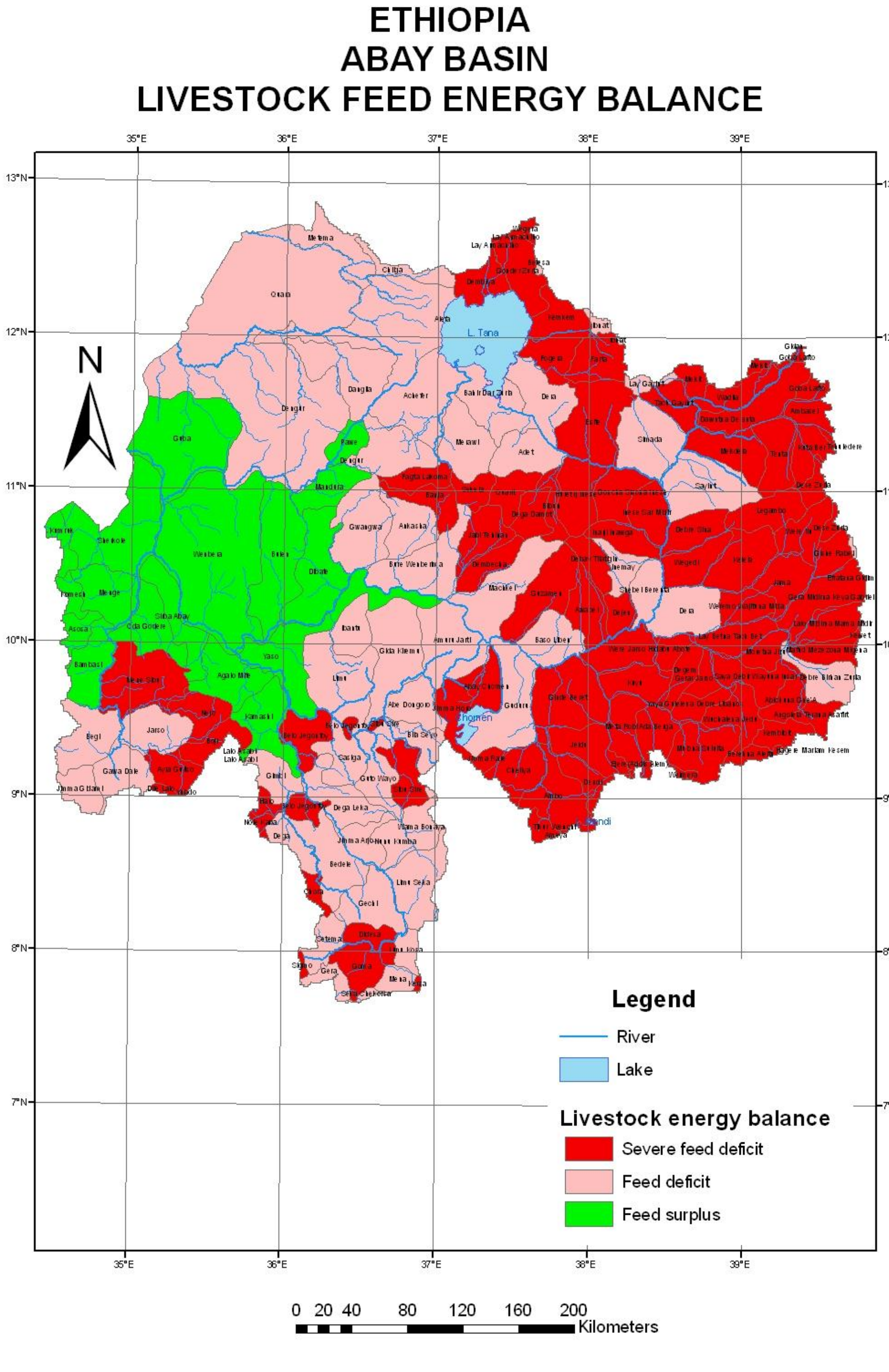
The Country Paper discusses woody biomass, noting that removal of wood in excess of the sustainable yield (after accounting for removal of dead wood and fallen branches, leaves and twigs) leads to declining stocks, which in turn leads to declining yields and so to progressive degradation of woody biomass. 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 Border dam site and Roseires (taken to be proxies for the same location) from the above reports, and our pre-feasibility engineering report, are summarised in Table 4.9.

Table 4.9: Estimates of sediment transport at Border, El Deim and Roseires

Estimate of sediment transport Mt/year	Source	Notes
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)	Border Pre-feasibility report (2007)

Source: This study, as stated.

These observations on sediment transport estimates at 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 140M tons and the annual sediment load entering Lake Nubia/Nasser as 142M tons (Table 4.10). The small difference (2M 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 at Border. 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 4.10: 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
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

LOCATION	NO WSM OR DAMS
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

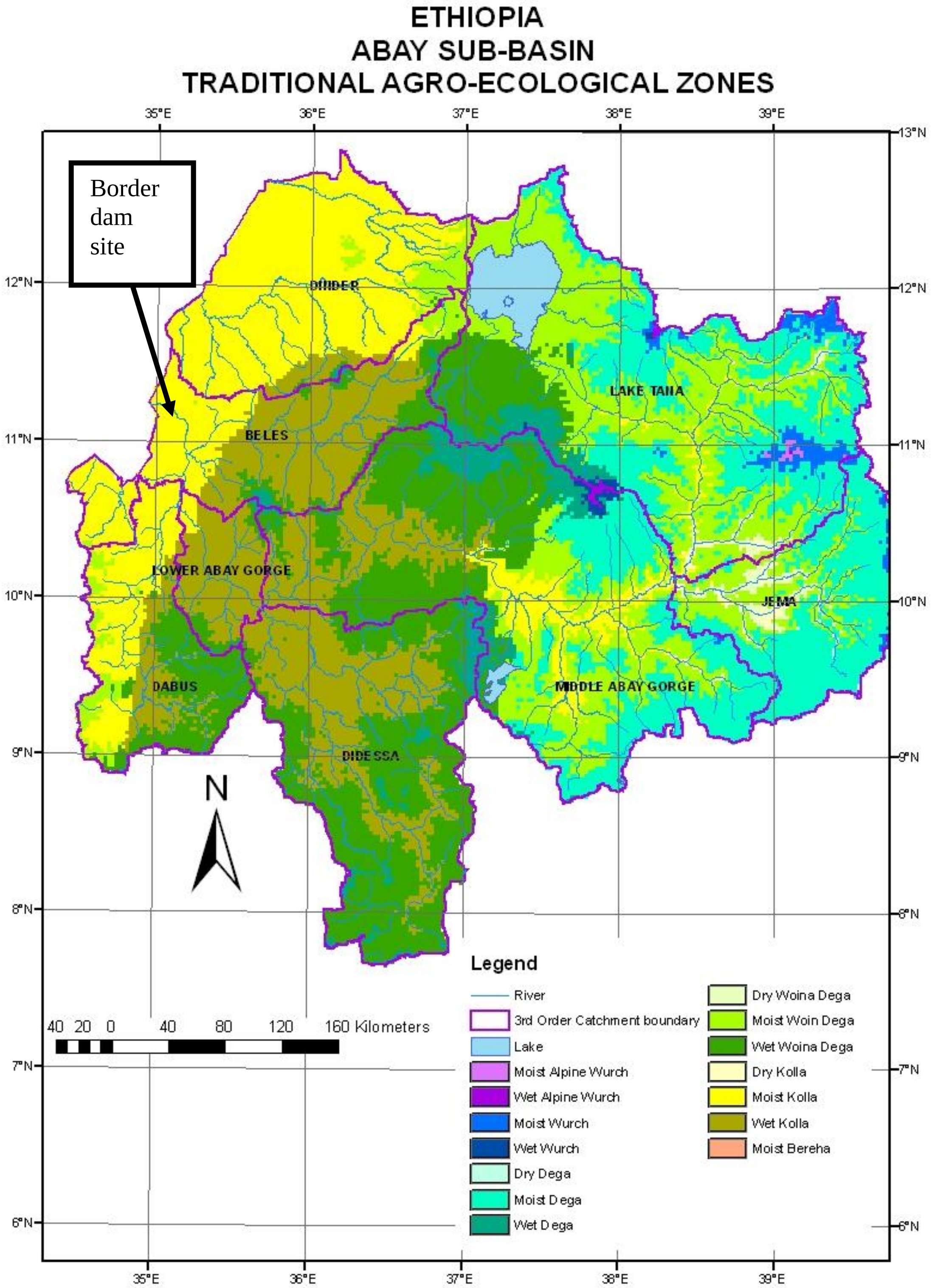
Source: Draft CRA report on Distributive Analysis (January 2007)

The Ethiopian Country Paper states that "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 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 Border reservoir area lies within the Moist Kolla agro-ecological zone. This is one of 14 agro-ecological zones, based on a combination of annual temperature and rainfall, which covers most of the lowlands near Sudan and occupies some 19% of the Abbay basin (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

Limited surveys were made of the Border dam site and potential reservoir area in October and November 2006 and in January 2007. The natural terrestrial vegetation of this area may be classified physiognomically as woodland. Within this vegetation type, there are three general plant associations: Riverine forest, *Combretum – Terminalia* woodland, and Lowland bamboo (*Oxytenanthera abyssinica*) forest.

Riverine forest vegetation

Very narrow and patchy but distinct riverine vegetation was noted immediately upstream of the proposed dam site. Here the river becomes very broad and the bordering hills lie well beyond the river banks. The vegetation here is an extension of this widely distributed woodland type with indications of a recent fire incidence. In January 2007, the riverine vegetation was distinct in its ever-greenness, in sharp contrast to the tree species away from the river and along the steep valley escarpments which are mainly deciduous, shedding their leaves during the dry season.

Typical trees in the riverine forest along Beles River in the potential reservoir area comprise *Acacia polyacantha, Breonadia salicina, Phoenix reclinata, Sapium ellipticum, Tamarindus indica, Celtic africana, Prunus africana, Tamarindus africana, Teclea nobilis, Acacia polyacantha, Lepidotrichilia volkensii, Kigelia aethipioca, Cordia africana.*

Combretum – Terminalia woodland

The *Combretum – Terminalia* woodland vegetation covers a vast area stretching from Chagni westwards all the way to Mankush and southwards. This is a deciduous vegetation type with a canopy height reaching 8 – 12 m.

The canopy woodland species along the Chagni – Mankush road comprise 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, Acacia polyachantha*. 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* (see below) 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.

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 Border reservoir area was severely limited but isolated bamboo patches were observed along Abbay river banks.

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 Border reservoir area

Analysis of the Woody Biomass Inventory and Strategic Plan Project report (WBIPP) for the Border reservoir area (57,400 ha) indicates that dense vegetation covers 38% of the area and open woodland and open shrubland together cover 52% of the area (Table 4.11).

In relation to our field surveys, we doubted the Woody Biomass report findings with respect to areas of cultivated land and bamboo vegetation. We considered that cultivated areas were larger than bamboo areas. In any case, the total area of dense bamboo (811 ha) and riverine forest (6,049 ha) taken from the Woody Biomass study are relatively very small in contrast to other land use categories which implies that the *Combretum – Terminalia* woodland vegetation type covers most of the potential reservoir area.

Table 4.11 : Land Use/Cover of Border reservoir area with FSL 580 masl

Land Cover	Land Use Category	Land use Area ha	Land cover Area ha	Land cover Area %
Cultivation	with few stock of woody biomass with light stock of woody biomass	30 230	260	<1
Dense vegetation	Dense Bamboo Dense Shrubland Dense Riverine Forest Dense Woodland	811 588 6,049 14,638	22,086	38
Grassland	With Few Stocks of woody plant With Light Stocks of woody plant With Moderate Stock of woody plant	25 1,981 16	2,022	4
Wood/Shrubland	Open Shrubland Open Woodland	14,838 15,092	29,930	52
Water	Water body	3,102	3,102	5
All/Total		**57,400**	**57,400**	**100**

Source: WBIPP (2003) and GIS this study

For scoping purposes, and anticipating that clearance of much of the woody vegetation in the Border 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 very 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 4.12.

Table 4.12 : Density of woody vegetation in DBH classes

DBH cm	Density No. /ha	Distribution %
≤ 10	7	6
10 < 20	12	10
20 ≤ 30	33	29
30 < 40	31	27
≥ 40	32	28
All	115	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 Border reservoir area. Also, the suppressed density value of woody species below DBH 10 cm may be due to 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 than at Border) 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. On the plain and on the banks at the Border dam site, trees grow taller and attain heights reaching about 10 -12 m.

Whilst this description provides a general assessment of biomass conditions in the potential Border 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

Although few species of animals were observed during field surveys, this does not indicate that the Border project area is poor in species composition. Discussions with local people and Guba woreda officers indicated the presence of species such as greater kudu, leopard, common bushbuck, duiker, roan antelope, lion, baboons and warthog. These are animals that are typical of savannah woodland habitats.

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 was listed in 1996 as a tentative candidate to become designated as an additional Important Bird Area of Ethiopia. The lowest elevations of this valley, at the Dabus/Abbay confluence, are just within the full supply level (580 masl) of the potential Border reservoir. 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 Border reservoir inundation 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 Border 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 or 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 4.13.

Table 4.13: 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 4.13 are found in the protected area system (Table 4.14). The Dabus Valley controlled hunting area, near the upper end of Border reservoir and near Mandaya dam site, is the nearest protected area to either projects.

Table 4.14: 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 twice that of habitat which would be lost in Border reservoir. Being “on the doorstep” of both, 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 an environmental offset for destruction of habitat in Border and/or Mandaya reservoirs. Websites provide little information on plants and animals, though elephant and lions are mentioned, and 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.

The lower section of the Dabus controlled hunting area lies in the potential Border reservoir. 1:50,000 topographic mapping series does not cover the Dabus/Abbay confluence area and it is not clear to the nearest one or two kilometres where the adopted full supply level for Border reservoir (580 masl) occurs along the lower Dabus river. Nor are the boundaries of the Dabus controlled hunting area clear on maps located for this study. What is very certain is that the 580 m contour extends along the Dabus river for a relatively short distance, perhaps 3 or 5 km and the reservoir, when full, would impact on the controlled hunting area to a very limited extent. If a length of 5 km by a width of 1 km is taken for current purposes, the area would represent 0.41% of the controlled hunting area.

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 37 km upstream of the uppermost end of the potential Border reservoir, and 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 Abay 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 37 km upstream of the uppermost end of the potential Border reservoir, and 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 river bed 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, located some 37 km upstream of the uppermost end of the potential Border reservoir, and some 15 km 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, upstream of the uppermost limit of the potential Border reservoir, 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 (which enters the potential Border reservoir on the right bank) 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 (which enters the potential Border reservoir on the left bank) 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.

The apparent general scarcity of fish in the Abbay could be genuine and caused by the extreme force of the currents and muddiness of the water. 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).

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 river bank areas.

During surveys made in March 2007 in the Abbay reach some 27 to 52 km upstream of the uppermost end of the potential Border reservoir, hippopotami were observed to be abundant and crocodiles present in various locations. 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. 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 Border dam site and the reservoir area. 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.

Nine regional states and two administrative councils were formed under the federal government. The Border project area lies completely within Benishangul Gumuz Regional State. The regionalization process gave power to the regional states to develop and manage their natural resources.

Benishangul Gumuz Region Administration and Border Project Area

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.

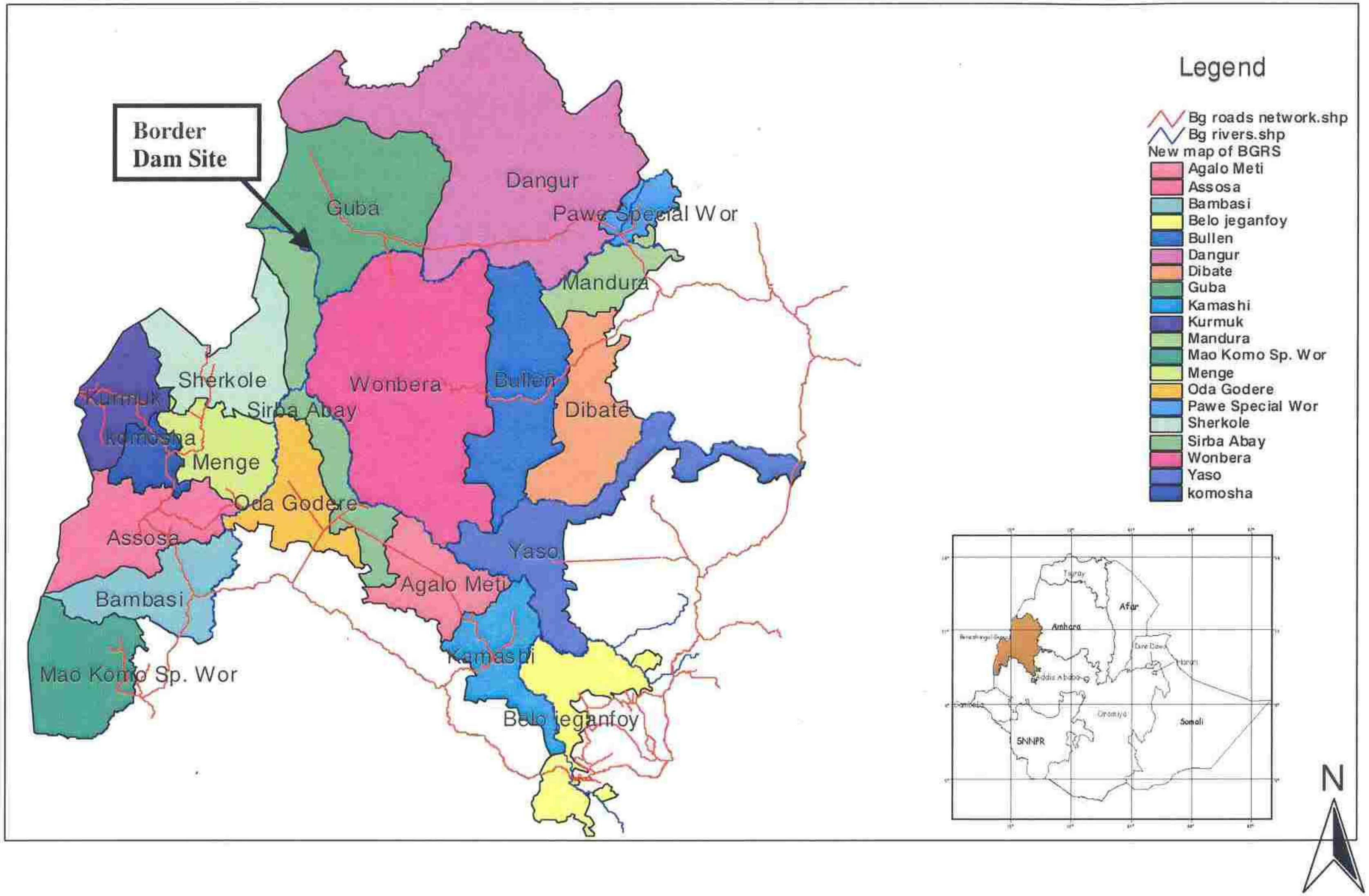
Benishangul Gumuz has a total population of 625,000 inhabitants (2006 estimate) of which about 93% reside in rural areas and the remaining 7% in urban areas. Population density of the Region is 9.3 persons per km^2.

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 4.10.

River Abbay divides the region into two parts. The northern part consists of Guba, Wonbera, Bulen, Dangur, Dibate Mandura, and Pawe Special Woreda. The right bank side of the proposed Border reservoir is administered by Guba and Wonbera woredas.

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. The left bank side of the proposed Border reservoir is administered by Sirba Abbay.

The potential Border reservoir is located therefore in three woredas: Guba, Wonbera and Sirba Abbay.



Source: GIS/RIS (BoFED) of Benishangul Gumuz

Figure 4.10 : 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 Border project 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

Religious Institutions

Dominating religious organizations are Orthodox Christian and Muslim. Protestant and Catholic religious institutions are also found to some extent in the project area. Traditional religion, very traditional and the oldest of all, is also visibly important but is not as organized as the others.

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.

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, only limited numbers of NGOs are operating in Benishangul Gumuz region. Very few are engaged in the project area. Activities of those in service in the project area are education, health, water, harmful traditional practices and, in rare cases, integrated development (Table 4.15).

Table 4.15 : NGOs operating in Border project area woredas

Name of NGO	Origin	Intervention	Host Woreda
Mujejeguura Loka Harmful practices on Women Organization	Local	Genital Mutilation, Women's Rights	Guba
Ethiopian Catholic Secretariat (ECS)	Local	Health, Education	Sherkole, Guba
Lutheran Church of Mekane Yesus (ECM)	Local	Integrated Development	Sirba Abbay
Volunteers Service Overseas (VSO)	International	Welfare fro street mother & Children	Sherkole, Guba
Rehabilitation and Development Organization (RDO)	Local	Provision of Physical Rehabilitation	Sherkole, Guba
ZOA Refugee Care	Local	Refugee	Sherkole, Guba
OXFAM/GB	International	Livelihood improvement	Various areas

4.3.3 Population Characteristics

Population Size and Structure

The Border dam site and potential reservoir area lie within Sirba Abbay, Wonbera and Guba woredas. These three woredas cover an area of 13,469 km^2.

Based on Population and Housing Census undertaken by CSA in 1994, the population of these woredas is now estimated at 79,341 (Statistical Abstract, 2005-

2006 estimates). Summary statistics on sex composition and population density are shown in Table 4.16.

Table 4.16 : Population characteristics of Border project area woredas

Woreda Name	Population			Woreda Area	Woreda population Density	Border 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 %	Proportion of reservoir in woreda %	Border project PAP No.
Sirba Abbay	6,341	5,889	12,230	2,184	5.6	246	11	43	5,800
Wonbera	27,409	28,851	56,260	7,343	7.7	144	2	25	2,605
Guba	5,305	5,546	10,851	3,941	2.8	184	5	32	5,500
All/Total	**39,055**	**40,286**	**79,341**	**13,469**	**5.9**	**574**	4	100	**13,905**

On average, 93% of the population in these woredas reside in rural areas. The remaining 7% of the population live in urban settlements (Table 4.17).

Table 4.17 : Urban population of Border project area woredas

Woreda	Town	Woreda	Urban Population No.			
		Population No.	Male No.	Female No.	Total No.	Urban %
Sirba Abbay	(none)	12,230	0	0	0	0
Wonbera	Debrezeit	56,260	1,936	2,243	4,179	7
Guba	Mankush	10,851	664	591	1,255	12
All/Total		**79,341**	**2,600**	**2,834**	**5,434**	**7**

During the nationwide polio immunization campaign conducted in December 2000 and January 2001, more people were counted than projected from the CSA census. The number obtained during the campaign was higher by 7%. All the woreda administrations contacted during our surveys claimed more people in their woredas.

Regarding household distributions of the three woredas, the total household number amounts to 14,187 (Table 4.18). The households are not evenly distributed among the project woredas. About two thirds are in Wonbera. The remaining is almost equally divided between Guba and Sirba Abbay.

Table 4.18 : Number of households in Border project area woredas

Woreda	Household No.	Household %
Guba	2,586	18.2
Wonbera	9,271	65.4
Sirba Abbay	2,330	16.4
All/Total	14,187	100.0

Source: GIS-BoFED of Benishangul Gumuz

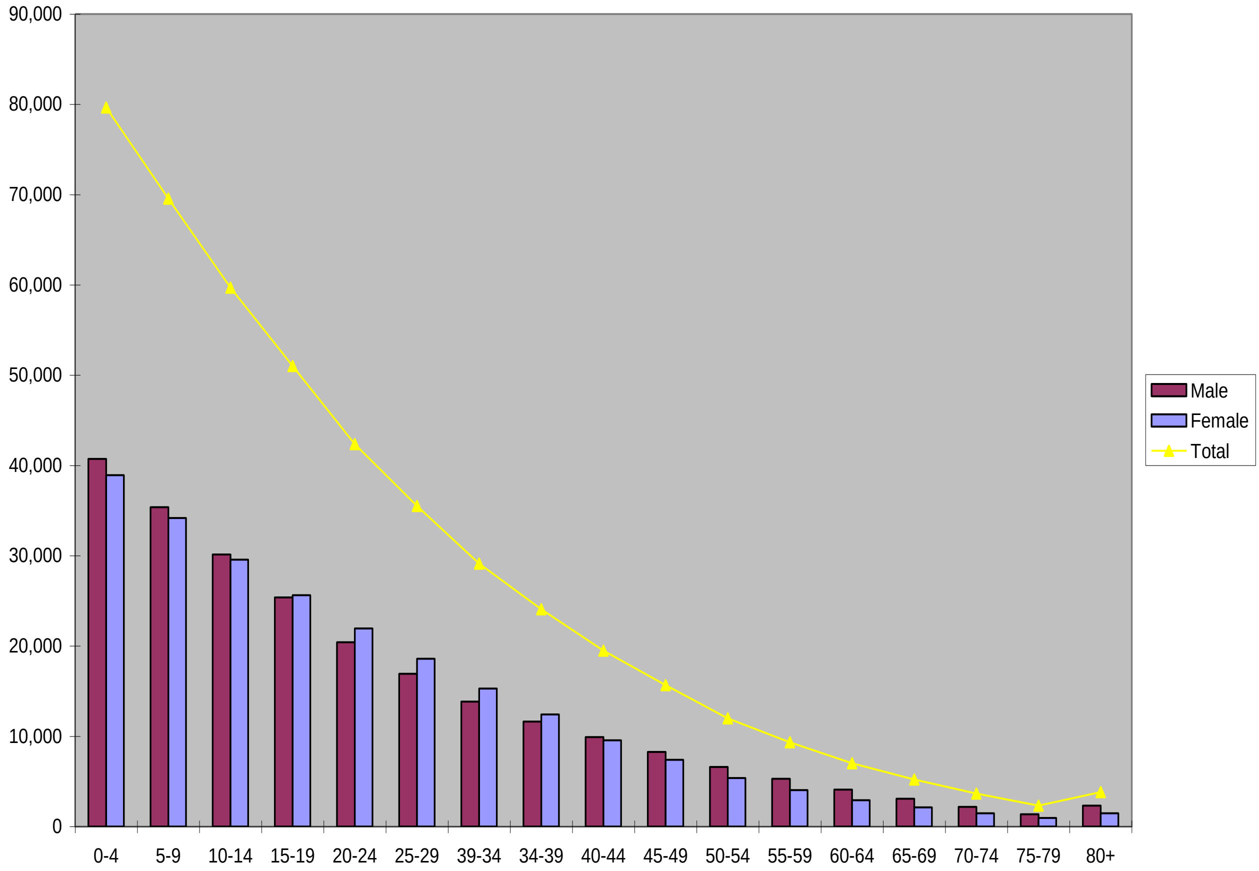
Age and Sex Composition

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 are therefore closely similar to the age structure of the region (Figure 4.11).

According to the CSA projection of the age structure for 2006, 56% of the age groups are less than 15 years old. Individuals over 49 years old comprise only 8% of the total population.

With respect to sex distribution, 49% of the population is male (Table 4.16).

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 50) represent only a small proportion of the total population (Figure 4.11). This indicates low life expectancy in the Benishangul Gumuz Region.



Source: Compiled from CSA 1994 Census Data

Figure 4.11 : Population Distribution of Benishangul Gumuz by Sex and Age

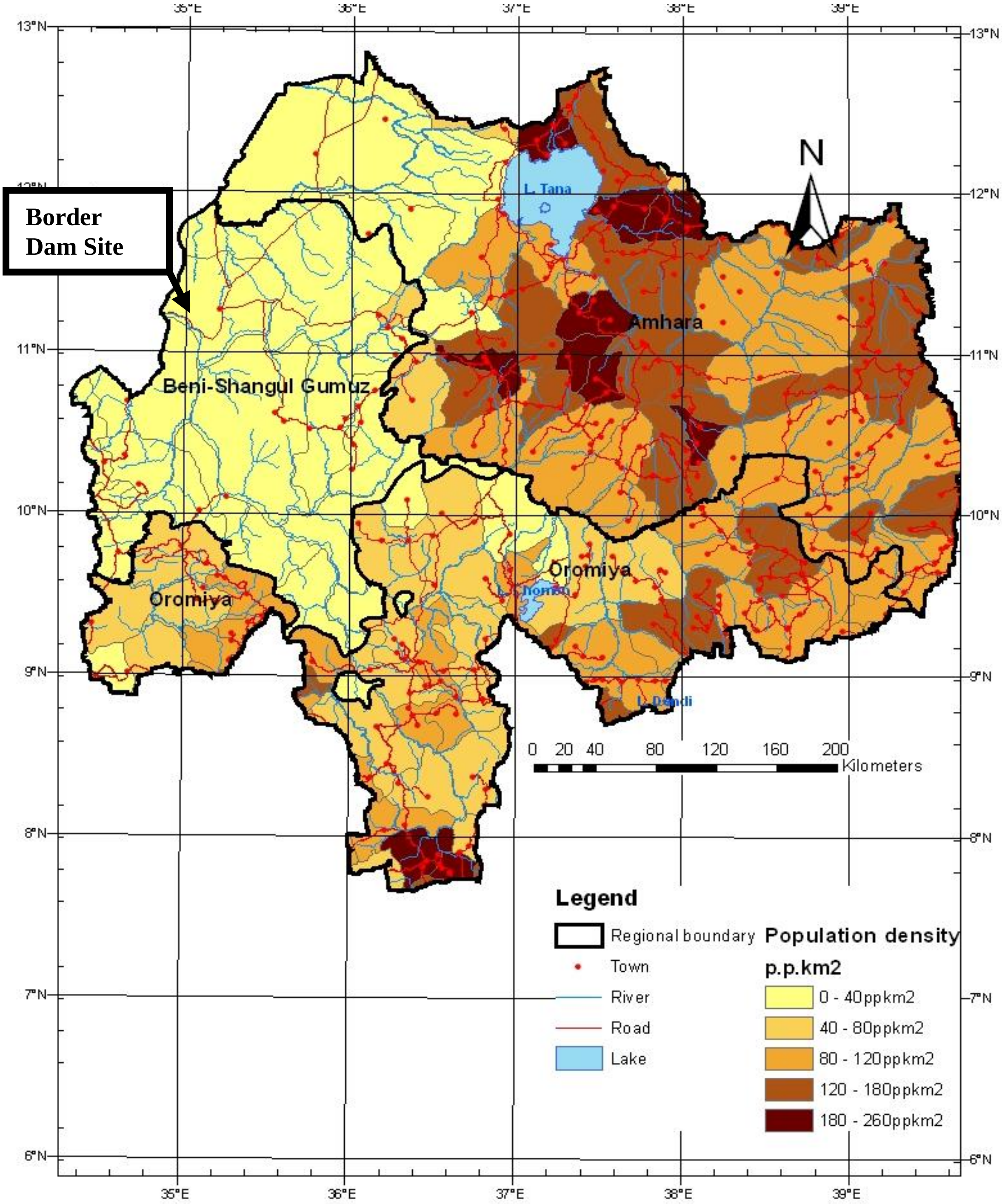
Ethnic and Religious Composition

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

The religious composition of the project area was discussed earlier under woreda administration. The majority of the people in the project area is Muslim, followed by Orthodox Christian and Protestants in this order. Traditional religion and non-believers are also present.

Population Density

The population density of the project area woredas is presented in Table 4.16. The low densities, ranging from 2.8 to 7.7 persons/km^2 are among the lowest in the region and may be seen in the Abbay basin context in Figure 4.12 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 4.12 : 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. There are on the average about 6 persons/km^2.

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 the regional government to resettle the people more closely together, as has been done near Boka in Sirba Abay – near the upstream limit of the potential Border reservoir.

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 1 and 2). By contrast, in towns one can see houses made of wood plastered with mud, and roofs with corrugated iron sheets.

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 most cases, there is no housing for livestock within the study area. 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. Examples of cattle housing and cattle are shown in Plates 3 and 4.

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 and Oromo. According to the 1994 census of Ethiopia conducted by CSA, the population reported “never married” is about 38%, relatively lower than in any other region.

Migration

Migration in Benishangul Gumuz is a common observable fact and notably higher than in the rest of the country for a number of reasons. The reasons are principally resettlement, temporary immigration (mostly from the Sudan due to drought and past conflicts) and trade.

The biggest migration into the region took place after the 1984 famine when people from various parts of Ethiopia were resettled.

Currently many people from different part of the country come to seek employment in government and for trade purposes. These are people from the Sudan and various parts of Ethiopia. There are also people migrating to the area for farming reasons and to take advantage of investment opportunities available in the region.

Out-migration is relatively smaller than in-migration in the region. People usually go out for better job opportunities and education.

Plate 1 : Typical House of Border Reservoir Area

Plate 2 : House for the Cattle

Plate 3 : Lady working in the kitchen in the project area

Plate 4 : Cattle of Project area

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 mining 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 region, in general, the following indicators are major characteristics of the areas:

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

Land Cover and Land Use

Land cover in the potential Border reservoir area is mainly open woodland and open shrubland (52%) with dense woodland, dense riverine forest, dense shrubland and dense bamboo together comprising 38% of the area. Cultivated land and grassland occupy a very small proportion of the area (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).

There are many peasant associations in the three projects affected woredas.

An extension program was introduced in Benishangul Gumuz region 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 67. 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 average area used for crop production in the state is 0.36 ha per capita (Bureau of Agriculture and Rural Development).

If this average figure is adopted, the total area used for crop production of 13,905 affected people in the potential Border reservoir area would be about 5,000 ha. Based on our field investigation and discussions with people in the area, the total cropped land that would be affected by the reservoir is estimated at 6,572 ha (4,172 ha rainfed and 2,400 ha flood recession agriculture).

Crop production is not evenly distributed. Wonbera woreda produces the highest proportion of crops in the area.

The main crops are sorghum, maize, pulse, oil seed and vegetables. The dominant crops are sorghum and maize.

Shifting cultivation is a common practice among the population. The forest wood is often stacked and burned - to get rid of it and permit cultivation.

Almost all people use hoes and sticks to prepare land for cultivation. In some areas where Amharas, Shinashas, Agew and Oromos people live, oxen are used. After a few years of cropping the land is exhausted and left fallow to enable the soil (mainly Nitosols and Alfisols) to regenerate.

Irrigation Development

In many reaches along the Abbay, the river flows in a gorge with associated steep escarpments that do not favour irrigation development. In the potential Border reservoir area, where the landscape is flat and undulating, there is better potential for irrigation development with regard to topography. However, despite the available land and water resources, there exists no irrigation practice (large, medium or small) in the Border reservoir and immediate surrounding areas. 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 observations and consultations with local people indicated the practice of recession agriculture on both banks of the Abbay River in parts of the Border area. The size of fields on both sides depends on the elevation of land that can be inundated by Abbay floods during the high flow season (July, August, September). At some localities, flooding and recession agriculture reaches a few kilometres from the river; in other places, it is confined to approximately 200 m (Plate 5).

Plate 5 : Abbay flood recession agriculture in Sirba Abbay

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 potential Border reservoir area could be in the order of 2,400 ha.

The naturally flooded land area used for recession agriculture downstream of Border dam site as far as the Sudan border is considered to be very small and insignificant but as with the estimate of recession agriculture area in the potential reservoir this would need to be thoroughly assessed in any further studies.

Livestock

Despite grass and bushland potential of the region, the livestock population of Benishangul Gumuz and that of the reservoir area is very low. The contribution of the livestock sector to complement crop production for households is negligible. The

Bureau of Agriculture and Rural Development conducted a livestock population, livestock per capita and density study in 1998. BoFEd of Benishangul Gumuz projected the current livestock figures based on the BoARD data (Table 4.19). Accordingly, Wonbera has the highest livestock population of the project woredas and has one of the highest in the region. Guba and Sirba Abbay have lower livestock population compared with the other woredas in the region.

Table 4.19 : Livestock population in Border project area woredas

Woreda	Cattle	Sheep	Goats	Equines	Poultry	Beehives	Woreda
Guba	6,915	2,770	9,467	779	98	10,917	107
Wonbera	32,626	13,761	21,860	2,468	917	41,445	9,355
Sirba-Abbay	5,927	3,347	10,674	533	25	18,159	3,936

Source: BoARD, Benishangul Gumuz, 2006

With regard to livestock densities, Guba has one of the lowest in the region, as is the case for human population density. With respect to livestock per capita, Guba has the highest in the region. (Table 4.20).

Table 4.20 : Livestock density in Border project area woredas

	Per km^2	Per capita	Per km^2	Per capita	Per km^2	Per capita	Per capita	Per capi
Guba	1.75	0.81	3.10	1.44	0.22	0.10	1.28	0.01
Wonbera	4.53	0.73	4.95	0.80	0.53	0.09	0.93	0.21
Sirba-Abbay	4.51	0.60	10.67	1.43	0.42	0.06	1.85	0.40

Source: BoARD, Benishangul Gumuz, 2006

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[1].

Animal diseases are prevalent. Insufficient veterinary services and medicines make the situation worse.

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:

- [1] Ethno-veterinary survey, June 2004

- 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,
- 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.

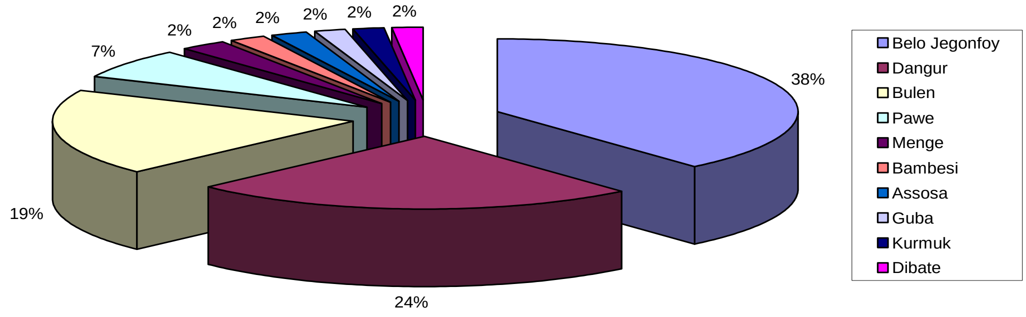
Investment

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 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 Border 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 4.13. As may be noted, investment in Sirba Abbay and Wonbera is so low that these woredas are not included in the chart.



Source: Compiled from Data obtained from BoFED of Benishangul Region

Figure 4.13: Investment Distribution in Benishangul Gumuz

Investment is highly encouraged in the Benishangul Gumuz Regional States. In order to attract the private sector to engage in the development of the existing potential resources in the area, the regional government 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, Beles, Dabus and some other rivers 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 (Plate 6) is somewhat different than most places in the country. The 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.

Plate 6 : Traditional Fishing Practices along the Abbay River

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, and in the Border project woredas in particular (Plate 7). 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).

Gold mining 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 woreda is one of the sites.

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

Plate 7 : Traditional gold panning in Border project area

Hunting

As everywhere in the nation, hunting is illegal in Benishangul Gumuz unless one has a licence to hunt. There is a controlled hunting area in the lower Dabus valley (upstream of the Dabus/Abbay confluence) 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 Border 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 spear 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 the Border project area are conducted by the indigenous people at a low level. There is no well-organized market structure and places, except in few locations. The only organized market was seen close to the Sudan border where the Sudanese bring commodities by vehicles and motorcycles.

There are limited commercial service providers in the project woredas. The Sudanese come to marketplace close to the border to trade industrial products such as bicycles, garments and bicycle spare parts. The Sudanese traders are better organized than the local people.

Hotels and restaurants exist in the Border project area but are limited to one or two places such as Mankush. There are tearooms and small restaurants in all the larger settlements (Table 4.21).

Table 4.21 : Social services in Border Site Woredas

Woreda	Police Stations No.	Tourism sites No.	Hotels No.	Restaurants No.	Tea/Coffee Rooms No.
Sirba Abbay	1	0	1	1	1
Wonbera	1	0	2	2	4
Guba	1	0	4	1	2
All/total	3	0	7	4	7

Source: BoFED of Benishangul Gumuz Region

Many people living in the area are engaged in trading products of the Baobab tree (*Adansania digitata*). The roots, the leaves and fruit of the tree are used as food and juice. It has the highest value of all the trees in the area (Plate 8). The fruit, called guangules, is exported to Sudan and sold at about ETB 1,380 per quintal.

Plate 8 : Baobab Tree in the Border Reservoir Area

Employment and Income Generation

The majority of people in the potential Border reservoir area (over 90%) obtain their livelihood from subsistence agriculture. Agricultural practice includes farming and livestock. Small numbers of people are engaged in trade, in government organizations and other activities. Generally, incomes generated from these activities are very small. Even those thus employed live in poverty.

A large number of the farmers and urban dwellers (men and women) of the woredas also engage in gold panning. The most active season of the year for gold mining is from January to April.

In general, the Border project area has considerable untapped potential of natural resources that could be utilized for income generation of the people. However, the development and contribution of resources for the well being of the society is minimal. The income obtained by the 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 from other sources such as 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 the regional government[1] shows that per capita annual income obtained from the sale of agricultural products and other non-farming income ranges from ETB 169 (Guba) to ETB 537 (Sirba Abbay).

The Food Security Strategy indicates that major constraints of the people to generate sufficient income for their needs are:

- Lack of appropriate technologies, lack of awareness and inadequate skills;
- Poor market infrastructure that is made worse by poor all-weather road network as well as unorganized market places; and
- Low private investment.

Unemployment in Benishangul Gumuz is reputed to be very low. The average rate of unemployment for the region is 0.7 %. The urban unemployment is reported as 7 % while rural unemployment is 0.3 % only (BoARD). Persistent poverty therefore is due to low income. 55% of the people of Benishangul Gumuz are under the food poverty line, i.e. earning less than USD 1 per day per capita.

Poverty and Food Security

As indicated in previous sections, poverty in the Border 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, pest and time consuming labour (such as gold panning) are considered to be among the principal causes. Chronic poverty is evident by the fact that a large number of people rely on relief assistance.

A report obtained from the region (Food Security Strategy, 2004) describes the nutritional status of people in the Benishangul Gumuz region. Nutrition and micronutrient deficiency are widespread in most places. The incidences of chronic malnutrition (shunting), acute malnutrition (wasting) and being underweight (for age) are very high, particularly among the indigenous people of the region. The report concludes that the Border project area is one of the most food insecure areas in the region.

The population of Ethiopia has tripled in the last 30 years (from 25 million in 1977 to 75 million in 2006). Assume similar population trends in Benishangul Gumuz, the pressure on infrastructure and family income is evident.

A document from the Federal Government of Ethiopia[2] described the causes of poverty in Ethiopia as:

- Population pressure,
- Low investment in human capital,

- [1] Food Security Strategy of Benishangul Gumuz, June 2004
- [2] Sustainable Development to End Poverty, MoFED, Oct., 2005

- Low level of infrastructure,
- Low risk and low return trap (farmers cannot risk changing their system of cultivation from subsistence agriculture to higher return crops such as growing cash crops),
- Early childhood trap (malnutrition during childhood affects long term mental and physical development affecting human productivity).

In conclusion, the ESIA team has observed and understood from field visits the existence of chronic poverty in the Border project area.

4.3.5 Social services

Education

The educational status in the Border project area is considered low by many studies conducted in the region. The primary enrolment rate in Benishangul Gumuz in general is one of the best in the nation. 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. Discussions with local people revealed that students would travel in the range of 1 to 6 hours walk from home to school.

As may be deduced from Table 4.22, the number of girls in school in the project area is only 39% 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 Border project woredas

Woreda	No. of Schools	No. of Teachers			No. Students		
		Male	Female	Total	Male	Female	Total
Sirba Abbay	9	53	22	75	1,870	906	2,776
Wonbera	24	174	85	259	5,873	4,264	10,137
Guba	12	78	17	95	1,263	583	1,846
All/Total	**45**	**305**	**124**	**429**	**9,006**	**5,753**	**14,759**

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. These, accounting for over

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

80% of cases, and others are shown for Yarenja in Table 4.24. The patterns of disease are very similar in all project woredas, although there are slight variations in magnitude.

Table 4.24 : Top 10 leading diseases treated in Yarenja, Guba woreda, in 2006

Type of disease	Cases No.	Cases %
Respiratory tract infections	5,844	41
Malaria	2,825	20
Diarrhoeas-watery /bloody	1,739	12
Skin infection	1,172	8
Intestinal Parasites	725	5
Urinary tract infection	705	5
Eye infection	667	5
Trauma	298	2
Anaemia	282	2
STDs	32	<1
Total	**14,307**	**100**

Source: Yarenja Health Centre, Annual Report 2006, UNHCR

Although malaria stands second in the table, reviews of monthly and annuals reports from all health facilities reveal that malaria is the single most important public health problem in the Border project woredas. It accounts for more than 50% of morbidities and mortalities in all health facilities in the project area. 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 project area. Although there is no consolidated data, an in-depth interview with relevant officials shows that the diseases 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.

Health Facilities and their Ratios to the Population

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 areas is far from being adequate to meet the demand 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 Border project woredas

Woreda	Health Facilities					Population	Ratio
	Hospital	Health Centre	H.S/C	Health Post	Total		
Guba	0	1	3	2	6	10,851	1:1,800
Sirba Abbay	0	0	2	2	4	12,230	1:3,000
Wonbera	0	1	1	6	8	56,260	1:7,000
Total	**0**	**2**	**6**	**10**	**18**	**79,341**	**1:4,400**

Harmful Traditional Practices

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 Border 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.

<u>Women's workload</u>

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 county. 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 10% of people 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 Border Project Area

No.	Woreda	Type of Schemes			
		Shallow well	Hand Dug Well	Deep Well	Spring
1	Sirba Abbay	0	5	0	0
2	Wonbera	6	12	1	2
3	Guba	9	13	2	0
	Total	15	30	3	2

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 about 75 kg.

Sanitation facilities in the Border project woredas are among the poorest in Ethiopia. Most people in the project area 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.

Plate 9 : Water Provision in the Border Project Area

Cultural Setting

The cultural setting of the people living in Benishangul Gumuz in general 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.

Major negative impacts of cultural practices are the business culture and working behaviour of the people. 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.

Market Places

There are no well-structured and organized market places in the Border project area. There are, however, informal transactions of trade and some organized market places in very limited areas. The market at Funguso kebele (Rob Gebeya) near the Sudan border (Plate 10) was found to be bigger and better organized; here Sudan traders come with motorbikes loaded with manufactured goods.

Plate 10 : Market Day in Funguso Kebele

4.3.6 Infrastructure

Road and Transport

The road infrastructure in Benishangul Gumuz region is one of the poorest in the country and hence travelling from one place to another place 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.

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, 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.

There are very few roads in the Border project woredas. In Sirba Abbay, the only existing road is Mendi (Oromia) to Koncho (Benishangul Gumuz) which is about 49 km in length, of which only 21 km is within Sirba Abbay.

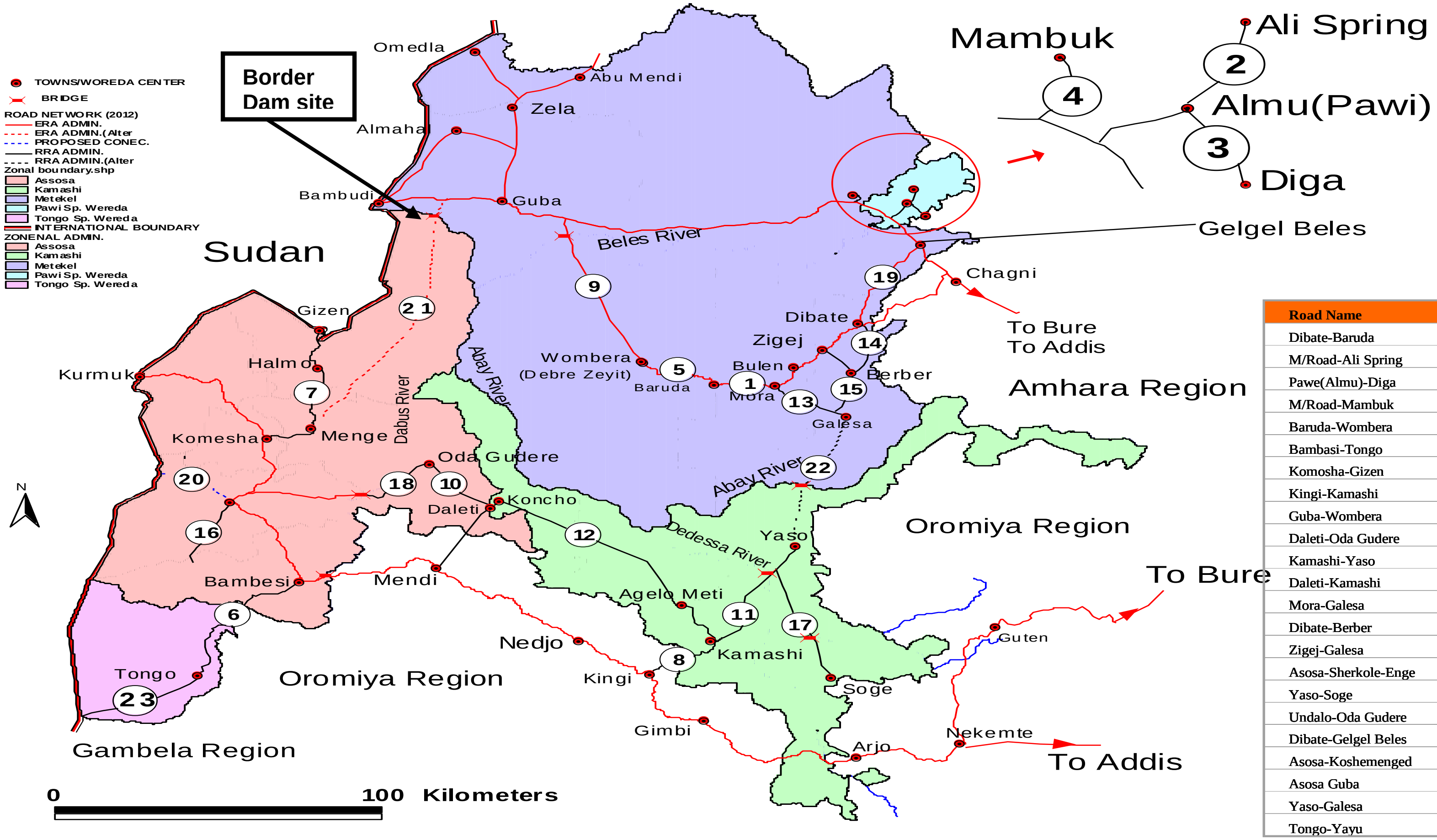
Guba woreda has a relatively longer road network compared to the other two woredas. Major all-weather roads in this woreda are Chagni to Mankush, Mankush to Wonbera, Mankush to Yarenja Refugee Camp and Mankush to the Sudan border.

Details of principal roads are given in Table 4.27. The network is depicted in Figure 4.14 (but note that Mankush is shown as Guba, and the bridge across Abbay near the Border dam site and the road leading to it does not exist but is proposed).

Table 4.27 : Existing road network

Woreda	Road Network		Total road length km	Portion inside project woreda km	Remarks
	From	To			
Guba	Chagni	Mankush (Guba)	147	96	
Guba	Mankush	Debrezeit	81	13	Under construction
Guba	Mankush	Yarenja Refugee Camp	16	16	
Guba	Mankush	Bambudi	58	58	
Guba	Mankush	Bambudi	37	37	Alternate road
Sirba Abbay	Mendi	Koncho	49	21	
Wonbera	Chagni	Debrezeit	120	22	
All/Total			508	263	

Source: Compiled from Data Supplied by Benishangul Gumuz Road Authority



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 4.14 : Existing and Planned Road Network in Benishangul Gumuz

Telecommunications

The Border 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.

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

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 about four crossing routes along the river in the potential Border reservoir area (Plate 11).

Plate 11 : Mode of Transport (Feluco) on Abbay River

4.3.7 Energy

The principal energy source of the region is fuel wood (Plates 12 and 13). 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).

Plate 12 : Fuel Wood Collection Near Border Reservoir Area

Plate 13 : 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 the 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 Border project woredas that are suitable for resettlement and that a list of these can be obtained in future.

Regarding resettlement of people from the project affected area, our survey shows that about 28 sub-kebele communities will be affected. A total of 2,781 households with 13,905 people are estimated to reside in the Border reservoir area.

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 Border reservoir or works areas.

This is not to say that archaeological or historical sites do not exist in the Border 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.

Some limited archaeological research in Benishangul Gumuz, but not in the Border project area, has been conducted. Caves, hot springs and prehistoric remains have been reported in some places of the region, also artefacts attributed to the Early and Middle Stone Age. During a 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. The two rock shelters with red schematic paintings are at Bel Bembesh and Bela Sharasu (Figure 4.15). 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).

These known sites will not be influenced by the Border 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.

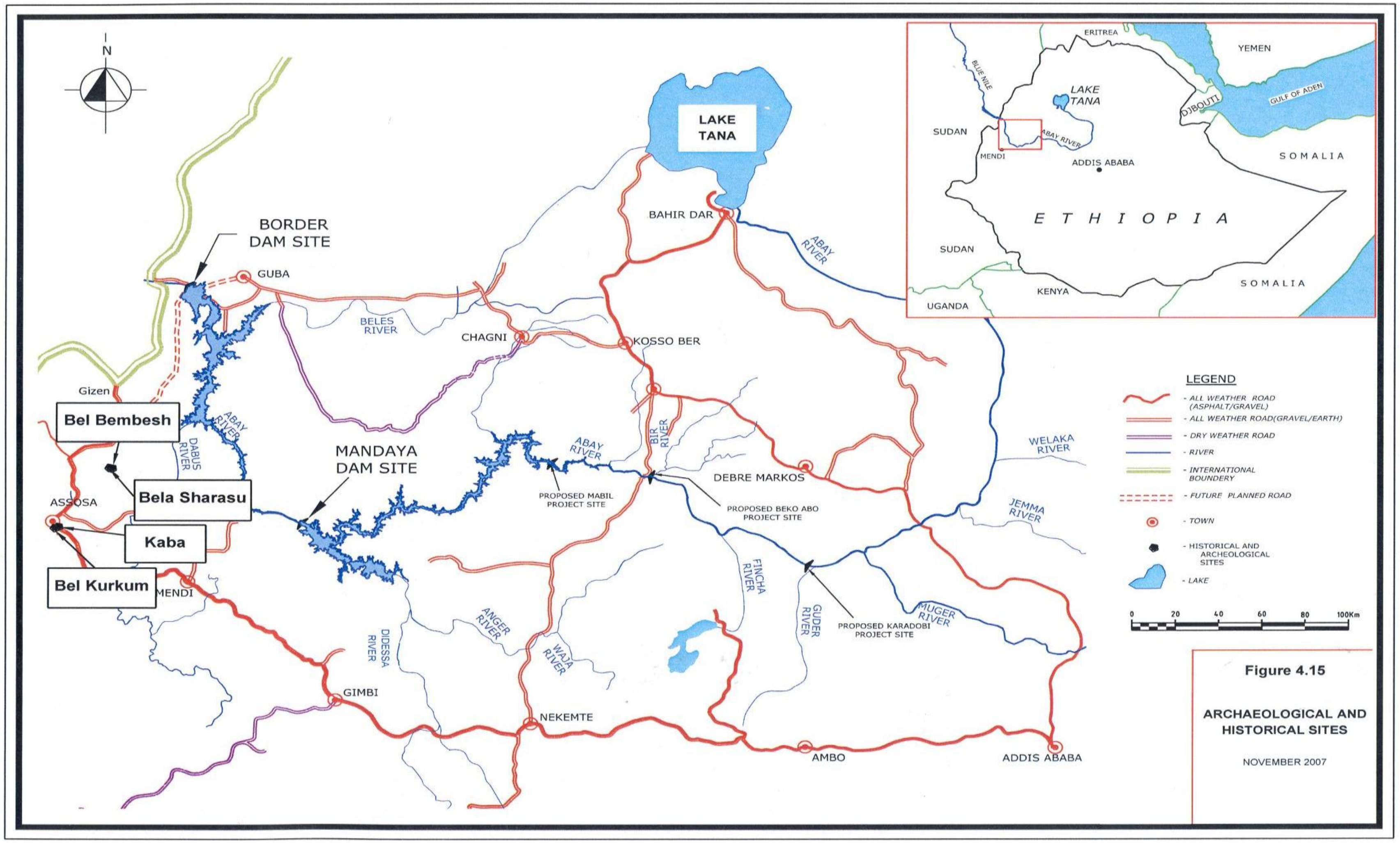


Figure 4.15

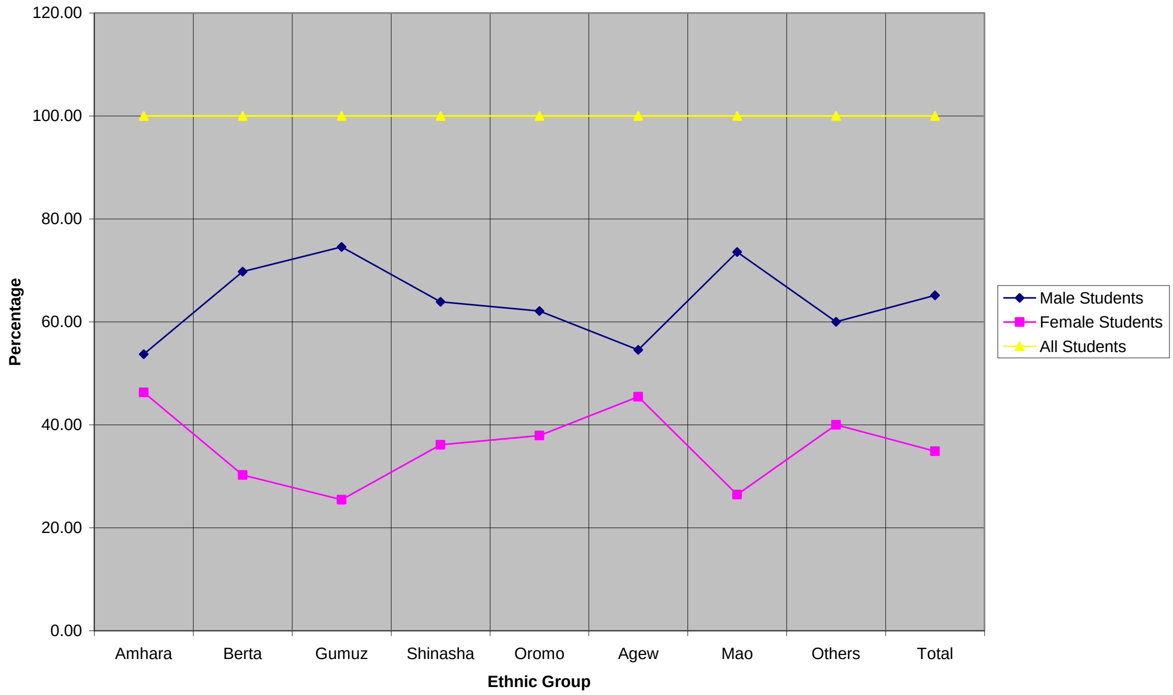
ARCHAEOLOGICAL AND HISTORICAL SITES

NOVEMBER 2007

4.3.10 Gender Conditions in Benishangul Gumuz Region

As already described, women in the project area are a marginalized part of society in Benishangul Gumuz region. 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 no access to improved technologies. Girls' school enrolments are generally less than boys in the region as seen in Figure 4.16. 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 4.16 : Gender disparities in school enrolment - Benishangul Gumuz

4.4 EXISTING INSTITUTIONAL CAPACITIES IN BENISHANGUL GUMUZ

Regarding human, financial and material capacities in Benishangul Gumuz in general and the Border project area in particular, they are found to be one of the worst in the country.

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 Border 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 Border project) that are the responsibility of the region and woreda governments.

4.5 PUBLIC PARTICIPATION

The socio-economic and environmental study carried out public consultations as part of field investigations and informed concerned people about the project under study at Border. 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.

4.5.1 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 4.8).

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 Abbay valley in the Border reservoir is generally limited due to the terrain and poor access. Regional infrastructure and woreda capitals are located in the accessible areas. There is reported to be no problem related to relocation of the limited numbers of affected people in the proposed Border 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 Border 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 area is completely within Benishangul Gumuz Region, specifically in Guba, Sirba Abbay and Wonbera woredas.
- 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.
- Major economic activities in the project area include crop production, livestock rearing, gold panning, fishing, hunting and handicrafts. Fishing and gold panning are conducted using traditional methods. Recession agriculture is considered an important economic activity.
- Market conditions are considered to be poor. There are active trade interactions between the region and Sudan.

- 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 office representatives, farmers, traders and elders. The number of participants ranged from 10 to 32 and included both men and women (Appendix 4.9).

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.

4.5.2 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.

4.5.3 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 Border hydropower project. Discussions and consultations with these organizations indicated top-most priority for a regional capacity building program.

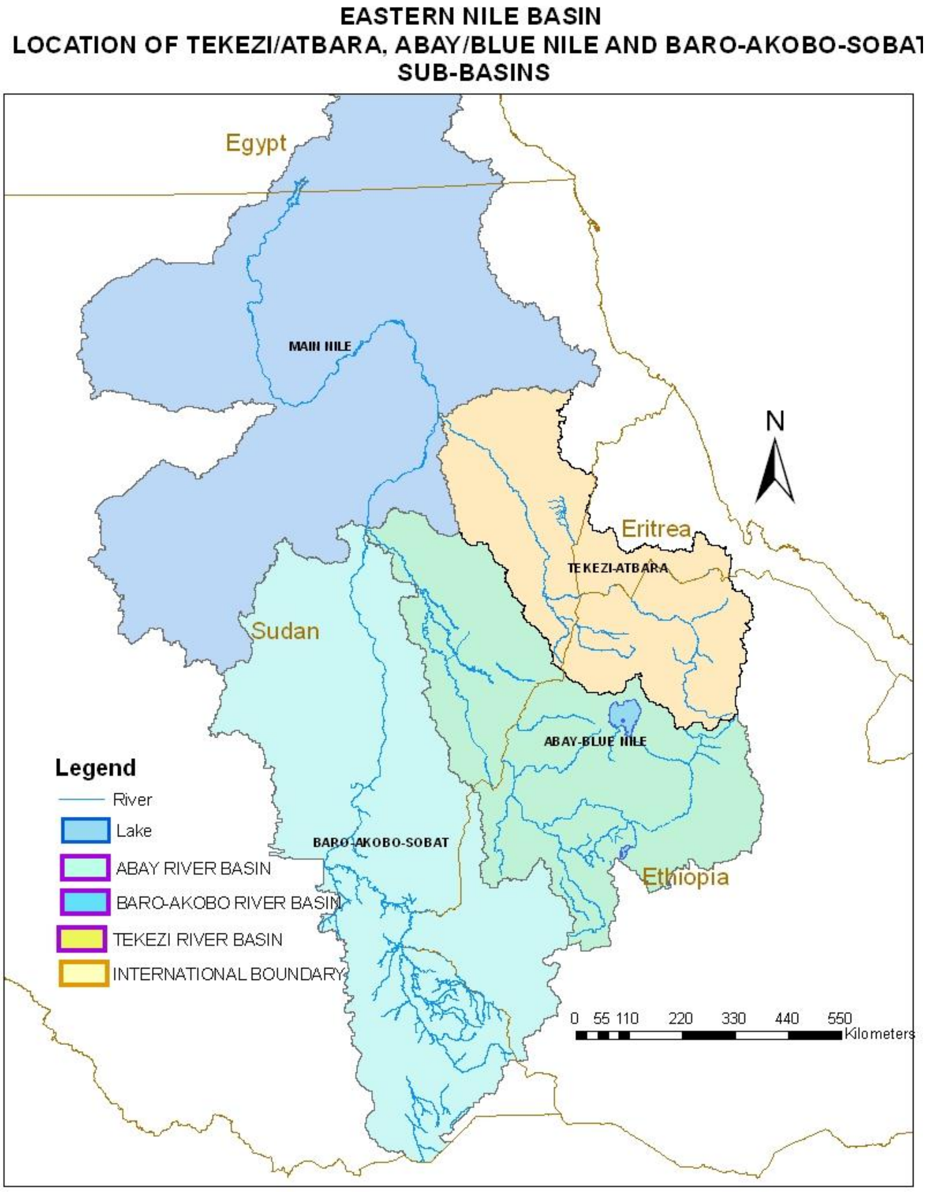
4.5.4 A Nurse's View

Because of the existence of a mission clinic at Boka, located on the left bank of Abbay between the upstream end of Border reservoir and 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 4.10.

5. EXISTING ENVIRONMENTAL CONDITIONS DOWNSTREAM OF BORDER PROJECT

5.1 INTRODUCTION

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



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.

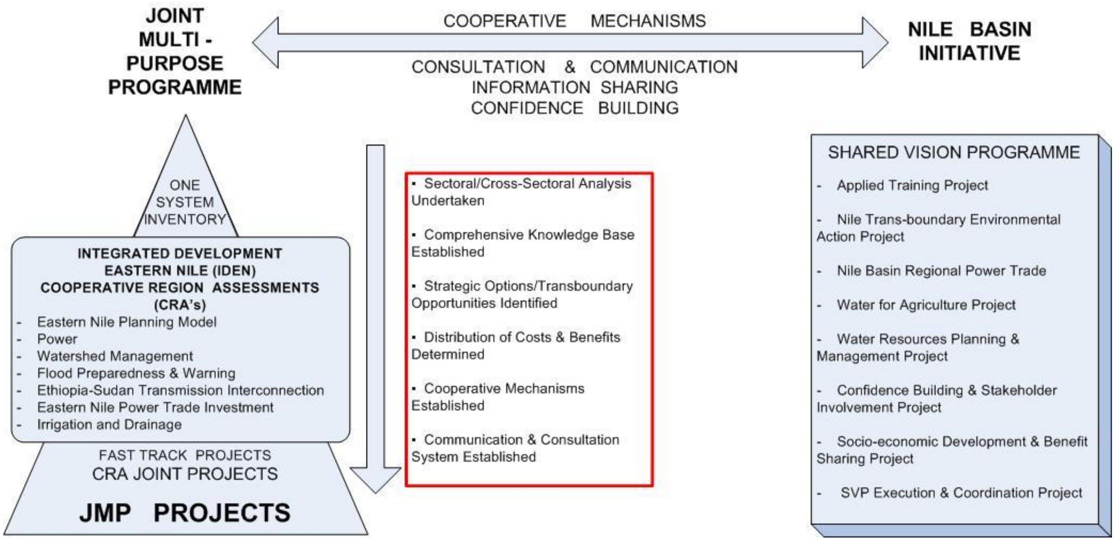


Figure 5.2 : Relationships among and processes of the IDEN CRA's, the Joint Multi-purpose Programme and the Nile Basin Initiative's Shared Vision programme

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 Border and/or Mandaya 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 Border hydropower project (described in Chapters 6 and 7) will be hydrological and hydraulic, and that these will occur in the Abbay river downstream of Border dam tailrace in Ethiopia, along the Blue Nile reach to Khartoum, and along the Main Nile in Sudan as far as 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 operation reduces 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.

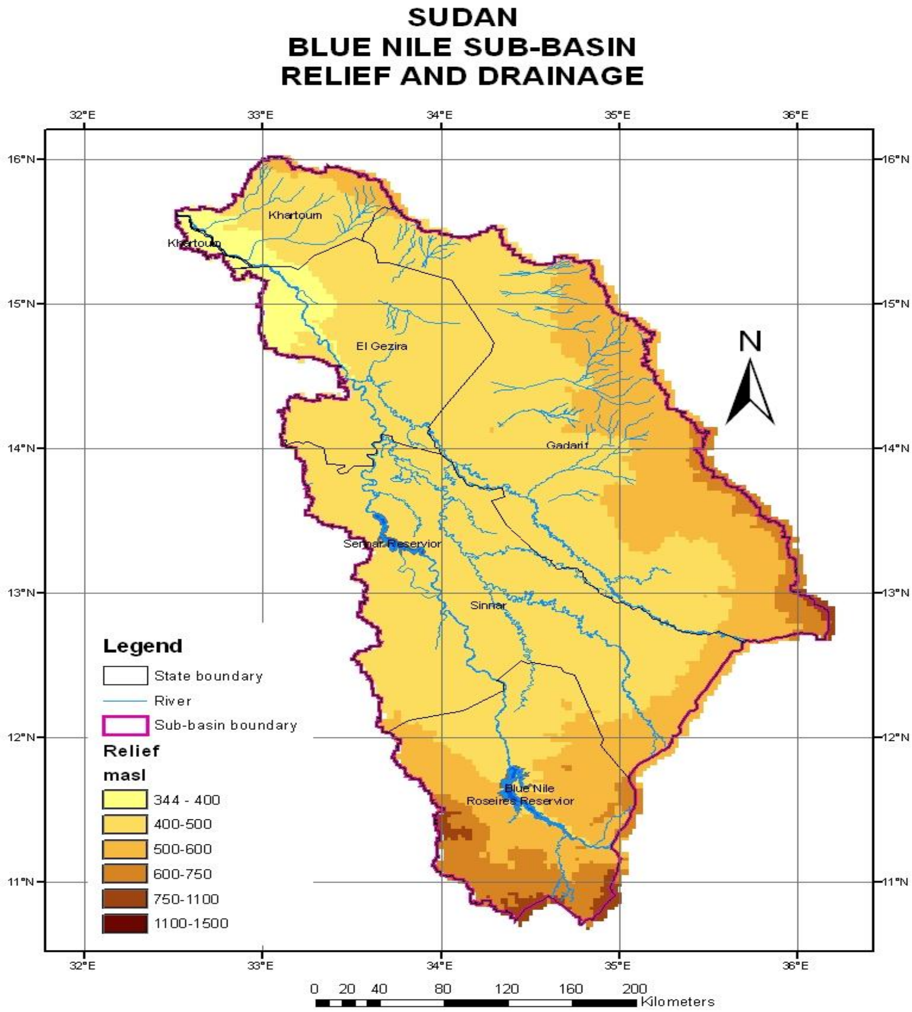
It is noted that all Nile flows reaching High Aswan Dam are comprehensively controlled by the large storage capacity in Lake Nasser/Nubia and operation of the High Aswan hydropower station and regulation release facilities for the Nile in Egypt. The Nile downstream of High Aswan Dam will remain completely controlled with or without the Border and Mandaya 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).

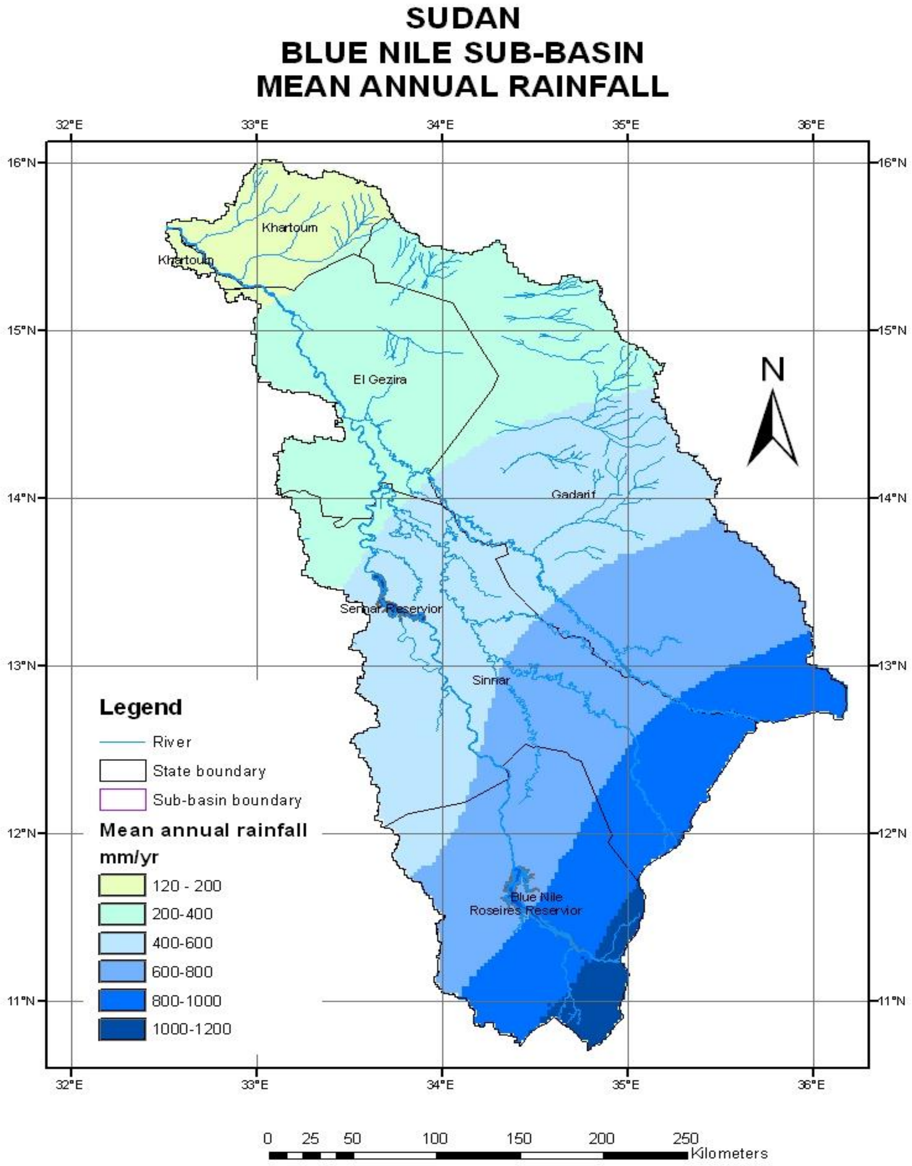


Source: CRA Sudan Report

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).

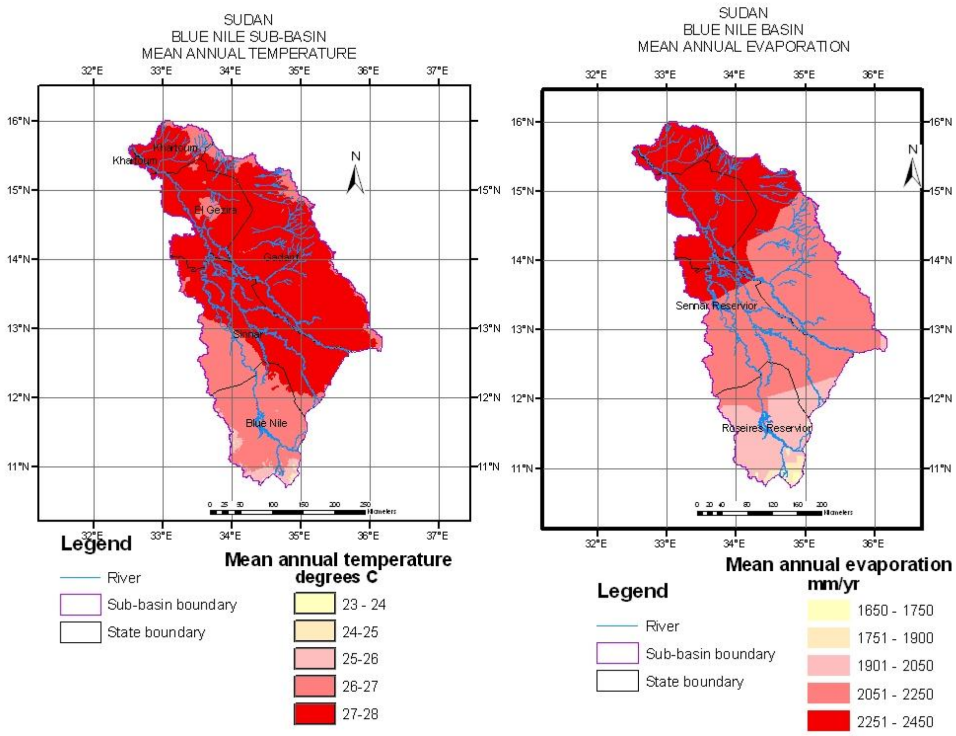


Source: CRA Sudan Report (2006)

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

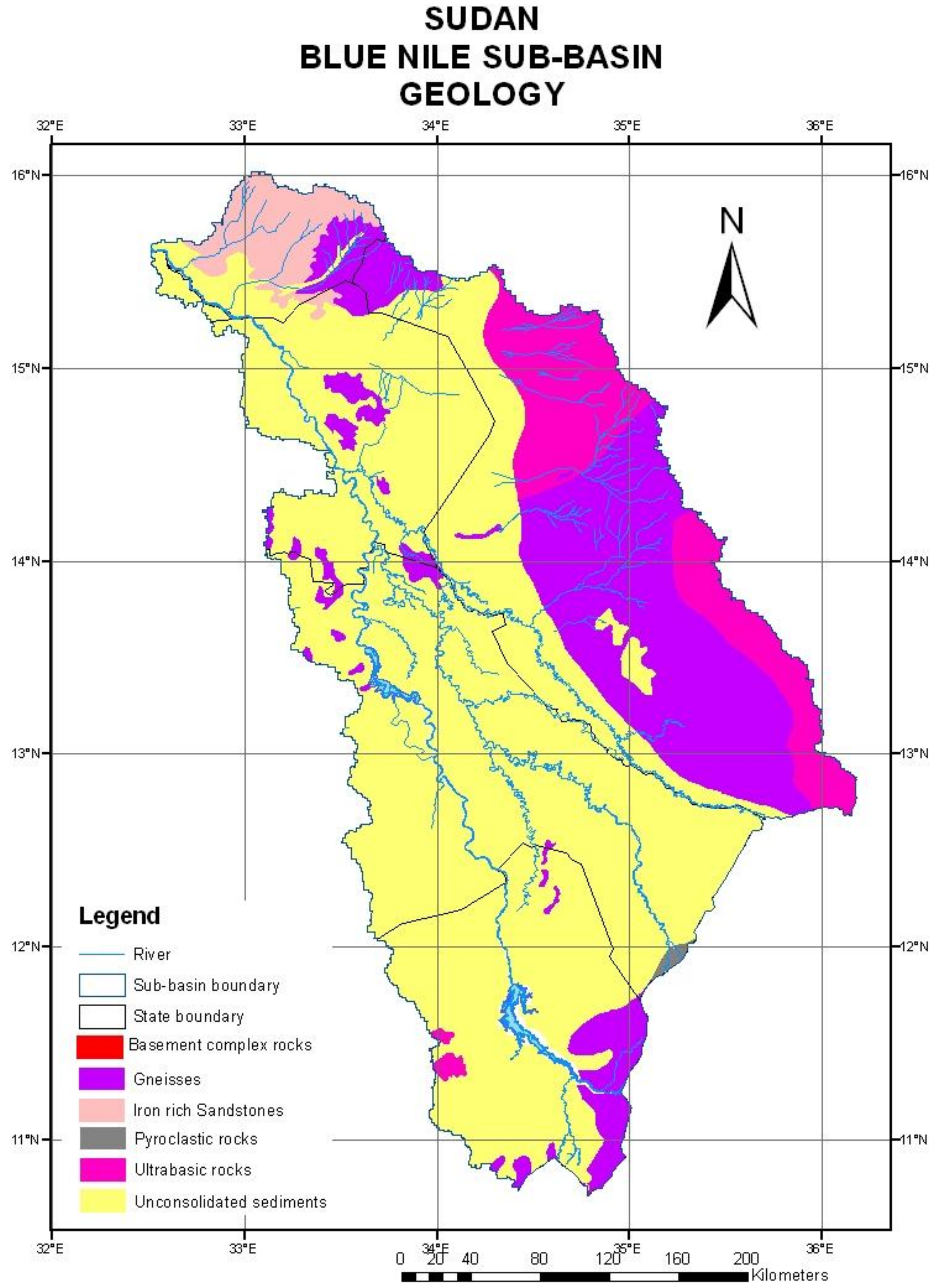
Source: RAPSO model, this study, and Sudan Meteorological Department

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.



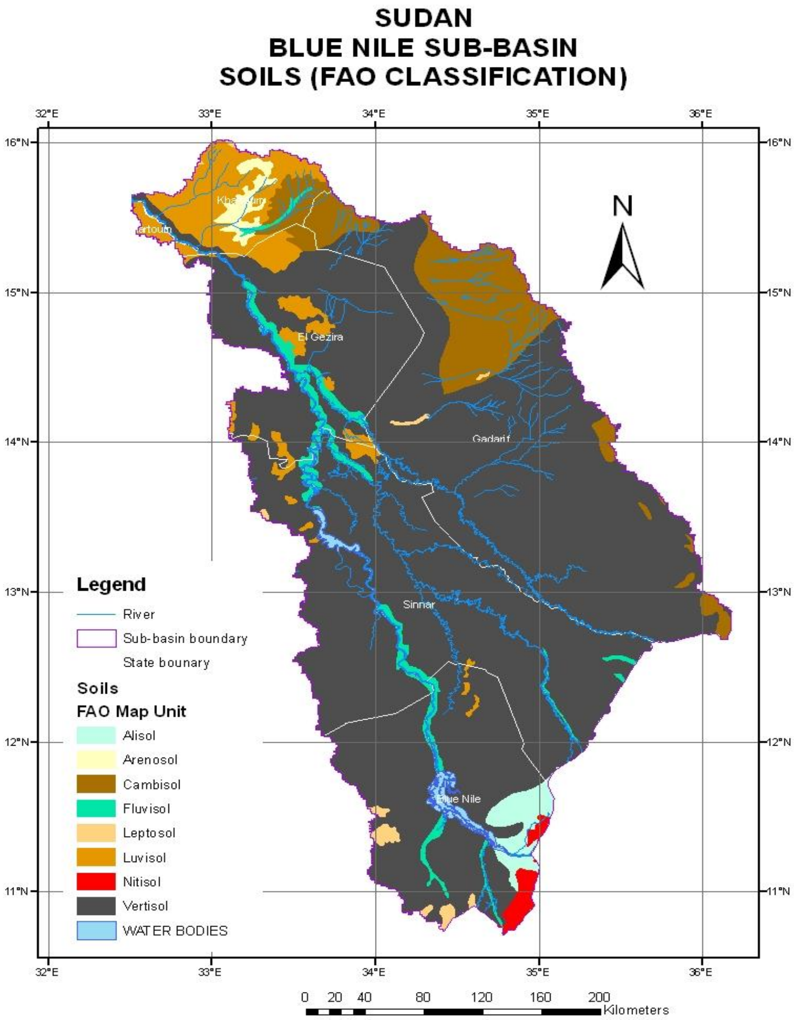
Source: CRA Sudan Report (2006)

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 Border and Mandaya projects are concerned, it is noted that construction of pylon towers for their interconnecting transmission lines to Hasaheisa, 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

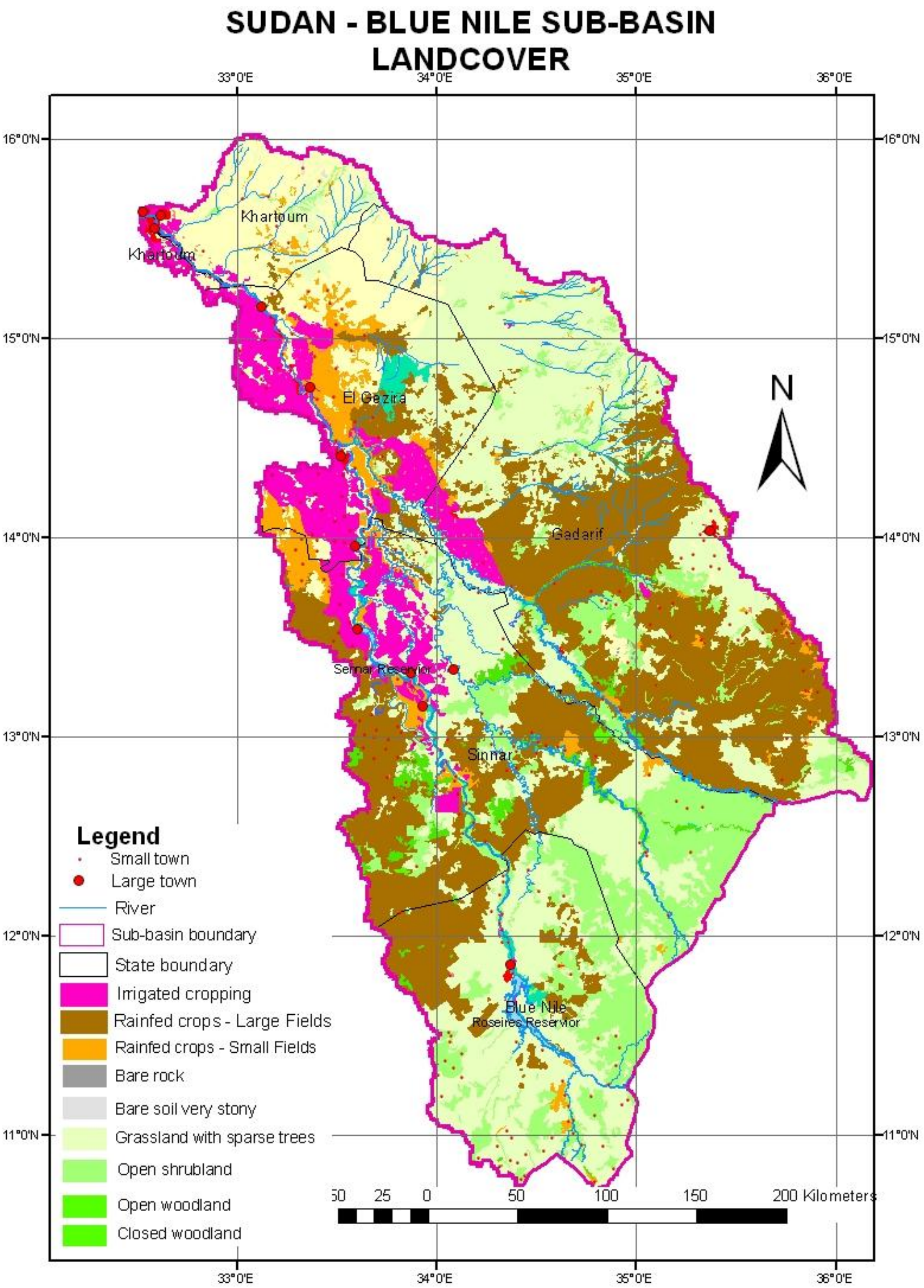
The Blue Nile sub-basin has experienced more removal of its original vegetation compared with others, first from large-scale development of irrigation, and latterly from the large expansion of semi-mechanized farms.

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.



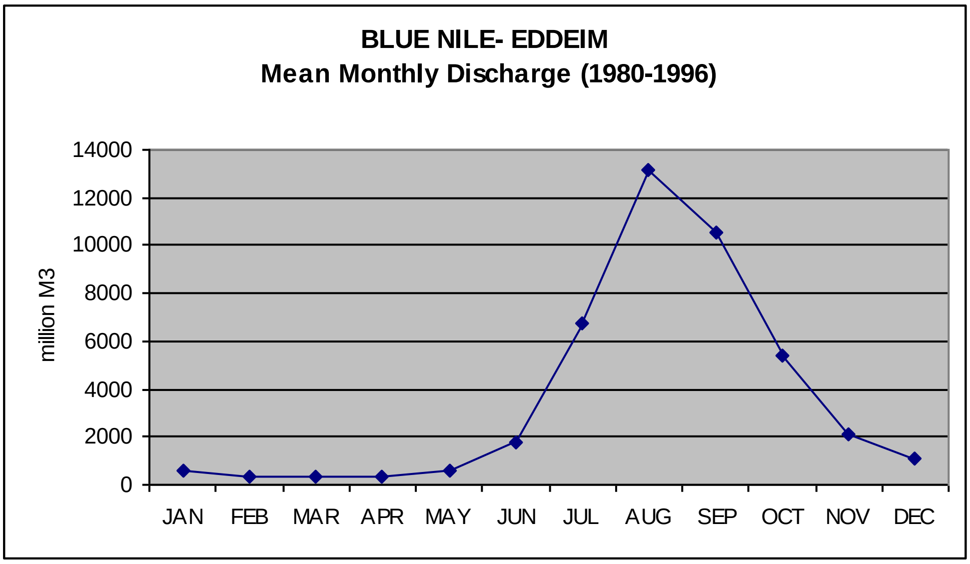
Source: CRA Sudan Report (2006)

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).

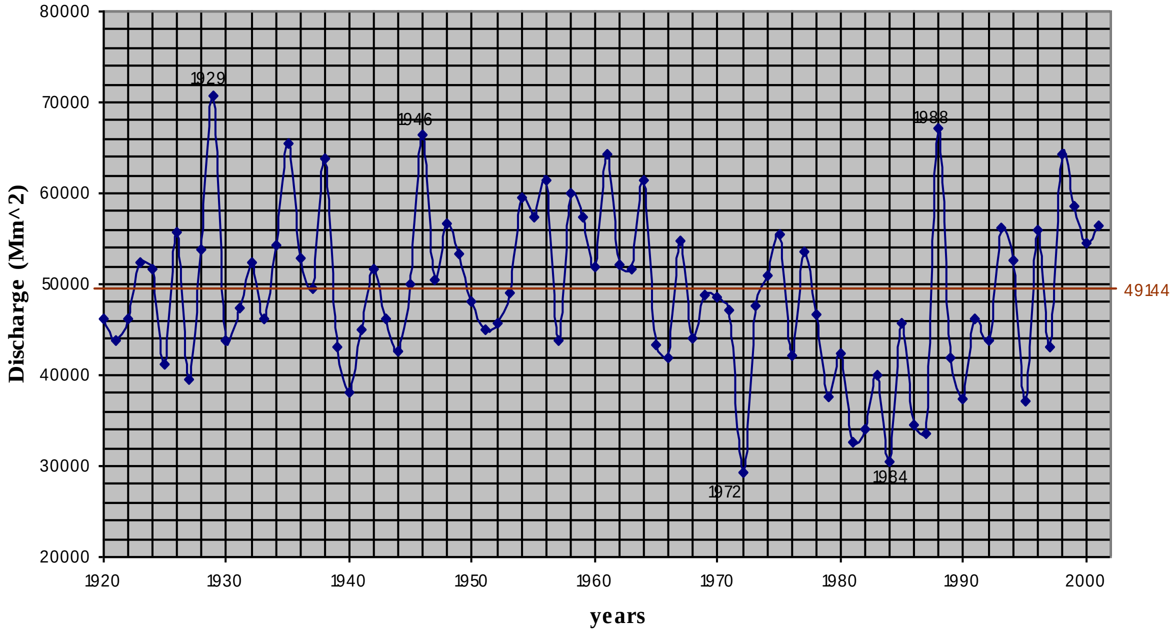


Source: CRA Sudan Report (2006)

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)

Figure 5.10 : Blue Nile Hydrograph 1920 - 2001 (million m^3)

Sediment transport in the upper Blue Nile in Sudan was discussed in Section 4.1.5 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 is 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 Border to Hasaheisa transmission line may unavoidably pass through some of the maya'as areas.

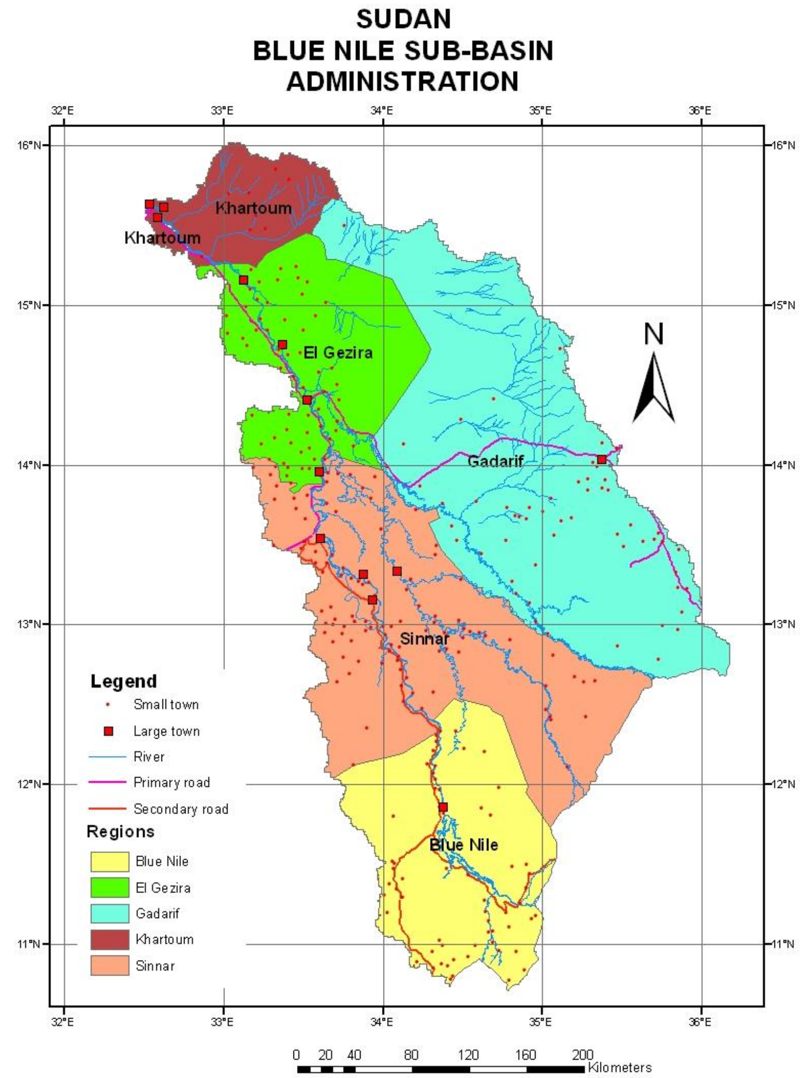
5.2.10 Socio-economic characteristics of Blue Nile sub-basin

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 (km2)	% 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.

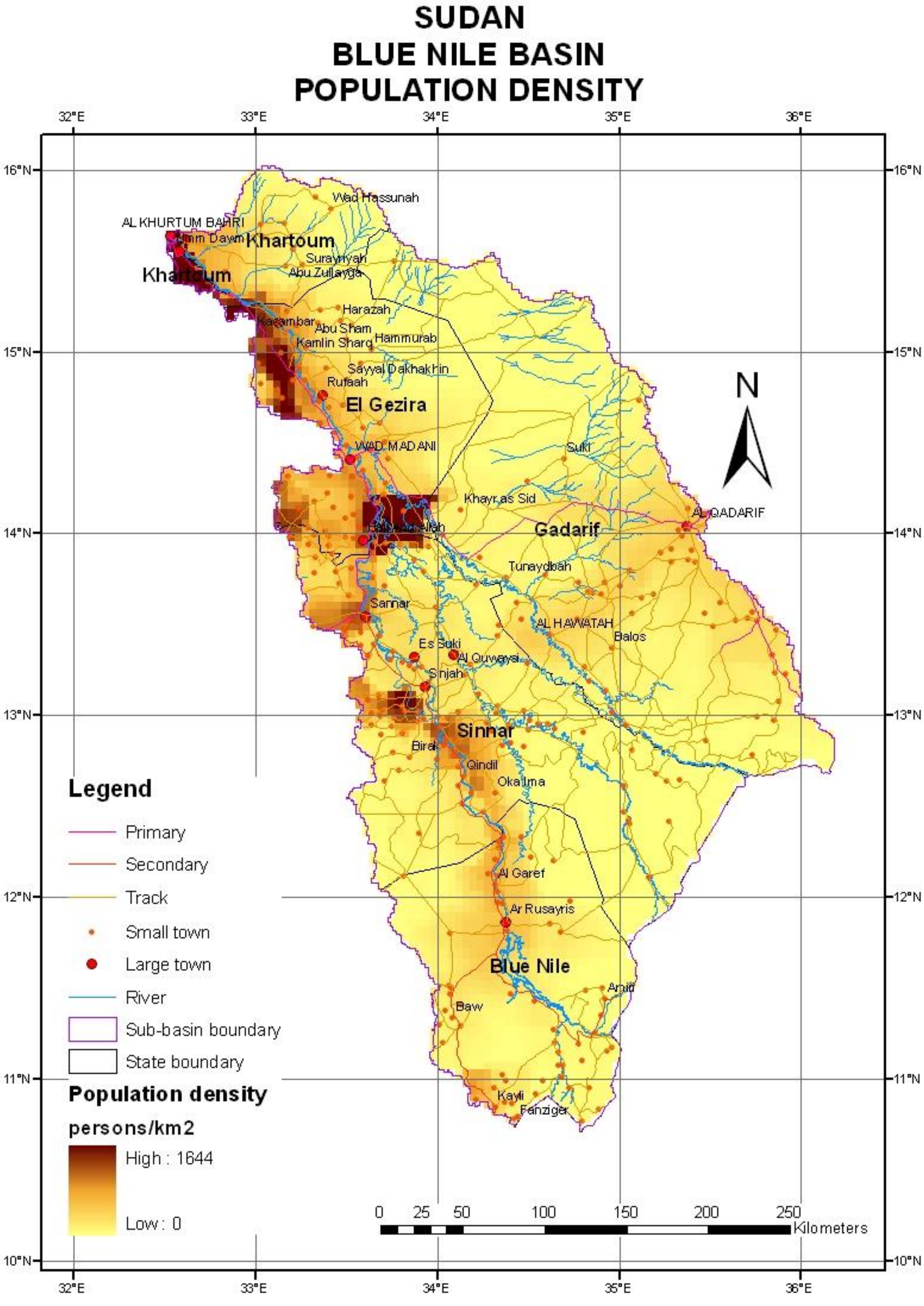
Table 5.4 : Administrative States - Demographic Characteristics

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 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)

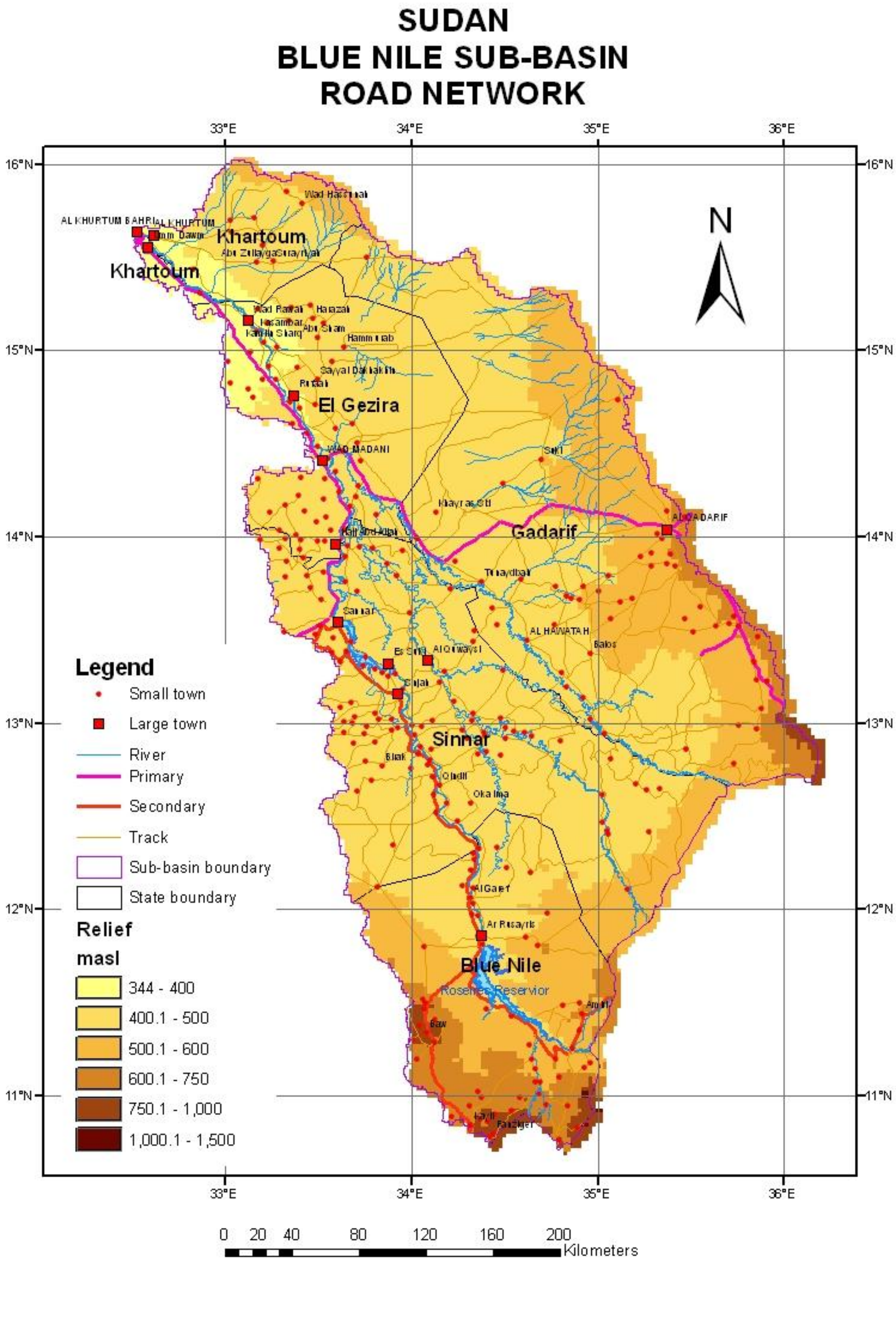
Wad Medani - Sennar (50km) – Damazin (278 km)

(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

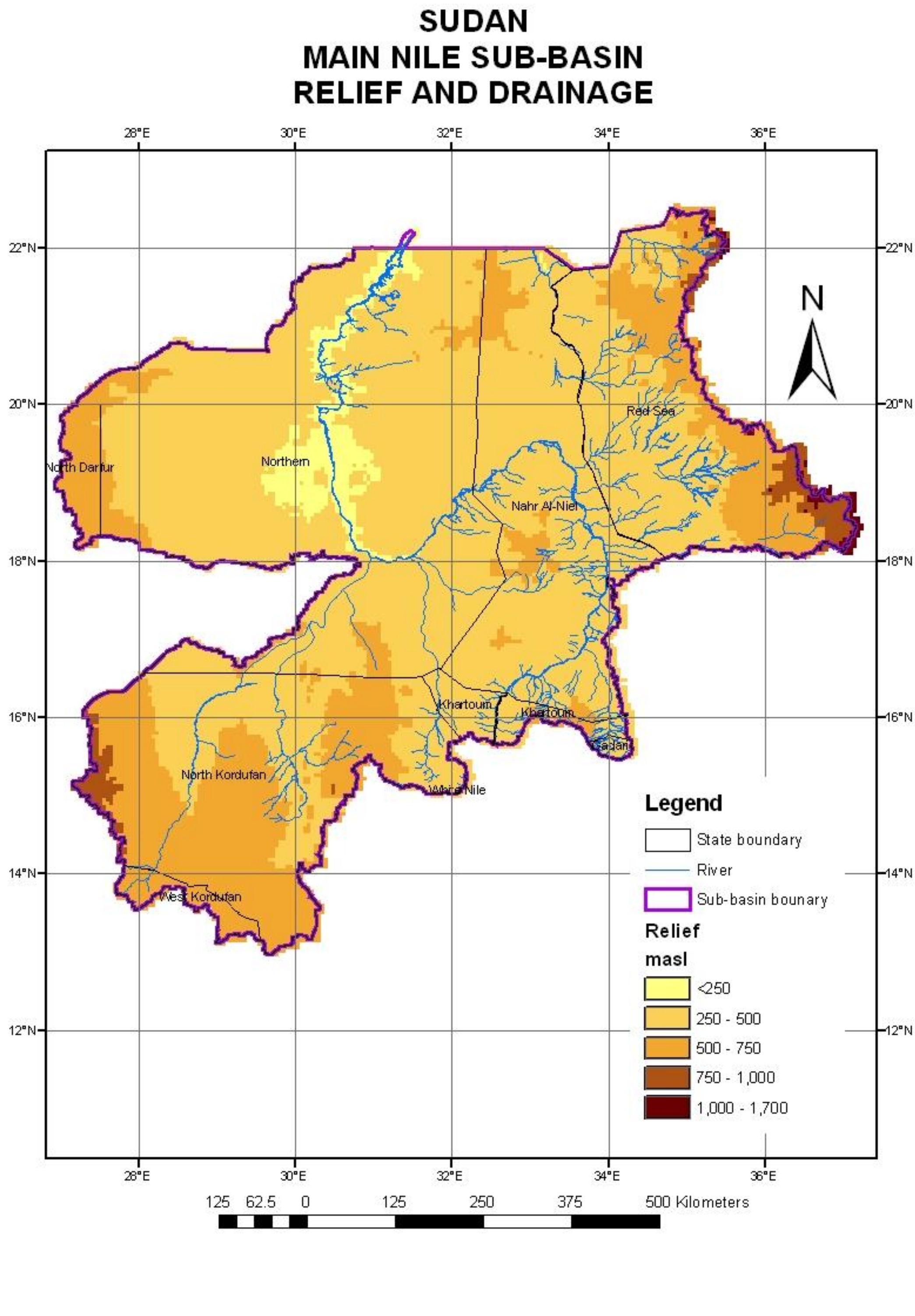
5.3 MAIN NILE ENVIRONMENT

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.

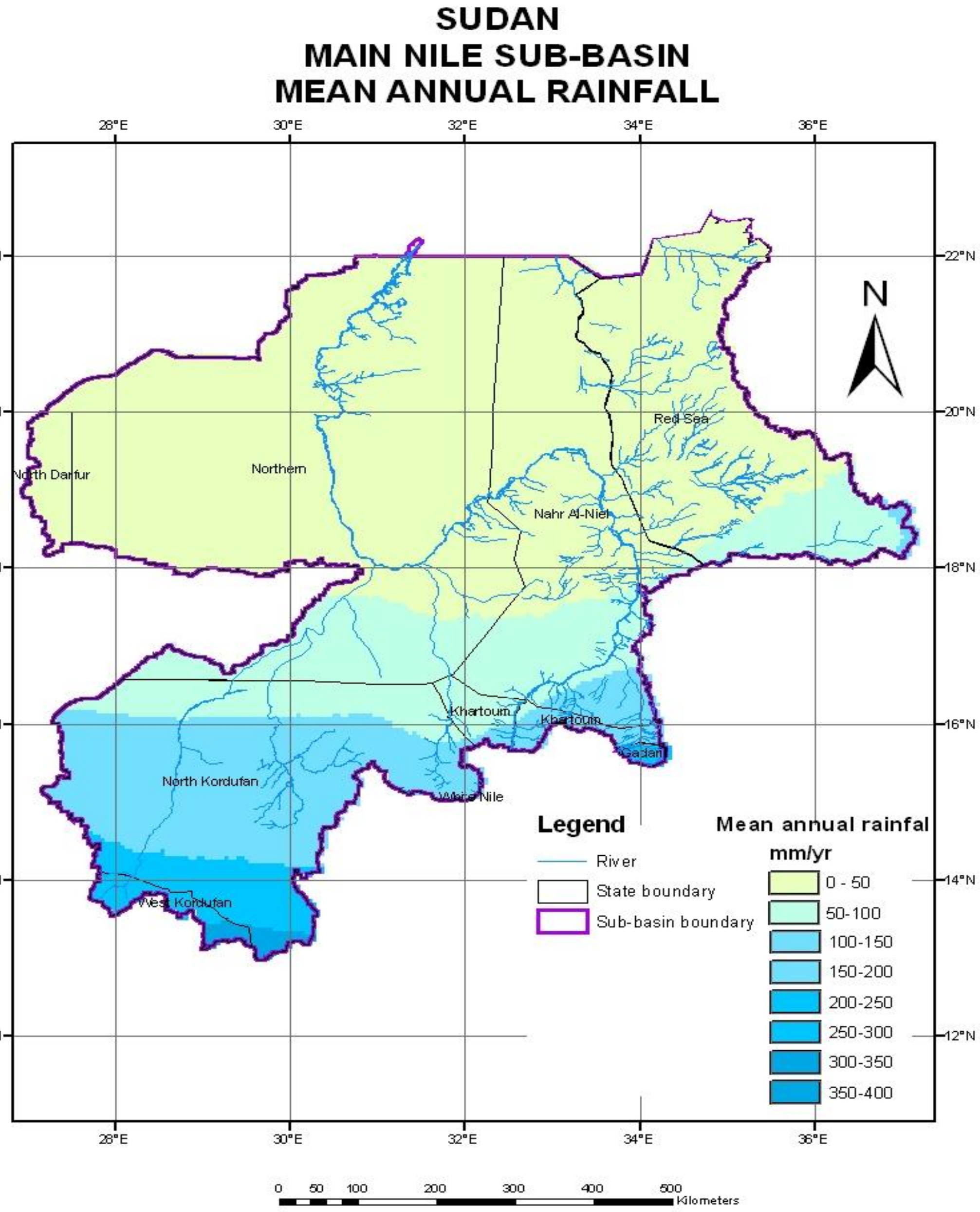


Source: CRA Sudan Report (2006)

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).



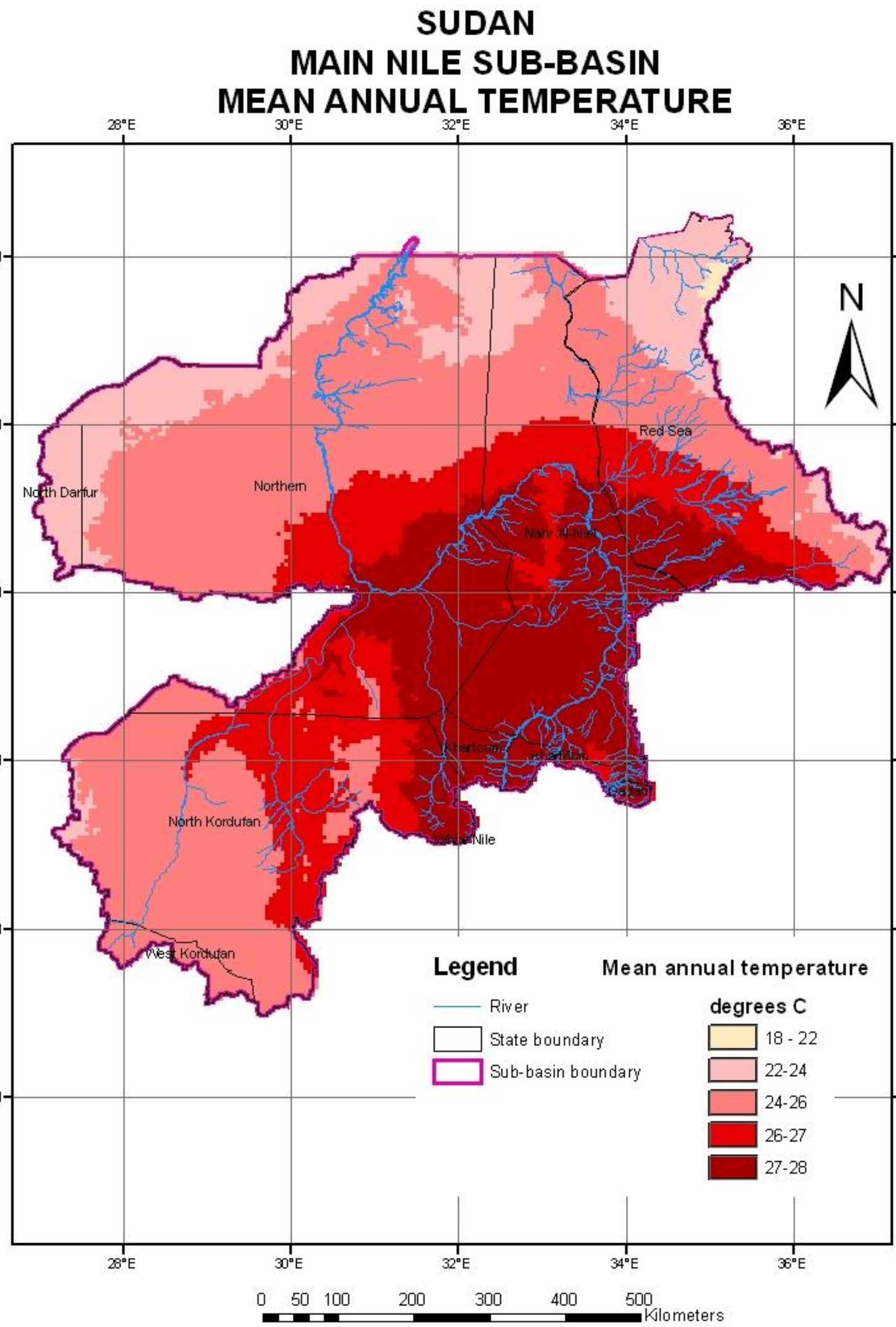
Source: CRA Sudan Report (2006)

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.



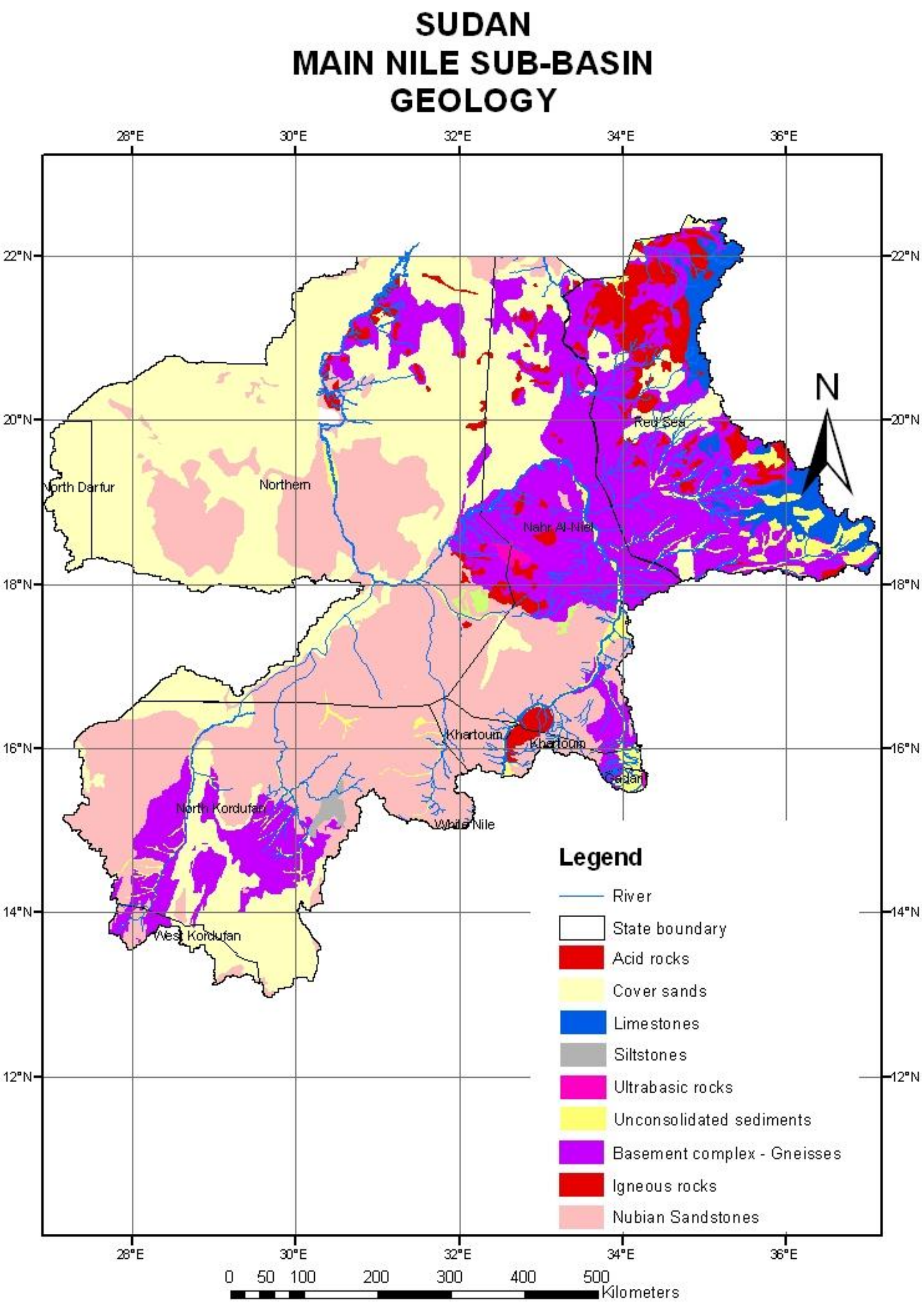
Source: CRA Sudan Report (2006)

Figure 5.16 : Main Nile: Mean annual temperature

5.3.4 Geology and Soils

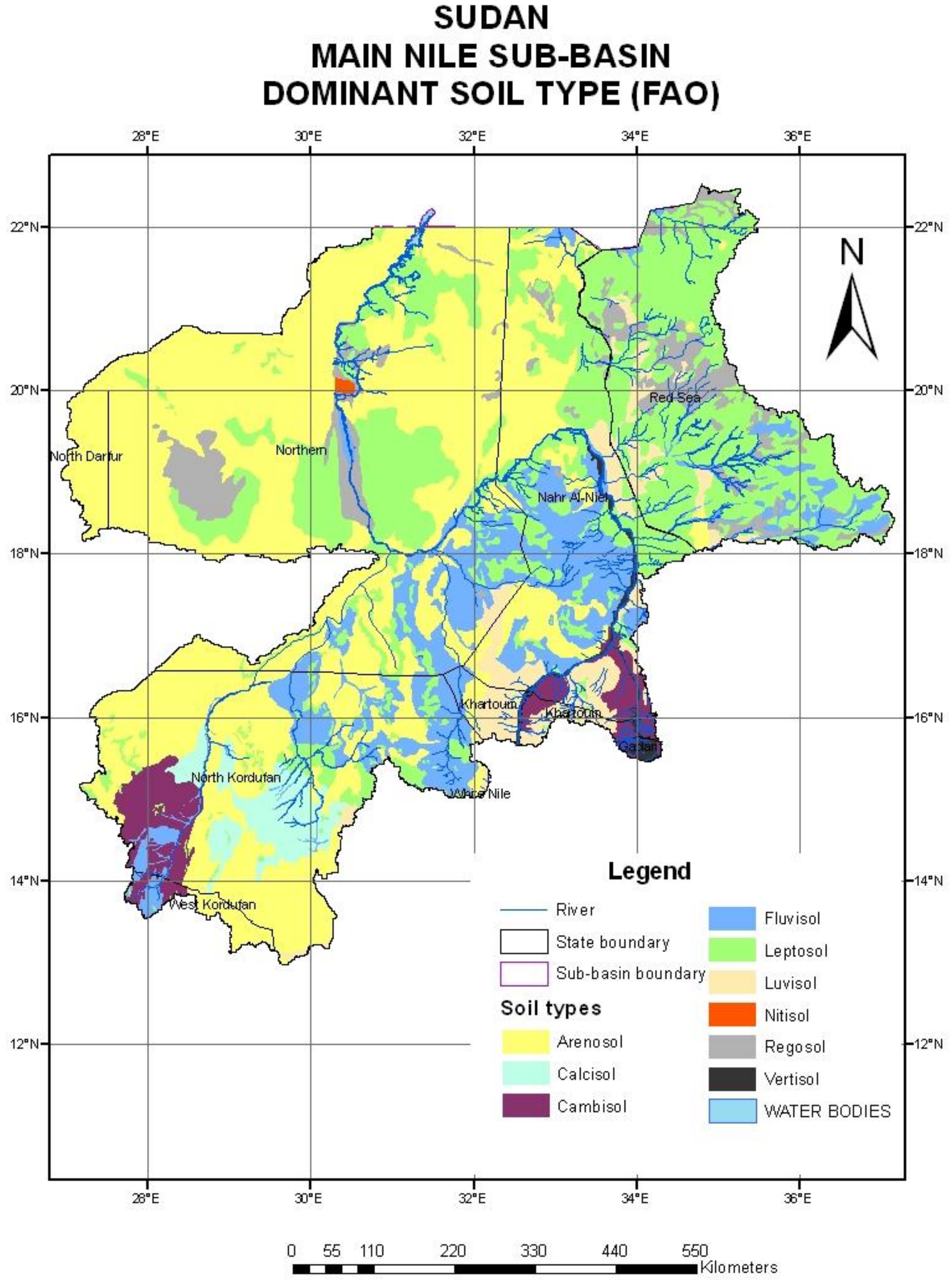
The main underlying geological formations within the Main Nile sub-basin include the Basement Complex rocks, the Nubian Sandstones, Tertiary unconsolidated sediments and Recent superficial wind blown sands (Figure 5.17). The Basement Complex comprises gneisses, schists, marbles and intrusive granites 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*.

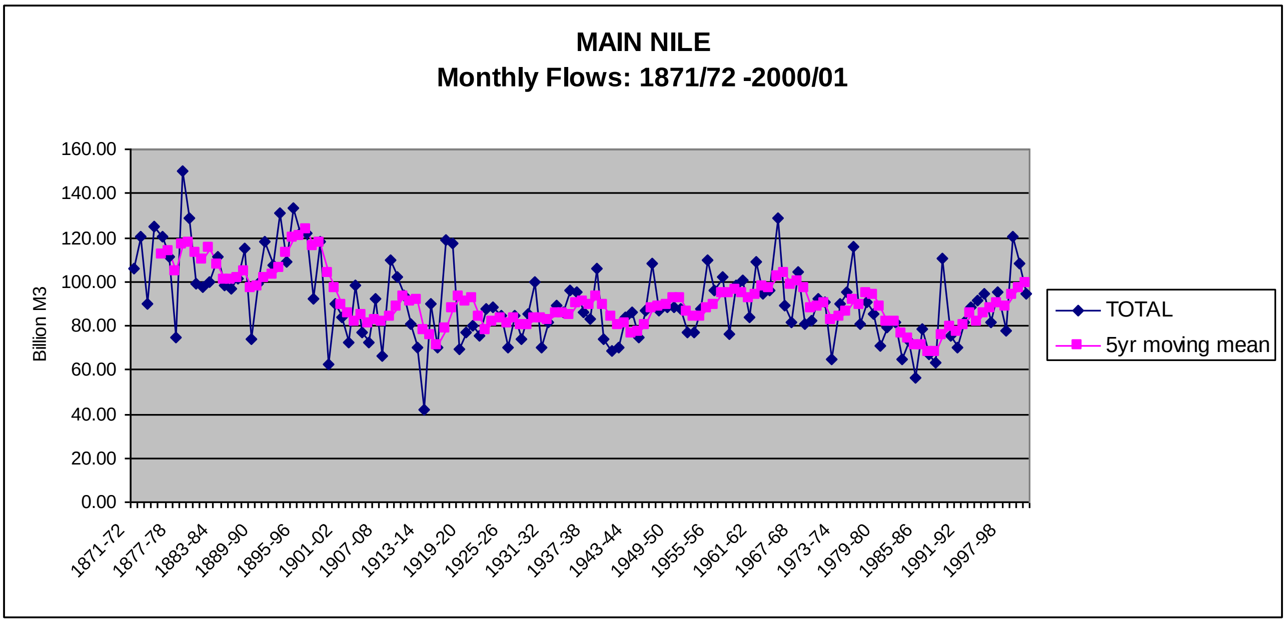
Vegetation in Wadis, Khors and Desert Hollows

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).



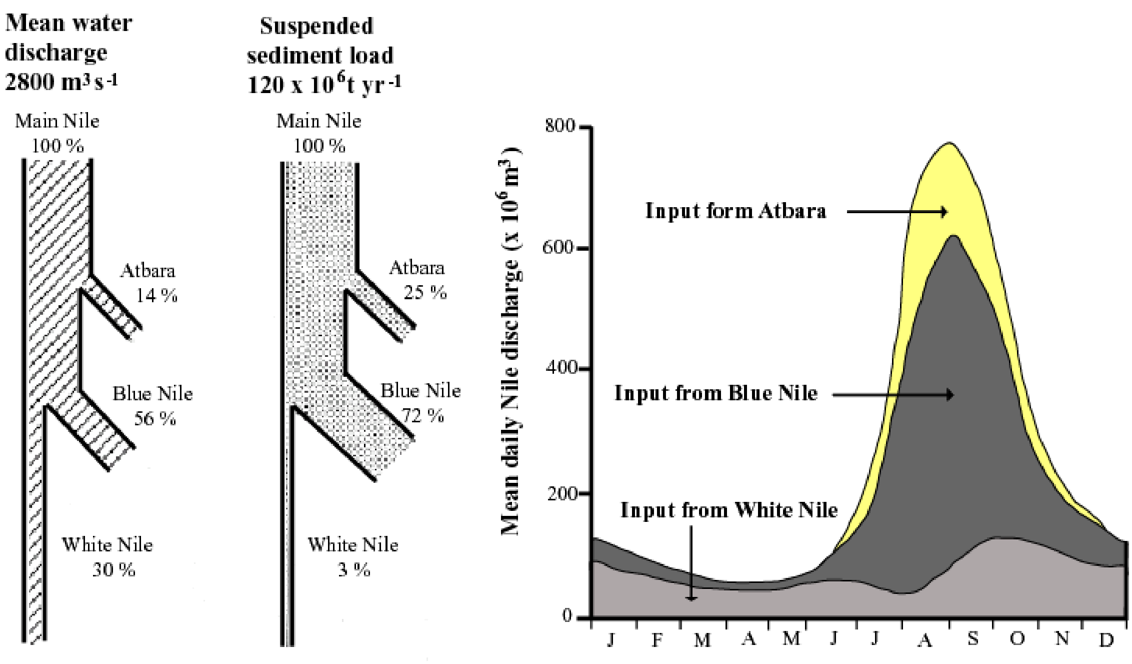
Source: CRA Egypt Report (2006)

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.

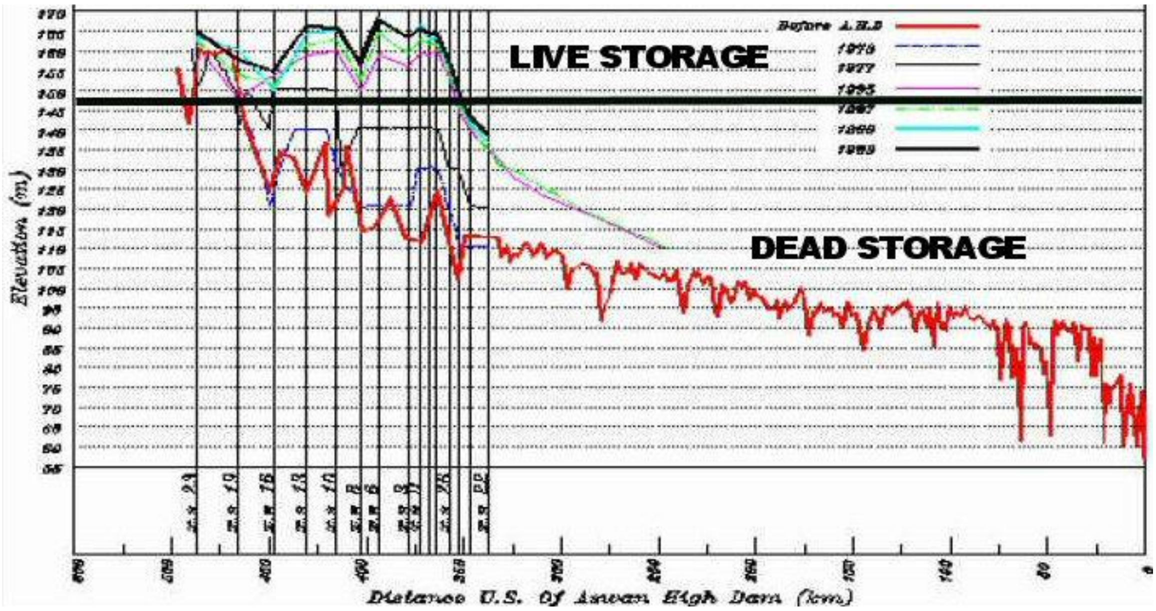
Based on sedimentation data over a 5-year study interval between 1987 and 1992 by Eldardir (1994), a sediment volume of 119 million m^3 per year was estimated to be annually deposited in the AHD Reservoir. This is equivalent (using Shalash's conversion factors) to 186 million tons per year (for the study 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 mattaras 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

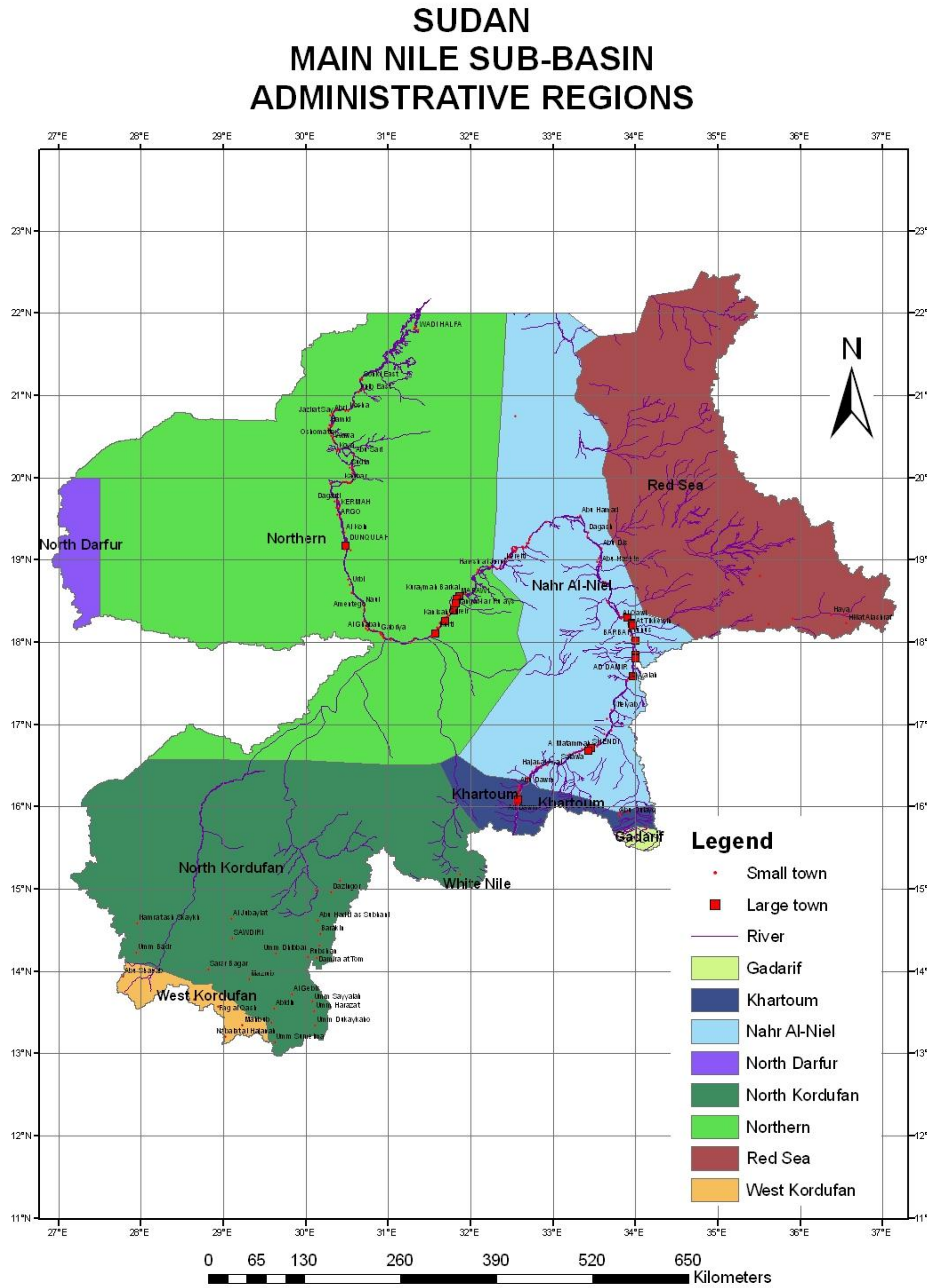
The population of the States contained mainly within the Main Nile Basin are shown in Table 5.9. About half of this population is in Northern and Nile regions and may be considered to be totally dependent on the Nile for both water and food supplies where flood recession agriculture and irrigation schemes 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**

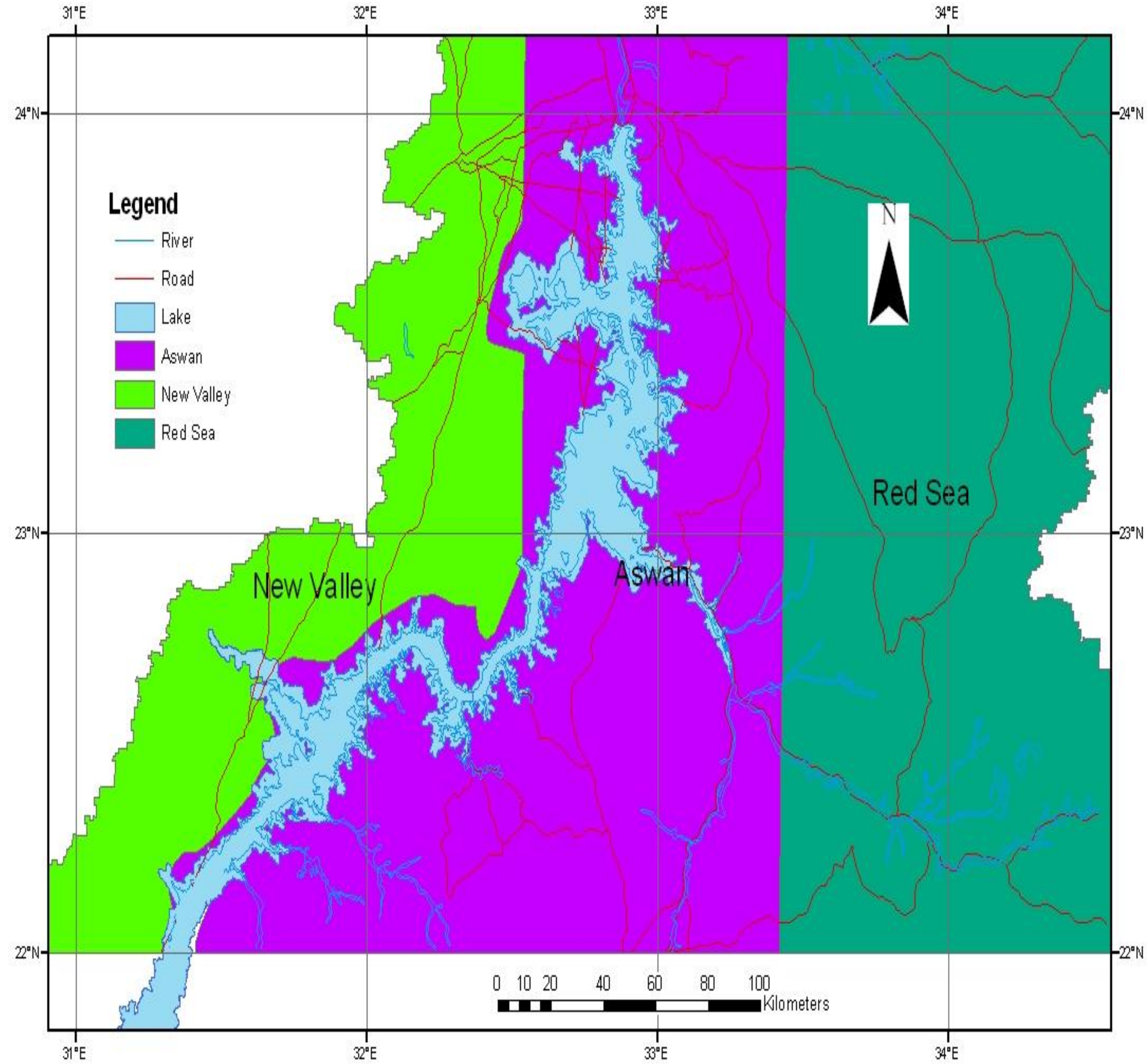
Source: CRA Sudan Report (2006)

The main areas of high population density along the Main Nile are north of Khartoum and 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.



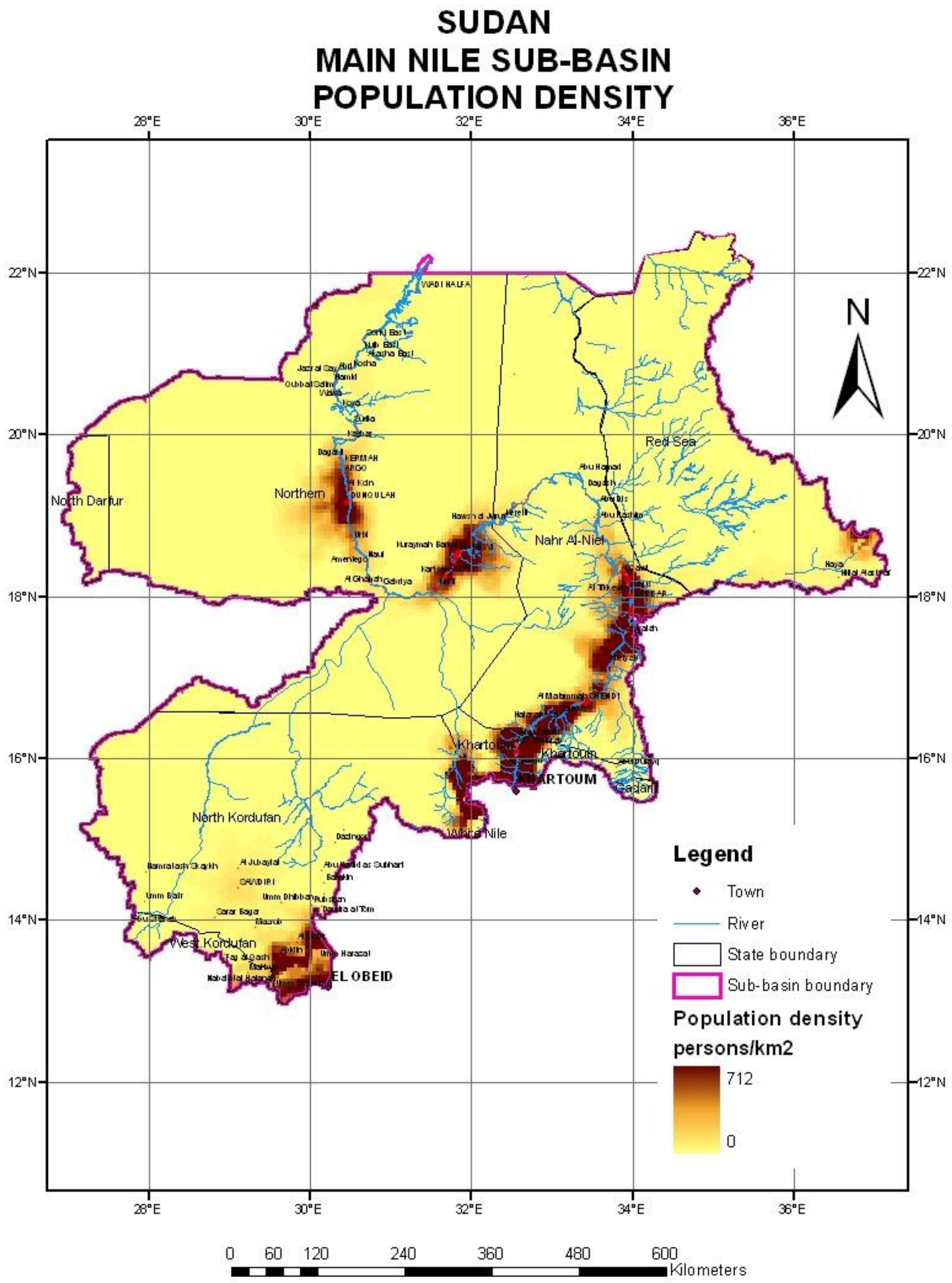
Source: CRA Sudan Report (2006)

Figure 5.22 : Main Nile: Administrative States



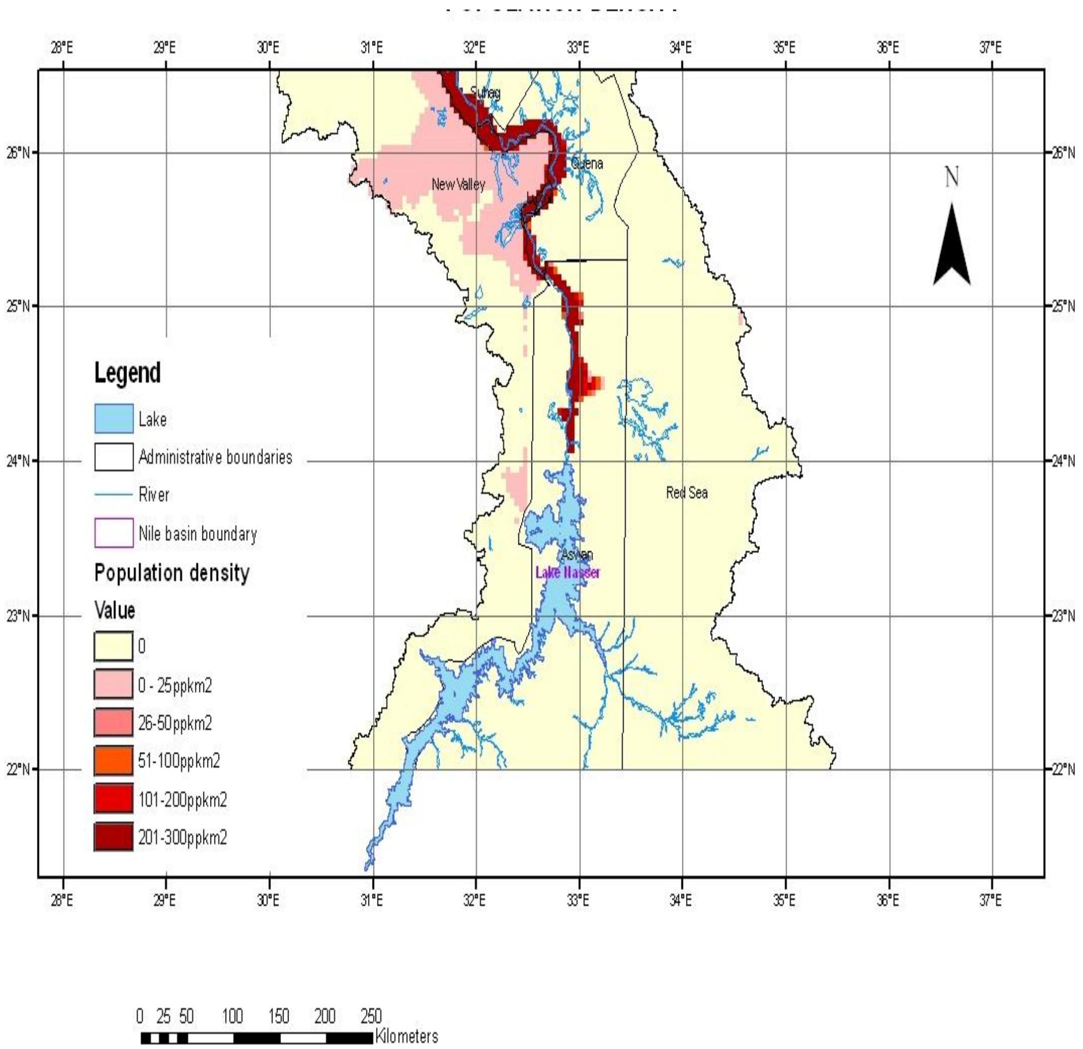
Source: CRA Egypt Report (2006)

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 %	% <15yrs	% >60yrs	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

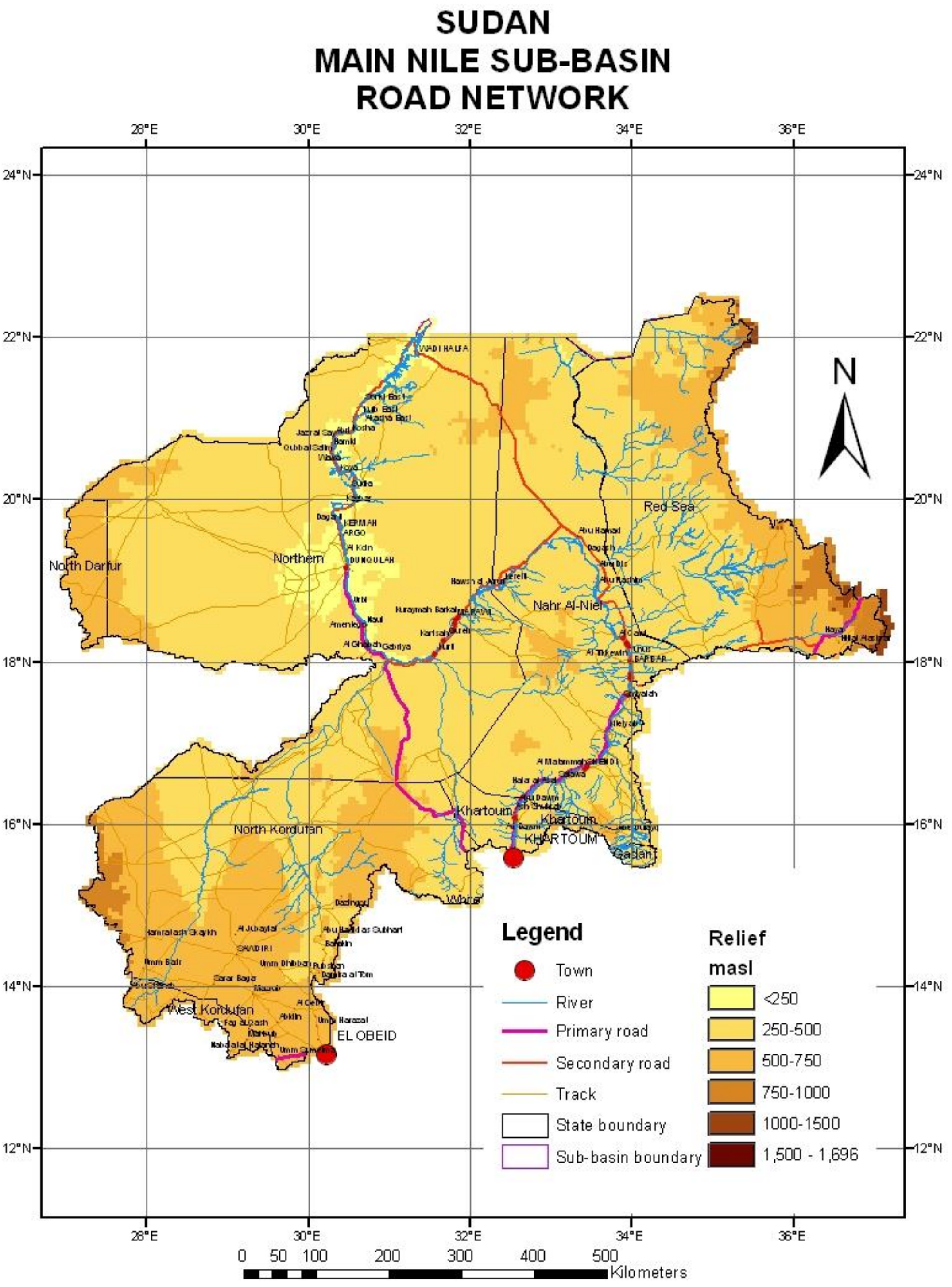
Khartoum - Atbara (312 km) and Atbara – Haiya (under construction)

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.

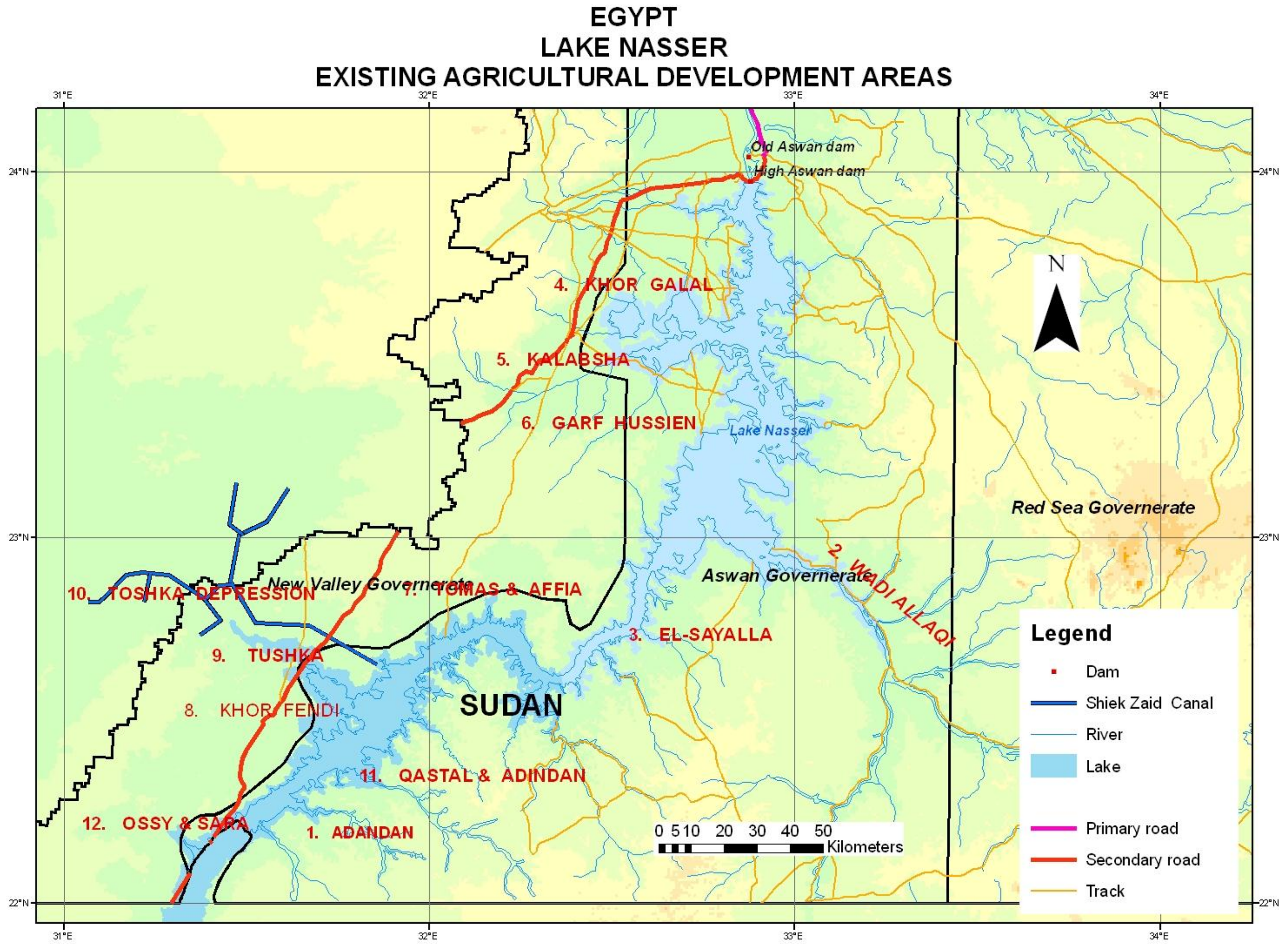
The most recent data (2006) regarding agriculture and farming around Lake Nasser show that the total agricultural area is 12,970 feddans, of which about half is cultivated and half is uncultivated. These areas are located around the lake as shown in Table 5.13 and Figure 5.27.

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)

Consultations with Ministry of Irrigation and Water Resources in Khartoum first indicated an overall irrigation development capital cost of USD 1,000 per feddan

[1] The net irrigation area is equivalent to 20,000 ha making the total 100,000 ha.

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 Border/Mandaya 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

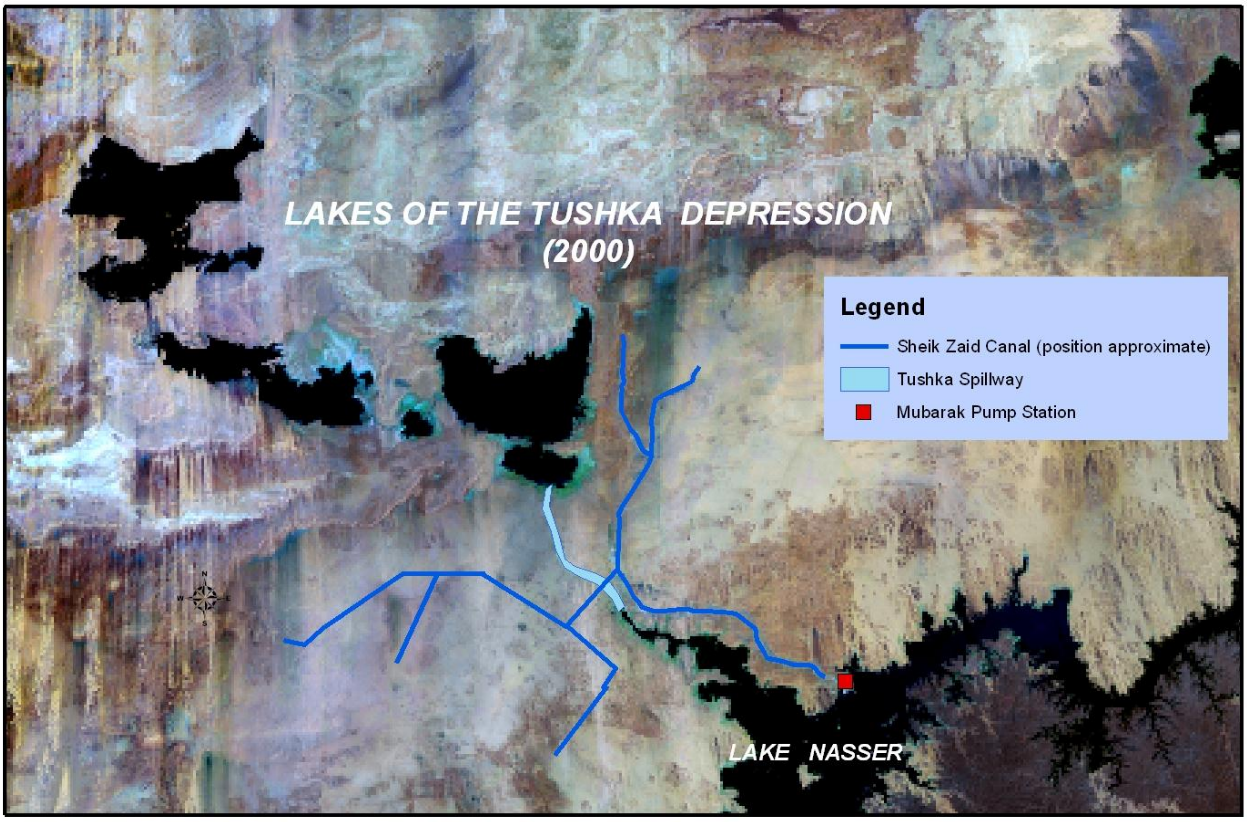
It was noted that sediment loads have increased at High Aswan Dam, especially it was reported in the last 10-15 years. (It may be noted that this comment therefore refers to the post-1992 situation when the mean rate for the 5-year study period between 1987 and 1992 was estimated at 186 million tons 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 Border or Mandaya 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.

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 ground water which 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 Border and Mandaya 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 mattaras, 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 mattaras 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.

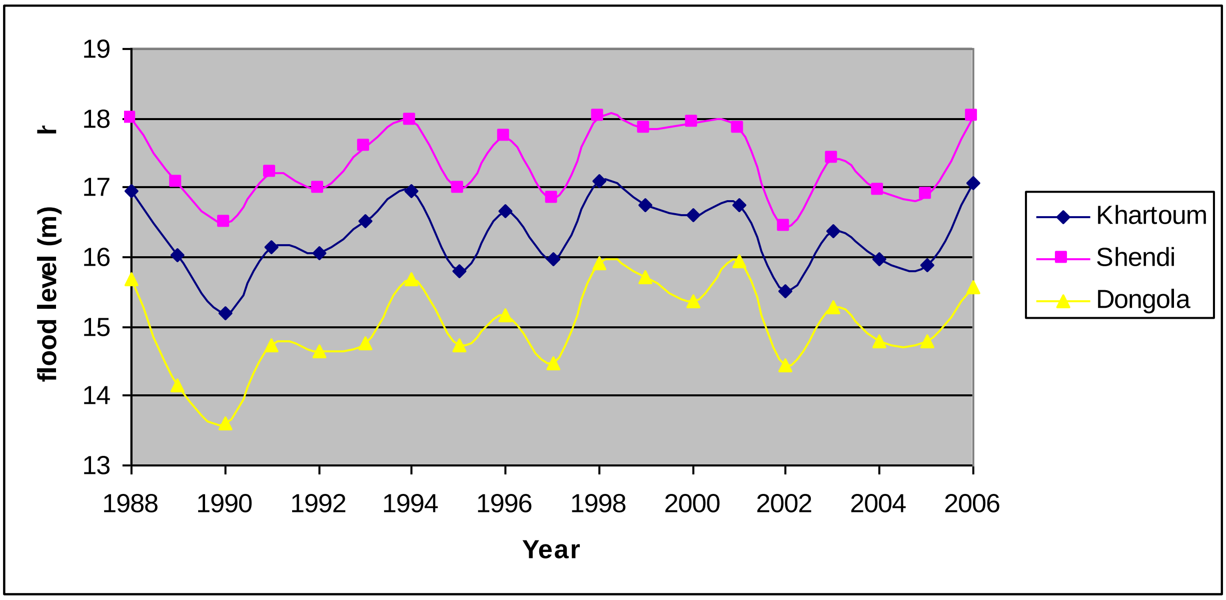
The chronological sequence of flood warnings in the 19-year period 1988 – 2006 is shown Table 5.25. The close agreement between stations for "Flooding" may be noted.

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 mattaras 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 Border 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 Border 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 river bed causing accelerated meandering and river bank 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 Border 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 six 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 Border region and mitigations for these – the direct impact zone.

Section 6.6 considers construction and impoundment impacts and mitigations 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 access roads for 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 Border 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 Border hydropower project

The energy requirement for the excavation, transport and placing of soil and rock material is covered under the estimated diesel fuel requirements of 69,000 tons. The burning of 69,000 tons diesel fuel will result in a CO_2 emission of about 223,000 tons.

If it is assumed that the energy required to produce the cement and steel is generated by a thermal mix (coal/gas = 50/50 per cent) then some 312,000 tons of coal and 179,000 tons of gas would be needed. The burning of these fossil fuels would ultimately lead to a CO_2 emission of approximately 490,000 tons.

The total emission of CO_2 associated with the construction of the Border hydropower project will thus be approximately 714,000 tons.

CO_2 associated with decomposition of biomass in Border reservoir

Decomposition of the biomass in the reservoir area could lead to a maximum CO_2 emission of about 890,000 tons, assuming that 70% of the woodland was used cut and as fuel wood, substituting for other sources and reducing deforestation elsewhere in Ethiopia.

Thus the implementation of Border hydropower project will lead to a total CO_2 emission of about 1,600,000 tons.

CO_2 associated with emissions from equivalent thermal power plants

The annual average energy to be generated by the Border hydropower project would amount to 6,012 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 4.2 million tons of CO_2 would be discharged to the atmosphere annually. It is noted that the CO_2 emission of 4.2 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 thermal power plants. Over a period of 50 years, the assumed commercial life of Border, this annual CO_2 emission would result in a total of 210 million tons of CO_2.

Consequently the generation of hydro-electric energy at Border yielding a total of some 1,600,000 tons of CO_2 emissions will be about 130 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 Border 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 coffer dam for river diversion becomes operational. These cofferdam impacts may be expected approximately two years after construction activities begin and continue until reservoir impoundment. The area flooded will be in the order of 28 km^2 (Table 6.2)

Table 6.2 : Border 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)	580	574	13.3
Minimum Operating Level (MOL)	560	288	5.4
Difference between FSL and MOL	20	286	7.9
Probable pool level during construction, after year 2. (Upstream coffer dam sill level + say 15m)	521	28.4	-

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 one, or two, 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 5th or 6th year of the six-year construction program.

It may be noted that the reservoir storage capacity at Full Supply Level (13.3 billion m^3) is less than one third of the annual average flow (48.7 billion m^3) and less than the average flow in month of August (15.3 billion m^3). Flows in most Augusts therefore in the 50-year flow record could fill Border reservoir in a single month. Whilst detailed studies of first filling have not been carried out, it is clear from this and from study of July and September flow records that first filling should be achieved rapidly, and almost certainly within two years, whilst making satisfactory releases downstream during the first filling period. This is a work area requiring very detailed cooperative studies.

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 and timing of cofferdam impoundment 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 Border reservoir area (574 km^2) to assess impacts on water quality from the time of cofferdam impoundment and after first filling. However, as a general statement, owing to the rapid throughput of water (the reservoir empties and fills every year in the 50-year simulation) and subject to further study when data becomes available, significant water quality problems related to stratification and turnover are not expected to develop.

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 with cofferdam impoundment and when first filling begins 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 is at least 140 Mt/year and could be 318 Mt/year, and is 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 Border. 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 (Chapter 7).

Border 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. Once these loads are received in Border 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 in upstream catchment areas before entering Border reservoir, and the sediment transports rates of Abbay's main tributaries (Dabus and Beles) and minor tributaries which feed directly into Border 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. Failure to arrest and reduce current rates of erosion and sediment transport may prevent or delay implementation of the Border project and, when constructed, may jeopardize its success in the medium and long term.

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 Border 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 Border project. With the Border project, the program becomes even more vital. The mechanism for Border 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

Under the circumstances of favourable topography and favourable geology, described earlier, the risk of slope instability following impoundment appears to be low or non-existent.

The steepest slope in the reservoir, falling below FSL, is near Tugojan village, approximately 15 km southeast of the dam centre line. At this locality the Abbay passes a narrow gorge through an intrusion of granitic gneiss and quartz-diorite. The submerged slopes will be of the order of 1 in 5, and up to 60 m high. This is an exceptionally steep gorge within an otherwise flat basin. Such slope is indicative of a very resistant, high quality rock mass. It is considered, therefore, that slope failure is unlikely at this locality, in spite of the steep slopes.

6.3.6 Groundwater and Reservoir Seepage

There is considered to be low risk of reservoir leakage. There may be some small seepage associated with pervious soils because in an arid climate there is likelihood of granitic rocks weathering into loose, angular residual gravel. However, although such soils are permeable, they have very high resistance against piping.

As mentioned earlier, there is a low neck encroaching on the reservoir basin at a point 9 km southwest of the dam site. This is a potential seepage path with a length 1.7 km. The high point of the neck is spot height 582.3 masl. The regional geological map shows a major fault passing through the neck, and this would exacerbate the depth of weathering in granitic bedrock. With Border reservoir's FSL at 580 masl, and an assumed depth of weathering of the faulted, weathered granite at the neck in the order of 10 to 15 m, i.e. down to elevation 572.3 to 567.3 masl, there is considered to be the possibility of minor seepage through the neck. This will require further investigation by pitting and drilling during feasibility studies.

With the benefit of further geological surveys during feasibility studies, areas adjacent to Border reservoir may be detected where rock type and structure may be favorable for seepage and groundwater supplies, either by wells or boreholes. Establishment of observation boreholes in the construction period should be considered for monitoring groundwater levels as a routine but also for development of water supplies for local communities.

6.3.7 Reservoir-induced Seismicity

The Border 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 Border such analysis will be needed during feasibility investigations.

6.3.8 Impacts on Minerals

On first impoundment in the construction period, Border reservoir will inundate an area of 574 km^2 including a long length of the Abbay river channel and shorter lengths of tributaries. All of these lengths of river contain alluvial gold, and therefore this renewable resource will be lost to the people living in adjacent areas.

The impoundment will also stop gold being transported and deposited in alluvial deposits downstream of Border 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 being worked currently are outside the impoundment area.

Mitigation

There is no mitigation for impounded alluvial gold deposits, certainly not in the dead storage zone (below MOL), and compensation payments will be necessary for communities engaged in gold panning.

Alluvial gold will continue to be available in tributaries of Border reservoir as occurs now. Gold will also be found in sediment deposits in Border reservoir and, in theory, available for extraction each year when water levels are drawn down exposing sediments and mudflats. It is unpredictable whether local people would wish to dig into these deposits in the hope of finding gold. Some safety issues may arise if this occurs as such mining, as with deep wells, can involve collapses and burying live people.

Although there is and will remain great uncertainty about the quantity of alluvial gold extracted, there is no doubt from our social surveys that many poor people are involved in these activities. Hence the gold issue is scoped as an important one to be addressed.

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, 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 Border will decrease as it (and some live storage volume) becomes progressively silted in the operational period. The surface area (288 km^2) associated with MOL will provide the aquatic habitat in the months when the reservoir is fully drawn down each year. 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 (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. This report therefore anticipates that most woody vegetation in the dead storage zone will 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 there being almost no existing roads in the Border reservoir basin area, and the near inaccessibility of some tributary areas, it is almost certain 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 are satisfied locally, there is no obvious local market for cleared timber. Transport costs over difficult terrain and long distances will be relatively 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; their linear distribution and amounts, however, require detail investigation. These are all areas to be examined in future studies.

It seems possible that an attractive procedure could be to award contracts in 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.

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 Border's 574 km^2 reservoir basin where it is impracticable to remove residual branches and other materials to locations outside the reservoir perimeter. These 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 Border and dams downstream.

Mitigation

One or more specialist or local community contractors may develop Border reservoir clearance plans. Nothing should be decided without seeking the views and having full consultations with 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 local labour availability and its other seasonal commitments.

Emergency contingency measures should also be formulated, especially for clearing the dead storage zone, which includes the area flooded by the upstream cofferdam. 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 (Table 6.3). This will not be satisfactory in future studies when both area and tree density and timber volume data 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, a small cultivated area and some grassland 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 more consideration is given to residual micro-habitats for aquatic life.

Table 6.3 : Border Reservoir Clearance Costs

Reservoir area to be cleared ha	Rate USD/ha	Cost USD million
51,600	500	25.8

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 developed and implemented 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 Border 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 Border dam and at structures in Sudan downstream. Costs of remedying these problems are not insignificant.

Mitigation

Border reservoir basin clearance needs to be effective. This aspect relating to dealing with additional trash at Border, and at Sudan’s river structures, from Border’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 coffer dam pool area and then 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 by 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 Border 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). At FSL 580 masl, Border reservoir only inundates the lowest few kilometres of this area but future surveys, particularly well planned bird and bird habitat surveys, should embrace a much larger area in consultation with the Ethiopian Wildlife and Natural History Society. This would not only make a worthwhile contribution to the Society but the results might lead to the Border hydropower project owner adopting the lower Dabus valley as an environmental offset, in full or part mitigation for the destruction of habitat in Border's 574 km^2 reservoir basin.

Silt will accumulate in the lower part of the Dabus valley – a mini delta in Border reservoir at full supply level. The silt may be expected to accumulate and be reworked during Dabus flood flows. This dynamic substrate may provide good habitat for water birds and other wildlife; it may also be attractive for cultivation and settlements. If both occur, human and wildlife conflicts may be severe. The wildlife EMP, and any sub-plan for the Dabus valley as a project offset and/or an IBA, will therefore need to consider a full range of monitoring and management measures for this area.

Whilst our scoping of issues has suggested Dabus valley as being a potentially suitable candidate for attempting to offset loss of riverine forest, bamboo and other woodland and grassland habitats in Border 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. These might, for example, include protection of one or more reserves in the mountains close to the left and right banks of Border dam site, and/or some areas along the north side of the new reservoir (between the dam site and the Beles wing of the reservoir) if surveys indicate significant migration movements for which the new reservoir will present a permanent barrier, and make such animals more susceptible to poaching.

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, Beles and lower Dabus rivers, and “inland” from these rivers to the Border 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 particular, 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.

6.4.6 Aquatic Fauna

When the upstream coffer dam is constructed, an area of river channel, river banks 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 coffer dam. Changes in aquatic life are expected during this time as the habitat changes from a running river to lacustrine environment.

During the first impoundment of Border 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 Border reservoir reach), it is clear that the Border dam project will stop such natural upstream migrations.

Mitigation - Aquatic surveys and Fisheries Development

It was earlier noted that baseline information on phyto-plankton, zoo-plankton and benthic fauna in the Border 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 Border 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 Border'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 Border, and because Roseires receives flows, water quality and sediment loads practically identical to a future Border reservoir. Indeed, as impact assessment of Border must consider Border'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 Border'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 at Border 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 Border 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.

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 Border's dam height (90 m) and the wide range in reservoir water levels. On the latter, it is difficult to engineer delivery of fish to a 20 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 owing to the Border 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 Border reservoir under its operating conditions and to prepare a plan to exploit fisheries sustainably.

6.4.7 Disease Vectors

The cofferdam pool, and reservoir impoundment later, will increase 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 should cover the workforce and camp followers. The project will need to boost these services in 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 significant loss of resources, income generation opportunities and assets in the direct impact zone of the Border hydropower project. An estimated 2,781 households will be affected by the reservoir. An estimated 8,343 houses will be submerged, there being, on average, about three houses per household.

Moreover, use of natural resources and an estimated area of 2,400 ha of flood recession agriculture and 4,170 ha of rainfed cultivation land will be lost due to the reservoir. In addition, a relatively small area of land and property will be lost due to construction activities. Regarding public and private buildings, 3 health facilities, 7 schools, a store, 4 bailey bridges, 4 fords and 75 km road will be lost due to the project.

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.

No significant social impacts are foreseen between Border 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 in 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.

The population density in the project area is low and the settlement pattern is highly dispersed. People lead a traditional way of life.

However, there is a significant loss of houses of the communities living within the reservoir area. An estimate of 13,905 inhabitants (2,781 households) will be affected when their villages are inundated (Appendix 6.2). Each household can have 2-4 houses depending on their wealth. Assuming three houses per family on the average, the total number of houses affected will be 8,343. In addition, one incense store, two mosques, seven schools and eight health facilities will be inundated. Details are given in Table 6.4.

Table 6.4 : Summary of Lost Assets and Compensation

No.	Social Structure	Unit	Unit Cost	Quantity	ETB
1	Houses	No.	600	8,343	5,005,800
2	Stores	M^2	3,500	40	140,000
3	Schools	No.	480,000	7	3,360,000
4	Health Post	No.	484,122	4	1,936,488
4	Health Station	No.	592,880	1	592,880
4	Health Center	No.	4,482,945	1	4,482,945
4	Health Clinic	No.	592,880	1	592,880
5	Mosque	No.	9,000	2	18,000
Total					**16,128,993**

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

There will be limited impact on arable land due to construction of transmission line towers, stringing, construction camps, stores and other structures along the Border to Roseires route but the impact on arable land and settlements is expected to increase further north. There will be greater impact associated with the line required to interconnect with the Ethiopian grid at Debre Markos because it passes through an intensively farmed area (Figure 6.1).

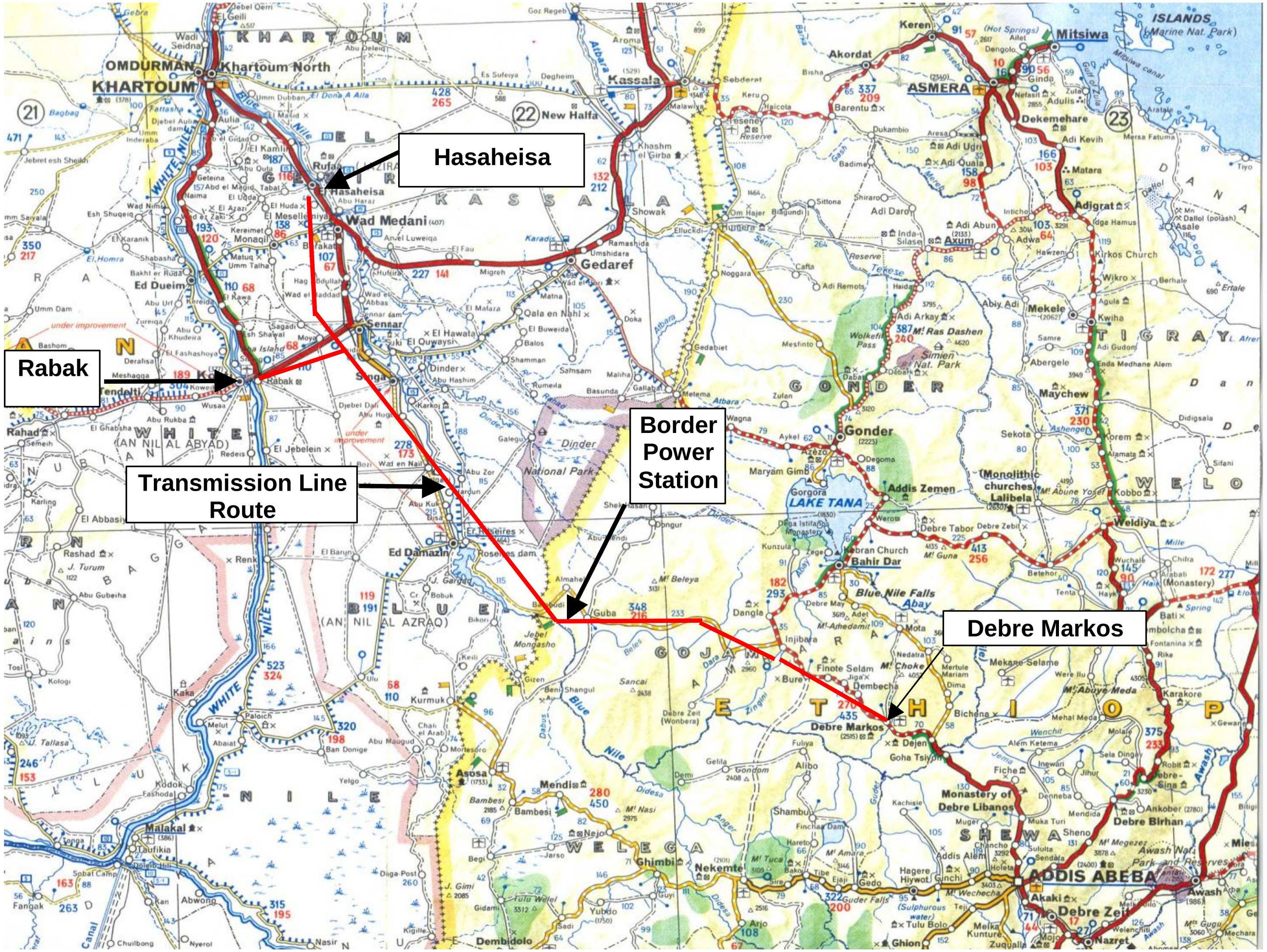


Figure 6.1 : Transmission Line Routes Border to Hasaheisa/Rabak and Debre Markos

The basis for roughly estimating compensation for Border project's two transmission lines is the Ethiopia-Sudan Power System Interconnection study report (SMEC, Oct. 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 Border, 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-Border	366	2,137,263	5,840
In Sudan Border to Roseires	82	118,140	1,440
Whole Line	448	2,255,403	5,030

Source: Ethiopia-Sudan Power System Interconnection (SMEC, Oct. 2006)

The possible routes of the interconnecting transmission line from Border hydropower project to Hasaheisa/Rabak in Sudan present several difficulties.

The first section of the preliminarily adopted line from Border switchyard to the frontier will be on the right bank and parallel with Abbay river through open shrubland; this has been surveyed at reconnaissance level from Border switchyard to the Sudan border during fieldwork for this study. The route from the Ethiopian/Sudan frontier to Hasaheisa/Rabak has not been visited for this study, and it is noted that difficult road access conditions along this route as far as Roseires prevented SMEC from carrying out detailed studies of it for Option B1.

Available land use mapping (Figure 5.8) and satellite imagery indicate that open shrubland continues northwards until some rainfed cropping occurs intermittently with shrubland and some wetland "maya'as" 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 (Figure 5.7).

Intensive land use along the final length from Sennar to Hasaheisa is regarded as a strong reason for preferring the alternative destination at Rabak, which would be slightly shorter. The Sennar to Rabak line would follow an existing road and rail route through semi-mechanized farmland.

Detailed surveys are required. The direct route closely follows the Blue Nile and parallel right bank tributary areas with maya'as in one reach, and there may be a strong engineering and environmental case to avoid passing through maya'as and an environmental case to keep a good distance from the main and tributary rivers. Alternative routes are available but without making alternative routes excessively long, it is difficult to avoid irrigated land, maya'as and running parallel with rivers. For estimating compensation, we have adopted 50% of the line length at the high and low rates respectively. (In future, if the Border project is developed after the Mandaya project, the selection of the Border transmission line route may be influenced by the route adopted for Mandaya – which is to the west of Roseires reservoir).

For the Border switchyard to Debre Markos route, the higher rate is adopted. This first passes through open shrub and open woodland before passing through continuous, intensively cultivated areas with significant impact on households, farms, woodlots and Eucalyptus plantations (Figure 4.9). The detailed alignment has not been surveyed for this study but travel along the Border – Chagni – Debre Markos road has given support to adopting the SMEC cost for a roughly similar alignment.

Unlike in the Border reservoir and the dam site works areas, 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. Thus, in this case, compensation has not been based on 10 times the annual lost value of crops.

Compensation estimates for transmission lines from Border switchyard to Hasaheisa and to Debre Markos are 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 : Border Transmission Lines Compensation

Border HPP Transmission Lines	Length km	Total Compensation USD/km	Total Compensation USD
Border HPP to Hasaheisa/Rabak (Sudan)	440	50% @ 1,440 50% @ 5,840	316,800 1,284,800
Border HPP to Debre Markos	380	5,840	2,219,200
Both Lines	820		3,820,800

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 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.

Additional points about the line routing in Sudan concerning the Damazin area and Roseires are made in Section 6.6.

6.5.6 Arable Land Compensation - Border Reservoir

Cultivation in the reservoir area is more favourable than in areas away from the river and its tributaries because of fertile alluvial deposits. These are along the Abbay itself but also in areas on the left bank upstream of the dam site and in the Beles valley. During field surveys, cultivation activities were observed as well as new interventions through clearing wood and shrub cover. Furthermore, extensive farming is observed using the residual moisture from Abbay’s annual flood.

Impoundment of Border reservoir is estimated to permanently destroy approximately 6,570 ha of arable land; of these, approximately 4,170 ha are rainfed and 2,400 ha under flood recession agriculture. Crops, prices, yields, areas under cultivation and estimated compensation costs are shown in Table 6.8. A fully developed compensation plan, as part of the RAP, will be required.

Table 6.8 : Reservoir Area Crop Compensation

No	Annual crop	Unit	Unit price ETB	Average yield	Crop Percent	Cropped area (ha)	Total Cost ETB	Compensation X10 (ETB)
II	**Annual cropped**							
1	sorghum	Quintal	170	13	53	2,230	4,928,300	49,283,000
2	maize	Quintal	150	20	21	869	2,607,000	26,070,000
3	Dagusa	Quintal	110	15	13	563	928,950	9,289,500
4	sesame	Quintal	350	7	12	510	1,249,500	12,495,000
5	tobacco	Quintal	600	7	0	0	0	0
5	vegetables	Quintal	300	10	0	0	0	0
	Sub-Total				**100**	**4,172**	**9,713,750**	**97,137,500**
II	**Recession agriculture**							
1	sorghum	Quintal	170	13	30	720	1,591,200	15,912,000
2	maize	Quintal	150	20	20	480	1,440,000	14,400,000
3	Dagusa	Quintal	110	15	13	312	514,800	5,148,000
4	sesame	Quintal	350	7	12	288	705,600	7,056,000
5	tobacco	Quintal	600	7	15	360	1,512,000	15,120,000
5	vegetables	Quintal	300	10	10	240	720,000	7,200,000
	Sub-Tota				**100**	**2,400**	**6,483,600**	**64,836,000**
	GRAND TOTAL ETB					**6,572**	**16,197,350**	**161,973,500**

6.5.7 Grazing Areas

There is estimated to be a small but not significant 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 Border reservoir area with FSL elevation of 580 masl.

During first-filling of Border 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

Site visits and GPS measurements taken in the area shows that at 580 masl there will be inundation of roads, bridges and fords. Estimated infrastructure costs are included in Table 6.9.

Table 6.9 : Infrastructure Compensation

No.	Infrastructure	Unit	Unit Cost ETB	Quantity	Total Cost ETB
1	Road	km	1,200,000	89	106,800,000
2	Bridge	No	280,000	4	1,120,000
3	Ford	No	90,000	4	360,000
Total					108,280,000

However, some 89 km of access roads for construction and a bridge across Abbay downstream of the dam are included in the project. Most of the new access roads (those not later inundated) and the bridge will be available for the community's use, generally soon after their construction. These will have very positive social and economic impacts, especially the Abbay bridge, locally and regionally.

Mitigation

Lost infrastructure should be compensated in monetary terms or in kind. Particular care is required to maintain or replace and improve communications along the right bank of the river (where the existing road will be flooded) and across the Abbay and Beles rivers. Provision of ferry boats may be suitable for crossing the reservoir but attention will be required to changing water levels – a 20 m range each year, and safe access to ferry terminals. Vehicular and/or pedestrian and/or suspension bridges may be required for access across narrow sections of the reservoir, and near its upstream limits where heavy sedimentation may be expected.

6.5.10 Patterns of Mobility and Navigation (roads and river crossing)

River crossing at Border construction site may not be possible when construction begins. It is estimated that about 30 people and 10 animals are crossing the river by traditional boat (feluco) at or near the dam site. About three boats are giving daily ferry services. Traditional ferry crossings near the dam site may not be possible for the whole of the main construction period. If other means of crossing the river become available, to mitigate this difficulty, feluko operators will lose income. We have assessed the annual lost income at ETB 211,700/year (Table 6.10).

Table 6.10 : Compensation for Ferrymen's Income

Ferry	Annual lost income ETB/year	10 years compensation ETB
Passengers and livestock	211,700	2,117,000

Felukos are used elsewhere also. Discussions with local people indicated that felukos are used at about five sections along the main Abbay river where river sections are wider and free of rock outcrops. It could not be estimated which of these crossing sections would be in the reservoir's dead storage zone (i.e. permanently flooded after first filling) or further upstream. Compensation for these has not been assessed for this scoping study but the point is noted for future reference.

Mitigation

During the project construction period, river crossing near the dam site using traditional means may not be possible. Local people may be restricted from using project bridges, at least in the early years of construction. Alternative river crossing facilities should be provided.

6.5.11 Resettlement

An estimated 28 sub-kebele communities with a total of 13,905 people and their properties, including farmlands, will be affected by first filling of Border reservoir. Some of these will be affected by cofferdam pool after the second year of construction. The number of PAPs is roughly estimated for current conditions (2007). The number may be expected to increase in line with population growth generally in the affected woredas.

Some resettlement may be required in association with transmission lines in Ethiopia and Sudan. Normally, this involves moving houses a relatively short distance from tower construction sites and the ROW.

Mitigation

Resettlement is required during the construction phase of the project and requires staged completion before the cofferdam pool is created and before first filling. The people shall be moved out and resettled elsewhere in the vicinity and compensation shall be paid for properties and incomes lost as a result of the project.

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. However, as probably the best land in the area is already cultivated and will be flooded by the project, resettlement sites may be associated with poorer soils and poorer accessibility to permanent water supplies.

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 to cover the construction period, with sequential movements of resettlers before cofferdam and first filling impoundments and before transmission line construction. RAP should also cover monitoring and management during the operational period.

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 in the project area are supplemented by uses of natural resources in the project area. These mainly include collection of gold, wild fruits, fish and possibly hunting wild animals. These activities (except gold and incense) are mainly meant for family consumption and generate income in rare cases. In all cases, resources are utilized through very primitive and traditional means. Estimates of the quantities and values of resources lost because of the Border reservoir project are given in Table 6.11. This assessment was made in consultation with woreda staff and local people.

In the case of gold collection from riverbeds and alluvial deposits, it is reported that the majority of the affected communities and many more in the project woredas are involved. Gold panning activities around construction sites will be affected as soon as construction begins. In the rest of the area, it will cease when reservoir impoundment occurs.

It is recorded that the Consultant's geologist, who spent considerable time in the field at and around Border dam site, and upstream at Mandaya, remains sceptical, even disbelieving, about the local administration's estimate of the quantity of gold collection – 180 kg/year on average. In adopting this quantity, which accounts for more than 90% of the value of utilized natural resources, we are faithful to what was reported but note that rigorous review in any future study may significantly adjust this average annual figure.

Fish and other aquatic animals are sensitive to construction noise and vibration and may be adversely affected by these and any water pollution during the construction phase. Based on the minimal rate of fish catching observed during the field visit, any adverse impacts on fish availability during project construction before cofferdam impoundment and reservoir first filling are expected to be insignificant. However, before reservoir impoundment takes place, resettlement will have occurred. Thus following resettlement, some resettled communities may be distant from the reservoir and unable to benefit from fishing.

The number of fish consumed is estimated at 10 fish per month per family. This is based on discussions held with some residents of the project area. Hence the current total monetary value of consumed fish in one year by 2,781 families is calculated to be ETB 1,001,160. All quantities of currently used natural resources are based on discussions with the communities.

Table 6.11 : Compensation for Natural Resources

No.	Natural Resource	Unit	Unit Cost ETB	Quantity	Total Cost ETB/YR	Compensation 10 Yrs (ETB)
1	Gold	g	120	180,000	21,600,000	216,000,000
2	Fish	No	3	333,720	1,001,160	10,011,600
3	Wild fruit	Sac	413	560	231,280	2,312,800
4	Incense	Kg	150	1,463	219,450	2,194,500
5	Honey	Kg	10	1,500	15,000	150,000
6	Hunting	No	100	5,562	556,200	5,562,000
Total					23,623,090	236,230,900

Source: Study team group discussion

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:

- 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 Border 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 Border 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 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.

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 6.12 provides a preliminary assessment of required infrastructure for social services for resettlement areas.

Table 6.12 : Proposed Social Services in Resettlement Areas

No.	Type of Social Service	Unit	Unit Cost	Quantity	ETB
1	Health Facility				
	Clinic	No.	4,482,945	3	13,448,835
	Health Post	No.	484,119	8	3,872,952
2	Schools	m^2	2,500	19,580	48,950,000
3	Water for Schools	No.	108,000	4	432,000
4	Water Schemes	No.	108,000	28	3,024,000
5	Latrine	No.	250	2,781	695,250
Total					70,423,037

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.

It may be noted that the estimated compensation for lost health posts, stations, centre and clinics in Table 6.4 should be available for investing in replacement health service facilities in addition to those proposed in Table 6.12.

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 Border area, the nearest supply being near Chagni. 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 Land and Other Resources Downstream of Border in Ethiopia

No significant negative impacts are expected on land in Ethiopia downstream of Border dam site during the construction period. The amount of recession agriculture and gold panning in this reach, which would be affected during and after Border reservoir impoundment, is thought to be very minor. There may be benefits for people in this area in terms of temporary employment at the project and through increased trading opportunities.

There would be various impacts if a project access road is required from Sudan to the Ethiopian border and onwards to Border dam site for delivering construction materials. Currently, this appears unlikely and is not included in the pre-feasibility engineering study report.

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 major 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 Border's case, this means people downstream of the dam for a short distance 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.

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 Border 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 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 Impacts

The physical impacts and timing of cofferdam impoundment and reservoir first filling are described in Section 6.2 and Table 6.2.

It has been noted that Border reservoir's storage capacity at FSL (13.3 billion m^3) is less than one third of the annual average flow at the site (48.7 billion m^3) and less than the average flow in the month of August (15.3 billion m^3) and that flows in most Augusts in the 50-year flow record could potentially fill the reservoir in a single month. Whilst detailed studies of first filling Border and impacts on Lake Nasser/Nubia levels and Aswan power generation have not been carried out, it is clear from this and from study of July and September flow records that first filling should be achieved rapidly, and almost certainly within two years, whilst making satisfactory releases downstream during the first filling period.

By retaining 5.4 billion m^3 at MOL, and then 13.3 billion m^3 at FSL, these volumes will necessarily reduce storage contents of Lake Nasser/Nubia by equivalent amounts. A reduction in level by 2 m is indicated. This reduction is fairly small in comparison with the estimated fall of about 7, 12 or 18 m in Lake Nasser/Nubia when Mandaya is first filled, and the impacts of Border on Lake Nasser/Nubia will be correspondingly very much smaller. Nevertheless, changes in the harsh desert environment around Lake Nasser/Nubia, even small changes, may have significant impacts on the socio-economy of the area even if the changes are small. For this reason, and although impacts are not expected to be major, observations are made about potential impacts on fish and fisheries, agriculture, settlements, navigation and employment in following sections.

In practice, one or more sets of downstream release regimes (or formulae for calculating downstream release regimes) may be developed for first filling at Border, all being agreed by Ethiopia, Sudan and Egypt. This agreed flexibility would provide agreed contingency plans for extreme hydrological conditions pertaining during first filling. For example, in the event of the preferred agreed downstream release regime being unsatisfactory in practice, a previously agreed contingency plan 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 people in Egypt. In such a case, greater releases would be made from Border and the delay in completing first filling and bringing on full power generation at Border 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. However, as stated earlier, in Border's case the storage capacity is relatively small and it is thought that only an extremely dry sequence would give rise to a serious delay in filling.

In all of these considerations, it needs to be always recalled that "Border'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 Border, 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 operation in relation to the sequence of construction and filling of all the potential reservoirs (Karadobi, Beko Abo, Mandaya and Border).

It is also noted here that although this assessment is about the impacts of developing the Border project, parallel planning studies (Module 6) indicate that Border may not be the first development in a hydropower cascade on the Abbay river. If this were the case in practice, Border's downstream water resources impacts would be quantitatively different from those described here. This is because the Border project would be receiving regulated flows from Mandaya and/or Karadobi during construction.

Mitigation

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 included in the project's EMP and incorporated in the Owner's requirements.

6.6.3 Water Quality Impacts

There is insufficient data available on Abbay water quality, soils and residual biomass in the Border reservoir area (574 km^2) to assess impacts on water quality from the time of cofferdam impoundment and after 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 with cofferdam impoundment and 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 Border 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 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 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 Border, 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, Border reservoir will inundate an area of 574 km^2 including a long length of the Abbay river channel and shorter lengths of tributaries. All of these lengths of river contain alluvial gold, and therefore this renewable resource will be lost to the people living in adjacent areas and downstream as far as Roseires reservoir. It is assumed that that Roseires is the downstream limit of this impact because Roseires dam itself will have had the same impact.

Mitigation

Compensation may be required for any communities engaged in gold panning along the Blue Nile in Sudan between El Deim and Roseires. This needs to be addressed in future studies. However, if Roseires dam has been raised before Border is constructed, any loss of gold panning resources in this reach in Sudan will have already occurred by the Roseires impoundment and compensation will not be required from the Border project.

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 Border 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 Border dam and at structures in Sudan downstream.

Mitigation

Border reservoir basin clearance needs to be effective. This aspect relating to dealing with additional trash at Border, and at Sudan's river structures, from Border'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.

During the first impoundment of Border 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 Border reservoir reach), it is clear that the Border 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 Border dam site as part of their life cycle. Impacts on Roseires fisheries and dependent livelihoods cannot therefore be assessed.

During first filling of Border, the Nile's normal annual flood and its normal sediment load will reduced at Lake Nasser/Nubia. By storing water in Border during first filling, the water stored upstream cannot sustain Lake Nasser/Nubia levels as before and a fall in lake level by some 2 m has been indicated. Thus, during first filling of Border, a smaller lake surface area and reduced sediment loads will occur at Lake Nasser/Nubia. 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 Border release and the annual floodwater of Rahad, Dinder and Atbara rivers.

Lake Nasser/Nubia has experienced lower levels 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 Border'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 Border 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 Border 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 Border 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 Border 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. 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 observations on and compensation for the route from Border to Hasaheisa/Rabak are included. An additional feature relating specifically to a part of the transmission line route in Sudan is made here.

In the Damazin area, resettlement commenced with the construction of Roseires reservoir. In the EIA report prepared for the subsequent heightening of the Roseires dam, some 54 villages (total of 58,804 persons) were assessed for further resettlement (Gaafer, Karrar, et.al., 1994). On the east bank of the Roseires reservoir (on which the Border to Hasaheisa transmission line may impinge), there are approximately 20 settlements, comprising a total population of 33,524 persons. The

EIA report recommends that attempts be made to relocate communities within their homestead areas, and in so doing, to improve standards in housing and community services. This was particularly important as most villages do not have piped water or electricity (Gaafar, Karrar et.al., 1992). Given the resettlement history of the area, as well as the impact of conflicts on population dispersal and local levels of service delivery, it is important that consideration be made by the transmission line project to ways in which it may minimize impact on PAPs and provide tangible benefits to local infrastructure. This was the position in 1994.

Roseires dam has not subsequently been raised. Work on this started but was subsequently curtailed. It is understood that Roseires will now be raised in the near future. Thus detailed selection of the Border transmission line route will need to take into account the new full supply level and extent of Roseires reservoir and the Roseires project's resettlement program.

Mitigation

For estimating compensation, we have adopted 50% of the line length at the high and low rates respectively. 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 Border switchyard to Hasaheisa/Rabak are given in Table 6.7.

Detailed surveys are required including bird habitats, raptors, water birds and flyways. The direct route closely follows the Blue Nile and parallel right bank tributary areas with maya'as in one reach, and there may be a strong engineering and environmental case to avoid passing through maya'as and an environmental case to keep a good distance from the main and tributary rivers. Alternative routes are available but without making alternative routes excessively long, it is difficult if not impossible to completely avoid irrigated land, maya'as and running parallel with rivers.

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 Border to Sudan transmission line.

6.6.9 Irrigation

During first-filling of Border 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.

Border's first filling, which may cause Lake Nasser/Nubia water levels to drop by about 2 m, may 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 Border's first filling, operational costs for pumping through greater lifts may be expected to increase.

Mitigation

As mentioned earlier, Border's storage capacity is relatively small compared to mean annual flow and first filling may be achieved rapidly whilst maintaining sufficient supplies downstream. A fully developed and agreed programme for reservoir first filling is required 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 Border begins. This is a very major undertaking requiring detailed studies (Chapter 7). Failure to provide mitigation could result in hunger and increased poverty on significant scale in some years, 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 may 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 Border'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

Border's first filling, depending on inflow sequences at the time, may cause Lake Nasser/Nubia water levels to drop by some 2 m. 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 Border'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 transmission lines will create temporary employment opportunities. When construction finishes, temporary workers will be laid off.

With regard to the anticipated 2 m fall in Lake Nasser/Nubia water levels during Border'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 Border'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 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 Border. 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.

"Border'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 line, 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 6.3 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 Border's case, this means people downstream of the dam for a short distance 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 Border 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 dam in the world 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 Border 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 Border area at the beginning of the operations phase.

Section 7.2 introduces the principal hydrological impacts of the operation of Border 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 Border region respectively – the direct impact zone.

Section 7.5 considers operational impacts in Sudan and Egypt – the secondary impact zone.

7.1 SITUATION AT BEGINNING OF OPERATION PHASE

Major impacts and mitigation measures for the 6-year construction period have been scoped in Chapter 6. This has included the time when turbines are tested and the power station is commissioned up until Border reservoir is at or near full capacity, with its full water surface area, and 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 contractor's mitigation and enhancement measures have been implemented and completed. Also, the resettled communities will have been living at their new village sites for some four years.

A small town will have become established at Border, with former senior staff houses built for the construction period now being occupied by operational staff. Shops, restaurants, one or more clubs or hotels, 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. Modern communication facilities will exist, providing telephone, internet and TV services to this former remote area.

Importantly, a bridge across Abbay will now be in use, linking Sirba Abbay and Guba woredas. Depending on project arrangements, it may be reasonably assumed that if a road link from Border bridge to Asosa has not already been established by project or other contractors (whether or not needed for the hydropower project construction), regional government will be pressing for this road to be constructed in order to take advantage of Border bridge for joining the region together and promoting social services and economic development throughout the whole Benishangul Gumuz region[1]. Thus Border town will assume increasing importance as a route centre and may grow rapidly.

Because the Border 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 and developed between Border/Mankush and Roseires, and that greater use will be made of the Ethiopia/Sudan border crossing with modern customs and immigration facilities being established by both countries. It is believed that this road link will be needed for the close cross-border collaboration required between the Border project and Sudan's government departments and utilities for management of technical interactions concerning flood forecasting and flood warning, regulation releases, opening and closing spillway gates, river gauging, water quality monitoring, fisheries development and the interconnecting transmission line. Indeed, although telecommunications can and will provide routine links, it appears essential that managers, and technical and environmental staff of Border 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 Border 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 Border town may be, we may consider the principal environmental and social issues relating to the Border project in the operational phase.

By taking the time when Border reservoir first fills 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.

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.

[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.

7.2 HYDROLOGICAL IMPACTS

The primary operational impacts on environment of the Border 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.

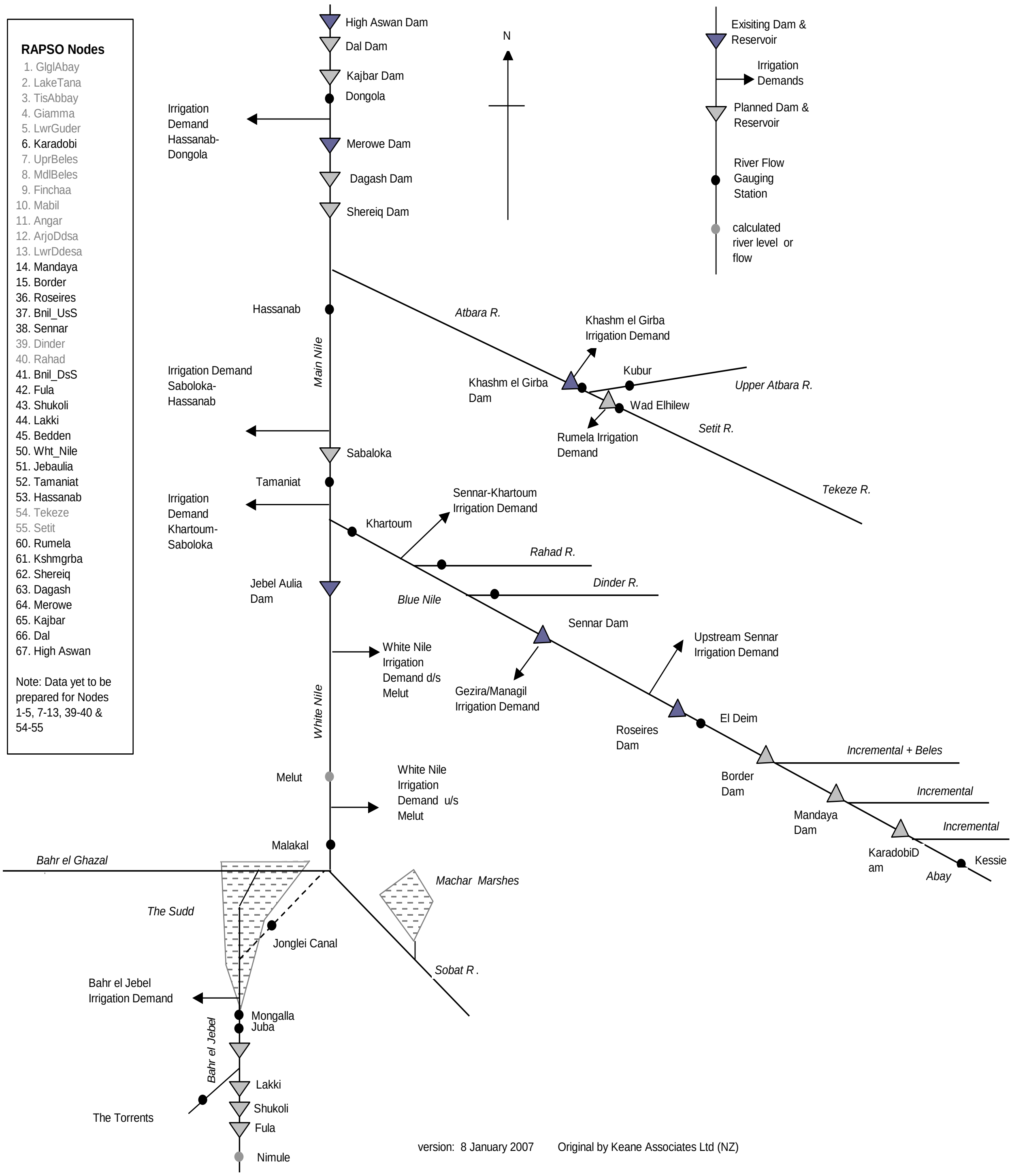


Figure 7.1 : Abbay and Nile system as modelled with program RAPSO

It is repeated here that dimensions of the Border 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 : Border 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)	580	574	13.3
Minimum Operating Level (MOL)	560	288	5.4
Difference between FSL and MOL	20	286	7.9

7.2.1 Summary of Simulations of Reservoir and Power Plant (1,200 MW) Operation

It may be seen that reservoir level vertical range is 20 metres. The reservoir surface area at FSL is 574 km^2. At MOL (the area permanently inundated) the surface area is 285 km^2. The operational surface area, which is variously inundated and exposed to air, is 286 km^2. In Border's case therefore the water surface area at FSL is double the area at MOL.

A 10-day inflow database was used for Border 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 some two thirds of flows are used in power generation and about one third discharge through the spillway. A relatively small quantity of water (1%) is lost to evaporation.

Table 7.2 : Border Reservoir 50 year Water Balance

Water balance component	Quantity m^3/s	Proportion of mean annual inflow %
Mean Annual Inflow	1,545	100
Turbined flow Spillway flow Total Downstream Flow	1,053 475 1,528	68 31 99
Evaporation losses	16.4	1
Mean of all outflows	1,545	100

Source: reservoir behaviour simulations, this study

7.2.2 Flood Flows

The annual frequencies with which Border 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 50 years out of 50. Border reservoir fills every year.	Spillway peak flows occur from 0 to 30 days later than natural flood peak.
Years in which peak 10-day flood flows are reduced downstream	In 27 of 50 years peak flood flows are reduced by 100 m^3/s or more (range 102 to 2,155 m^3/s). In other 23 years, essentially no difference.	

In about half of the years (27 of 50 years), downstream peak flood flows (for 10-day periods, not instantaneous floods) are reduced by between 102 and 2,155 m^3/s. In every case, there is between a 10-day and 30-day lag time between the peak of the natural flood and the peak of the regulated flood (Table 7.4).

In about half of the years (the 23 other years), there is no significant, indeed no reduction in peak flood flows and regulated peak flows occur in the same 10-day period as natural flood peaks (Table 7.4). This is because Border reservoir has a relatively small storage capacity compared to the mean annual flow, refills rapidly and is on these occasions already full to capacity when Abbay's peak flood arrives. (The very slight increase in flood flows in many of these years (typically 26 m^3/s, in August) is attributed to net evaporation being set at –122 mm/month (the negative sign reflecting more rainfall than evaporation). This additional water is discharged through the spillway. This is insignificant and need not detain us.

Table 7.4 : Annual maximum 10-day flood peaks at Border, natural and regulated (turbined plus spillway flows), lag times

Year	Month/ 10 day period (1,2 or 3)	Maximum Natural 10 day peak m3/s	Month/ 10 day period (1,2 or 3)	Maximum Regulated 10 day peak m3/s	Natural peak minus regulated m3/s	Lag in 10 day peak days
1954	8/3	7224	8/3	7249	-25	
1955	8/3	6535	8/3	6561	-26	
1956	8/3	6506	8/3	6532	-26	
1957	8/2	7164	8/3	6878	286	10

Year	Month/ 10 day period (1,2 or 3)	Maximum Natural 10 day peak m3/s	Month/ 10 day period (1,2 or 3)	Maximum Regulated 10 day peak m3/s	Natural peak minus regulated m3/s	Lag in 10 day peak days
1958	8/3	7788	8/3	7814	-26	
1959	8/3	7374	8/3	7400	-26	
1960	8/3	7182	8/3	7208	-26	
1961	8/3	7421	8/3	7447	-26	
1962	8/3	6376	8/3	6274	102	
1963	8/3	6809	8/3	6835	-26	
1964	8/3	7333	8/3	7359	-26	
1965	8/2	6046	8/3	5249	797	10
1966	8/3	5890	8/3	5916	-26	
1967	8/2	6123	8/3	5815	308	10
1968	8/1	6289	8/2	5931	358	10
1969	8/2	8123	8/2	8122	1	
1970	8/2	7600	8/3	6508	1092	10
1971	8/2	6968	8/3	5933	1035	10
1972	8/2	4742	9/2	2587	2155	30
1973	8/2	8108	8/3	6654	1454	10
1974	8/2	7048	8/2	7074	-26	
1975	8/2	7148	9/2	6722	426	30
1976	8/2	6050	8/3	5314	736	10
1977	8/2	6985	8/2	7011	-26	10
1978	8/2	5468	8/3	4939	529	10
1979	8/1	5351	8/3	4189	1162	20
1980	8/2	6132	8/3	5750	382	10
1981	8/3	5776	8/3	5802	-26	
1982	8/3	5340	9/1	3381	1959	10
1983	8/2	5716	8/3	5562	154	10
1984	8/1	4766	9/1	3072	1694	30
1985	9/1	6917	9/1	6910	7	
1986	8/1	4809	9/1	3851	958	30
1987	8/3	5029	9/1	2951	2078	10
1988	8/2	7656	8/2	7682	-26	
1989	8/3	6375	8/3	4966	1409	
1990	8/2	5909	8/3	4643	1266	10
1991	8/2	6092	8/3	5826	266	10
1992	8/3	5668	9/1	4607	1061	10
1993	8/1	6685	9/1	5951	734	30
1994	8/2	7649	8/2	7675	-26	
1995	8/1	5223	8/3	4905	318	20
1996	8/3	7197	8/3	7223	-26	
1997	8/2	5533	8/3	4635	898	10
1998	8/2	8432	8/2	8459	-27	
1999	8/2	7111	8/2	7137	-26	
2000	8/2	8323	8/3	7271	1052	10
2001	8/1	7949	8/2	7040	909	10
2002	8/1	5258	8/3	4276	982	20
2003	8/3	5914	8/3	5940	-26	
Count		**50**		**50**	**50**	
Mean		**6542**		**6021**	**521**	
Max		**8432**		**8459**	**2155**	
Min		**4742**		**2587**	**-27**	

Table 7.5 presents the same data as Table 7.4 but where the annual maximum 10-day flood natural peaks at Border 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. It is noted that the largest reductions in flow (12 No. are greater than 1,000 m^3/s) caused by the project are neither associated with the greatest nor lowest natural flood flows; the largest reductions occur across the range.

In the right hand column of Table 7.4, the differences between annual maximum 10-day flood natural peaks at Border and corresponding regulated peaks are ranked from largest to smallest.

Table 7.5 : Ranked annual maximum 10-day flood peaks at Border, corresponding regulated peaks, differences and ranked differences

Rank No.	Maximum Natural 10 day peak m3/s	Maximum Regulated 10 day peak m3/s	Natural peak minus regulated m3/s	Rank No.	Natural peak minus regulated m3/s
1	8432	8459	-27	1	2155
2	8323	7271	1052	2	2078
3	8123	8122	1	3	1959
4	8108	6654	1454	4	1694
5	7949	7040	909	5	1454
6	7788	7814	-26	6	1409
7	7656	7682	-26	7	1266
8	7649	7675	-26	8	1162
9	7600	6508	1092	9	1092
10	7421	7447	-26	10	1061
11	7374	7400	-26	11	1052
12	7333	7359	-26	12	1035
13	7224	7249	-25	13	982
14	7197	7223	-26	14	958
15	7182	7208	-26	15	909
16	7164	6878	286	16	898
17	7148	6722	426	17	797
18	7111	7137	-26	18	736
19	7048	7074	-26	19	734
20	6985	7011	-26	20	529
21	6968	5933	1035	21	426
22	6917	6910	7	22	382
23	6809	6835	-26	23	358
24	6685	5951	734	24	318
25	6535	6561	-26	25	308
26	6506	6532	-26	26	286
27	6376	6274	102	27	266
28	6375	4966	1409	28	154
29	6289	5931	358	29	102
30	6132	5750	382	30	7
31	6123	5815	308	31	1
32	6092	5826	266	32	-25
33	6050	5314	736	33	-26
34	6046	5249	797	34	-26
35	5914	5940	-26	35	-26
36	5909	4643	1266	36	-26
37	5890	5916	-26	37	-26

Rank No.	Maximum Natural 10 day peak m3/s	Maximum Regulated 10 day peak m3/s	Natural peak minus regulated m3/s	Rank No.	Natural peak minus regulated m3/s
38	5776	5802	-26	38	-26
39	5716	5562	154	39	-26
40	5668	4607	1061	40	-26
41	5533	4635	898	41	-26
42	5468	4939	529	42	-26
43	5351	4189	1162	43	-26
44	5340	3381	1959	44	-26
45	5258	4276	982	45	-26
46	5223	4905	318	46	-26
47	5029	2951	2078	47	-26
48	4809	3851	958	48	-26
49	4766	3072	1694	49	-26
50	4742	2587	2155	50	-27
Count	**50**	**50**	**50**		**50**
Mean	**6542**	**6021**	**521**		**521**
Max	**8432**	**8459**	**2155**		**2155**
Min	**4742**	**2587**	**-27**		**-27**

A typical 5-year period of operation of the Border project as simulated by RAPSO is illustrated in Figure 7.2. 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, in and around the month of August.

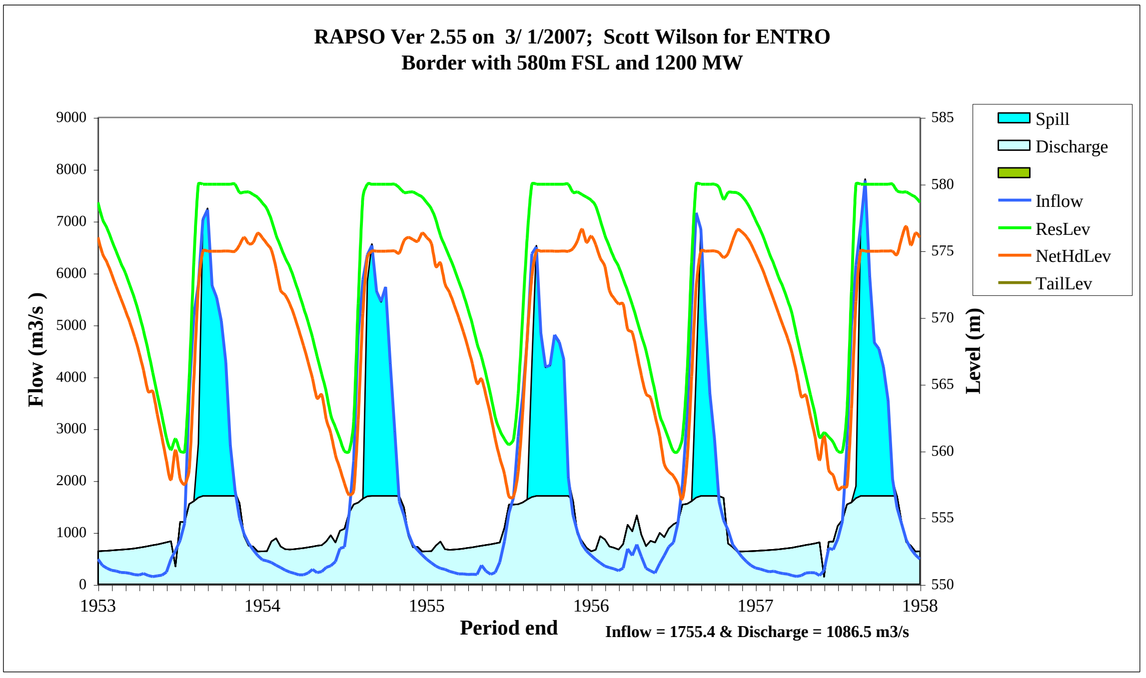


Figure 7.2 : Border hydropower project simulation, 1954 – 1958

In all years, the total regulated peak discharge (turbined flow plus spillway flow) in the 50 years series, the maximum turbined flow comprises 1,706 m^3/s of the total peak flow. The remaining passes through the spillway.

In all years, Border reservoir gains in level from the time when Abbay flood flows begin to arrive (usually in May/June) until the reservoir attains full capacity. As Abbay flood flows begin to arrive, power generation steps up quickly from its normal dry season firm generation of 452 MW up to the maximum turbined discharge of 1,706 m^3/s for six units giving 1,200 MW.

The annual reservoir refilling period typically occurs between early June and the last 10 days of August. It is this annual refilling period, on the rising limb of the annual flood, when downstream flood flows will always be reduced. This is shown as the uncoloured wedge under the inflow hydrograph.

7.2.3 Low Flows

The annual frequency with which Border reservoir is fully drawndown and the periods when downstream flows are reduced to prescribed flows are shown in Table 7.6.

Table 7.6 : 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 in at least one 10-day period	MOL is reached in 50 years out of 50.	Border reservoirs draws down every year from FSL to MOL, exposing an area of 289 km^2 .

Figure 7.2 shows how turbined regulation releases generally exceed natural inflows in the dry season. However, on rare occasions turbined flows are equal to or less than natural flows towards the end of the dry season. In order to provide a protected or “hands off” flow, minimum flow releases are prescribed in the model (Table 7.7).

Table 7.7 : 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)	**150**	**150**	**150**	**150**	**150**	**150**	**300**	**1500**	**450**	**300**	**150**	**150**
Minimum natural inflow (m^3/s)	200	152	141	144	182	369	1575	3962	2481	960	457	285
Mean natural inflow (m^3/s)	324	239	217	218	295	696	2696	5808	4290	2238	902	495
Mean regulated downstream flow - turbined flow plus spillway flow) (m^3/s)	706	683	711	753	752	921	1497	4097	4283	2276	937	674
Mean regulated downstream flow minus mean natural inflow (m^3/s)	382	444	494	535	457	225	-1199	-1711	-7	38	35	179
(10-day Period) / month / year when prescribed minimum condition occurs in 50 year simulation	none	none	none	(3)/4/85	(3)/5/58 (2)/5/70 (3)/5/71 (3)/5/73 (3)/5/80 (3)/5/82 (2)/5/83 (3)/5/84 (1)/5/85 (2)/5/85 (3)/5/85 (1)/5/87 (2)/5/87 (2)/5/88 (3)/5/91 (3)/5/03	(1)/6/70 (1)/6/75 (1)/6/80 (1)/6/82 (1)/6/83 (1)/6/84 (1)/6/88 (1)/6/90 (2)/6/90 (1)/6/91 (1)/6/92 (1)/6/95	none	none	none	none	none	none
No.of 10-day periods when prescribed flow condition occurs	0	0	0	1	16	12	0	0	0	0	0	0
No.of years when prescribed flow condition occurs	0	0	0	1	13	11	0	0	0	0	0	0

The frequencies with which these prescribed minimum releases occur are zero in nine months of the year (July through to March). They are not called in the simulation.

They are required once in 50 months of April (for three consecutive 10-day periods in 1985), 13 times in 50 months of May (for 16 No. 10-day periods) and 11 times in 50 months of June (for 12 No. 10-day periods) (Table 7.7). On these 29 occasions, 150 m^3/s are released through turbines, typically generating 70 MW – the minimum power output in the record.

The longest continuous sequence of release of prescribed flows (150 m^3/s) is in 1985, when they begin in the last 10 days of April and continue throughout May.

There are seven other occasions in the record when releases are greater than the prescribed minimum flows but lower than normal, making up the 36 occasions (2%) in 1,800 10-day periods when energy shortfalls occur. Conversely, in 98% of time firm energy is reliable.

The regular, year-by-year, uplift in low flows in the dry season (on average raised by 400 to 500 m^3/s from January to May, Table 7.7) 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 (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 extreme low flows (in one April, 13 months of May and 11 months of June (see above) occur in a limited period of the year, and not in most years, 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 Border. These reservoirs are expected to operate at full supply level most of the time, giving maximum power output. On the few occasions when Border 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 Border 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 Border project improving downstream low flow conditions for most of record, and releases from Roseires' storage assisting irrigation supplies downstream in those Aprils, Mays and Junes when Border 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 Border project's management, woreda administrations and regional government headquarters in Asosa.

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 Border'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

Border'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 Border 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.

The Border river gauging station downstream of Border dam site currently requires rehabilitation and calibration. During the operational period, regular monitoring work at the station will be facilitated by good accommodation for Ministry hydrologists being available at the Border project's accommodation. 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 Border dam (at the resuscitated gauging station) will also be required by agencies implementing the Abbay watershed management program.

The need for laboratory facilities at Border 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 operation 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

Border's gross storage volume (13.3 billion m^3) is subject to siltation. The rate of this is unknown, sediment sampling at Border and El Deim gauging stations downstream of Border being inadequate to provide an up-to-date assessment. The current estimate of 318 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 Border 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 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 Border 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 60 years and 130 years are indicated, adopting a settled density of 1.4 tons per m^3.

The impact of reservoir sedimentation on Border'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

Border'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 Border'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 Border'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 agreed 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 Border 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 Border 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 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

Slope failures may be expected in the project area. Some susceptible areas will have been noted 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. Once established after first filling, they will fluctuate according to rainfall received and in part according to the 20 m range in Border 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 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 Border 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 Border reservoir and its tributaries, and that these will be coordinated with aquatic surveys in 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 Border 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 Border 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 Border 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 each year below Border's spillway, and rarely at the Border tailrace. Typically, numerous fish may be netted when spillway gates close at the end of the wet season 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 Border's development, continuing close liaison is expected to continue in the operational phase, including jointly conducted surveys and exchange of data between Border and Roseires reservoir managers.

7.4 SOCIO-ECONOMIC IMPACTS IN OPERATION PHASE

As stated earlier, by taking the time when Border 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 four years). A small town will have become established at Border and, as anticipated earlier, a bridge across Abbay will now be in use, linking Sirba Abbay and Guba woredas providing the possibility of promoting social services and economic development throughout the whole 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 Border'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 Border 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 Border reservoir behaviour and the 1,200 MW installed capacity of the power plant over a 50-year period, giving a reliable firm annual energy generation of 3,966 GWh, and average annual energy (reliable firm energy plus discretionary or dump energy) of 6,011 GWh/year. Summary simulation results are presented in Table 7.8 for the Border base case (as a stand-alone project), and for four 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

Full Supply Level masl	Installed Capacity MW	Firm Energy GWh/year	Average Energy GWh/year	Development scenario
575.5	1400	2593	5969	As USBR
575.5	1400	4984	7384	As USBR, with Karadobi
580	**1200**	**3966**	**6011**	**Border as a "stand-alone" project**
580	1200	6192	7278	With Karadobi
580	1200	7429	8114	With Karadobi and with Mandaya (FSL 800 masl)

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 may be gained by considering that the annual sale of firm energy alone at US cents 4 per KWh implies sales worth some USD 158 million/year.

The generated energy will be transmitted to the Ethiopian grid at 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

No involuntary resettlement scheme has ever been perfectly implemented. For Border's resettlers (currently estimated at 13,905) 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 (Border) 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 and therefore three woreda administrations. 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.

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, government, 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 Border 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 Border, with well-devised procedures involving stakeholders (possibly through a Trust Fund, with banking facilities at Asosa or Border 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 government 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 Border reservoir in the neighbourhood will inevitably raise questions about utilizing water from it for irrigation around the reservoir’s margins. Indeed, some may request provision be made for gravity fed or pumped irrigation downstream of Border 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. With regard to irrigation around the margins of the reservoir, assuming for the moment that the soils may be suitable or with treatment may become suitable, it must be noted that the range in operating levels is 20 metres, implying increasing pumping heads and longer suction/delivery pipes as reservoir levels recede. Also, the geology of the surrounding area is not considered to have significant aquifers which might be annually recharged or otherwise be favourably affected by the Border reservoir impoundment, and provide substantial water supplies for irrigation distant from the reservoir. However, with good monitoring, as recommended earlier, some areas of groundwater may be found suitable for domestic supplies and for limited irrigation.

7.4.6 Access across Border Reservoir

As foreseen in the construction impacts, ferries and footbridges (across narrowest sections of the reservoir) are expected to be required. Ferries will have to operate over an annual range of levels of 20 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, Border reservoir may offer sustainable employment and fish related commerce 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 Border 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 4.10 – 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 Border 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 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 Chagni and Asosa.

In the case of Border, where a lot of land (574 km^2) 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 region in general. This is scoped here as a major issue for the project promoters and Benishangul Gumuz government.

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 1200 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 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 Border 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 OPERATION PHASE IMPACTS IN SUDAN AND EGYPT

7.5.1 Electricity Supplies from Border project

The primary purpose of the Border 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 alone at US cents 4 per KWh implies sales worth some USD 158 million/year. It is planned for Border 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 Border high voltage supply to Sudan is not suitable for this.

7.5.2 Electricity Supply Uplifts in Sudan

River regulation by Border reservoir operations will increase dry season flows from Border tailrace to High Aswan Dam. The regular, year-by-year, uplift in low flows in the dry season (on average raised by 400 to 500 m^3/s from January to May, Table 7.7) 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 Border project on generation at existing hydropower projects in Sudan have been estimated by comparing the regulated downstream flows of the Mandaya and Border projects of approximately 840 m^3/s and 630 m^3/s respectively. It is estimated that the uplift due to Border project would be as indicated in Table 7.9.

Table 7.9 : Uplift in Generation at Sudan Hydropower Projects due to Border

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 Border, with Roseires flushing operation	1966	443	6173	8582	942
With Border, without Roseires flushing operation	2087	466	6745	9298	1658
With Border, with Roseires MOL raised to El. 471 and 3 x 45 MW extension	2421	466	6745	9632	1992

The potential sale value of the electricity generated may be gained by considering the case without Roseires flushing operations following construction of Border. The annual sale of the uplift of energy at US cents 4 per KWh implies sales worth some USD 37 million/year.

7.5.3 River Hydraulics

Substantial changes to river morphology may be expected in Sudan in Border's operational phase. This is demonstrated by the change in flow regime (Tables 7.4, 7.5 and 7.7). The normally expected rise in water levels will not occur when Border is refilling each year; then the full force of the peak discharge will occur in a very short time (as Border spillway gates are opened), without the normal preceding build up of the rising limb of the flood hydrograph. Once Border is spilling, flood flows will be received as before, but with much less sediment. When the Border spillway gates are finally closed each year, dry season flows will be much greater than prior to regulation. The operation of Roseires reservoir may adjust Border's releases to some extent.

Changes to river morphology are expected to be initiated during periods of spillway discharges. As mentioned, the "new" rising limb of the flood hydrograph will be steeper than has occurred before, and the floodwater will be completely free of bedload and virtually free of medium-sized and coarse suspended sediment. In about 50% of years, the peak discharge will not be noticeably reduced but will arrive downstream with greater ability to erode bed and channel banks. In some of the other years, the peak discharge will be noticeably reduced.

The current rates of sediment transport are unknown because comprehensive suspended sediment sampling has not been carried out at the Border or El Deim river gauging stations for more than 30 years. Whether we adopt an earlier estimate of 140 Mt/year or 318 Mt/year, the estimate put forward in this study, 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.

7.5.4 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 Border's operational phase (Tables 7.4, 7.5 and 7.7) 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 Border 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 7.7, when Border 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 Border, 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 Border and Roseires, and Roseires reservoir fisheries, is related to those relatively rare occasions when Border cannot sustain its normal releases of turbined flows at the end of some dry seasons (Table 7.7) and only prescribed flow releases are made. On these occasions, assuming Roseires is used conjunctively with Border, Roseires reservoir will be drawn down, receiving water from Border which may be of poor water quality.

Thus, attention is drawn again to the Border project improving downstream low flow conditions for most of the time but aggravating conditions in some Aprils, Mays and Junes. The prescribed flows and conjunctive use of these reservoirs is an area that requires much more attention in future studies.

7.5.5 Irrigation along Blue Nile and Main Nile in Sudan

By the same means, the increase in dry season flows from Border tailrace to High Aswan Dam will increase dry season water availability at existing and new offtakes for public water supply and irrigation (Table 7.7). 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 Border 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 Border 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.

7.5.6 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 Border and Mandaya hydropower projects 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 mattaras adjacent to the floodplain, supply in 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 Border.

In making this comparison, the working assumption is made that the annual (10-day) peaks of Border 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 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 Border on Flood Control Levels

	Flood Level (m) and colour code			Border Flow Reduction m^3/s	Border Impact
	Khartoum	Shendi	Dongola		
1988	16.94	18	**15.69**	0	No change
1989	16.04	17.07	**14.15**	1409	**Reduction**
1990	15.20	16.5	**13.6**	1266	**Reduction**
1991	16.14	17.22	**14.72**	266	Minor
992	16.05	16.98	**14.64**	1061	**Reduction**
1993	16.53	17.59	**14.76**	734	Minor
1994	16.94	17.96	**15.69**	0	No change
1995	15.81	16.97	**14.74**	318	Minor
1996	16.67	17.72	**15.17**	0	No change
1997	15.97	16.85	**14.48**	898	Minor
1998	17.09	18.01	**15.91**	0	No change
1999	16.75	17.84	**15.72**	0	No change
2000	16.60	17.93	**15.37**	1052	**Reduction**
2001	16.74	17.85	**15.93**	909	Minor
2002	15.52	16.42	**14.44**	982	Minor
2003	16.38	17.4	**15.29**	0	No change

Flooding	Critical	Alert	Normal

In the 16 years with gauge height data provided by the Ministry for comparison, Border causes reductions in flooding of greater than 1,000 m^3/s (86.4 Mm^3/d) on four occasions. One of these four years produced a “Flooding” condition at Khartoum, Shendi and Dongola (2000) and the reduction would have been beneficial. In the other three years, “Critical” and ”Alert” occurred, and the reduction in flood discharges at Border would have reduced the spatial extent of flooding and silt deposition.

An indication of the reductions in flood levels for these four events may be estimated by reference to river gauging rating curves at Khartoum and Dongola (Table 7.12). These suggest that reductions of flood levels at Khartoum might be in the order of 0.89 to 1.26 m and at Dongola 0.48 to 0.79 m.

Table 7.12 : Changes in Annual Flood Levels at Khartoum and Dongola

Station	Year	Peak Level Gauge height	Peak Flow	Border Reduction in flow	Reduced Flow at station	Gauge height for reduced flow	Change in Gauge height
		m	Mm^3/d	Mm^3/d	Mm^3/d	m	m
Khartoum	1989	16.04	469	122	347	14.78	- 1.26
	1990	15.20	386	109	277	13.98	- 1.22
	1992	16.05	470	92	378	15.11	- 0.94
	2000	16.60	527	91	436	15.71	- 0.89
Dongola	1989	14.15	562	122	440	13.36	- 0.79
	1990	13.60	476	109	367	12.82	-0.78
	1992	14.64	645	92	553	14.09	- 0.55
	2000	15.37	781	91	690	14.89	- 0.48

Rating curves:

Khartoum: $Q = 20.96\,(G-8.8)^{1.57}$

Dongola: $Q = 7.20\,(G-6.7)^{2.17}$

Where Q is million cubic metres per day, and G is gauge height in metres

In the 12 other years in Table 7.11, Border impacts are described as “minor” (less than 1,000 m^3/s) for six years, and as not occurring for six years.

Impacts on Flooding of Property

The implications of this are mixed. On some occasions, “flooding” of properties will be relieved and this will be valuable. However, this beneficial impact is rare. Border does not assist Khartoum in eight of the nine “flooding” events in the 16 years. Similarly, Border does not assist Dongola in six of the seven “flooding” events in the 16 years.

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 Border to a large extent. This is because the Border project cannot provide flood relief on a large scale and regularly as a multipurpose benefit.

Impacts on Recession agriculture and wetlands

With regard to recession agriculture and wetland areas along the Blue and Main Nile, we may return to the 50-year database. In about half of the years (27 of 50 years), downstream peak flood flows (for 10-day periods, not instantaneous floods) are reduced by between 102 and 2,155 m^3/s. In every case, there is between a 10-day and 30-day lag time between the peak of the natural flood and the peak of the regulated flood (Table 7.4). In these years, farming on the flood recession will be affected to a greater or lesser extent. Irrigated farming will not be affected; indeed water levels will be raised in the dry season, thereby reducing pumping heads.

In about half of the years (the 23 other years), there is no significant, indeed no reduction in peak flood flows and regulated peak flows occur in the same 10-day period as natural flood peaks (Table 7.4). In these years, farming on the flood recession will not be adversely affected. Also, irrigated farming will not be adversely affected but benefit as in other years from reduced pumping heads.

The conclusion on this is that some farmers and communities dependent on recession agriculture will be worse off with the Border project in about half of the years, to a greater or lesser extent. Further studies would be required to determine the extent of these impacts but in general terms it appears clear that mitigation by pumping supplies would be required.

As described in Section 7.5.5, 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 Border.

There remains an undetermined amount of land which would be affected by reduced flooding caused by Border 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 7.13).

Table 7.13 : Irrigation Mitigation for Reduced Annual Flood

Nile reaches Ethiopian Border 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 Mm3/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 7.14 and 7.15.

Table 7.14 : 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 a unknown number of years.

Table 7.15 : Annual Energy Costs for Mitigation of Reduced Annual Flood

Annual Water Pumping Mm^3	Power required assuming 8 months, 26 d per month, 12 h per day, 5 m head, efficiency 70% MW	Energy required MWh	Cost USD per MWh USD	Energy cost per 1,000 Mm3 USD million	Energy cost for pumping 3,000 Mm^3 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 1% of the average annual energy generated at Border. 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 an upstream storage reduces owing to progressive siltation. The medium to long-term sustainability of the project therefore remains an important issue 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 the Abbay river catchment.

7.5.7 Reduction of Reservoir Siltation Rates in Sudan and Egypt

Estimates of the mean annual total sediment load (suspended and bed loads) of Abbay at Border dam site are very uncertain. They may be between 140 and 318 million tonnes per 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 Border 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.

Furthermore, additional future losses in Roseires and Sennar reservoir storage capacity should be reduced (though not curtailed completely). 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 Border 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 Border 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.

7.5.8 Reduction of Sediment Loads at Abstraction Locations and Irrigation Canals

Storage of all bed load, and much of the suspended sediment load in Border 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 7.16).

Table 7.16 : 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 7.17. Total present value of these costs is USD 46.26 million.

Table 7.17 : 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 Border will benefit many users of the river.

7.5.9 Reduction of Sediment Loads and Use of Artificial Fertilizers

Storage of much of the Abbay's suspended sediment load in Border 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 Border 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 7.18).

Table 7.18 : Estimated Sediment Deposition along Blue and Main Nile

Location of Sedimentation in irrigation schemes and in river bed and alluvial plains downstream of Border (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

Location of Sedimentation in irrigation schemes and in river bed and alluvial plains downstream of Border (excluding reservoirs)	Annual Sediment deposition in million tons/year
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 4.10

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 Border’s sediment load will continue to arrive downstream.
- The 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 Border may be expected to re-mobilize and entrain bed and bank sediments in some alluvial reaches during spillway flood flows, 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.

7.5.10 River Crossings of Blue Nile

Border'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. Border 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.

An illustration of the change in river levels is made by reference to the rating curve for El Deim river gauging station (Table 7.19). This indicates that levels will increase by some 0.75 m and 1.11 m in January and April respectively, compared to long term average conditions. El Deim is not representative of much of the Blue Nile but these changes give some indication. Where a man can just wade across the river in safety at a favourable site will become impossible with such increases.

Table 7.19 : Increase in Blue Nile's Dry Season River Level with Border Regulation

Dry Season Month	Mean natural flow at El Deim	Natural river level at El Deim	Regulated Mean Flow at El Deim	Regulated river level at El Deim	Increase in river level
	m^3/s	m	m^3/s	m	m
January	324	7.17	706	7.92	0.75
April	218	6.88	753	7.99	1.11

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 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.

7.5.11 Evaporation and Water Supplies from High Aswan Dam

Mean evaporation at High Aswan Dam (HAD) has been historically estimated at 10 billion m^3/year (Nile Waters Agreement, 1959). 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 Border reservoir behaviour shows that some 0.52 billion m^3/year (16.4 m^3/s) evaporation losses would occur at Border 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 might occur because of Border 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 Border with a lower evaporation rate and a relatively small reservoir surface area.

Table 7.20 provides some comparative data for Border and HAD.

Table 7.20 : Comparison of Evaporation Losses at Border 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 Border[1] and adopting 10 BCM at Aswan BCM/year
Border FSL	580	574	1.0	0.57	-	0.52
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/ Border	-	x 9	x 2.5	x 22.7	-	x 19.2

Note[1] Evaporation from 1800 No. 10-day periods in 50 years RAPSO simulation (this study)

This potential trade-off in evaporation losses, although at the expense of some reduction in energy generation at HAD, is considered to be significant, converting evaporation losses into usable water supplies from the Main Nile and 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.

7.5.12 Lake Nasser/Nubia - Fisheries, Agriculture, Navigation

The first filling impacts of Border on fisheries, agriculture, settlements, navigation, employment and the economy around Lake Nasser/Nubia have been described in Chapter 6 in relation to the indicated 2 metre fall in lake level.

Because Border has a relatively small storage capacity and is expected to fill rapidly, no simulations have been carried out to indicate the impact on energy generation at Aswan during first filling scenarios and during the operational period. In these circumstances, in order to consider socio-economic impacts around Lake Nasser/Nubia in the operational period, after first filling at Border, it is reasonable to assume that the indicated first filling impacts will reduce as the lake level recovers.

As Border is drawn down to MOL every year, and spills every year, in the 50-year sequence (Section 7.2), according to the characteristics adopted in the simulation of Border, impacts on Lake Nasser/Nubia's levels, and on fisheries, agriculture, settlements, navigation, employment and the economy around Lake Nasser/Nubia, appear likely to be modest and regular. They require examination in future studies.

However, as parallel planning studies indicate that the development of Border is likely to follow Mandaya, the impacts of Border will need to be examined not in isolation but in the light of impacts of the developing hydropower cascade on the Abbay/Blue Nile including the raising of Roseires dam in Sudan.

7.6 SUMMARY OF BORDER'S PRINCIPAL IMPACTS AND MITIGATIONS

The major impacts of the Border project described in Chapters 6 and 7 are summarised in Table 7.21

Table 7.21 : Summary of Principal Project Impacts of Border Project

Positive Impacts	Principal Benefits	Negative Impacts	Mitigation measures
Ethiopia			
Border project	Border power generation, a major national energy benefit and increase in foreign exchange earnings	Involuntary resettlement	Resettlement and development program
Border project	Construction employment, new skills for the future	Loss of wildlife habitat and wildlife	New reservoir wetland and management of environmental offset(s)
Border project	New roads, Abbay bridge, promoting regional development	Loss of natural resources	Development of reservoir fisheries and
Border 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		
Regulated flows and reduced sediment	Incremental fisheries production		

Positive Impacts	Principal Benefits	Negative Impacts	Mitigation measures
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	Some 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	Reduction in Lake Nasser level Less energy at Aswan and Socio-economic (fisheries, agriculture, navigation) around lake	Compensation, or negotiate tariff for importing Border energy to compensate for foregone energy at Aswan Various, to be determined, and/or compensation
Regional			
Border project	Carbon emissions savings of some 210 million tonnes compared with equivalent thermal generation		

8. PROJECT ALTERNATIVES

8.1 PROJECT LOCATION

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

8.2 DAM ALIGNMENT

Within the Border dam site area, the topography and geology offer no alternative alignments. The dam alignment has been selected to be on sound foundations and to avoid outcrops of biotite schist/marble.

8.3 FULL SUPPLY LEVEL

The Full Supply Level (580 masl) is at or close to the maximum possible for the site. Higher levels would involve construction of saddle dams, and potentially an increase in resettlement, in reservoir evaporation, in river morphology changes and a decrease in frequency of "critical" and "alert" flood control levels in Sudan – levels which currently benefit farmers.

However, further study may reveal that the benefits of a slightly higher or even maximum possible Full Supply Level justify additional project costs. The benefits of additional storage capacity relate to increased power generation at Border and sustaining this longer, increased uplift in power generation at Roseires, Sennar and Merowe and sustaining this longer, increased dry season flow supplies for irrigation in Sudan (with higher river levels, reducing pumping costs) and sustaining these longer, extending the period of holding back sediment from the Blue Nile (with so many benefits) and reducing the frequency of "flooding" control levels in Sudan – levels which bring public health problems, urban flooding, disruption to infrastructure and services and major restoration and rehabilitation costs.

Because of Border site's relatively low evaporation rates, from a water resources/water supply point of view, any increase in evaporation should be more than counterbalanced by the potential additional saving in losses at High Aswan Dam.

The ultimate physical limit of FSL would be determined by not encroaching on Mandaya dam site, topography concerning saddle dams, and geology.

A lower FSL is possible. It would provide a smaller storage capacity, less firm energy generation at Border, 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. Topographical mapping is currently imprecise and insufficient to determine precisely the impacts on resettlement of a lower FSL.

8.4 MINIMUM OPERATING LEVEL

There are alternatives to the Minimum Operating Level of 560 masl. It could be higher or lower but would have to be within a sensible range (currently 20 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 Border. They have not been optimised.

Explicit conjunctive use studies of Border with these downstream reservoirs are required in future. These should ensure that Roseires can satisfy downstream irrigation demands by drawing on its own storage on those relatively rare occasions when Border 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 14,000 people, 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 number takes no account of population growth. 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 Border 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 selected routes (Border to Hasaheisa/Rabak, 440 km, and Border to Debre Markos, 380 km) are the shortest routes between Border switchyard and these sites which provide connection with national grids. The routes have been considered at desk level but, apart from in the Border area itself, not in the field. The routes require thorough studies and may require adjusting. A point about the construction track for the Border to Roseires section of the Border to Sudan route is made below.

8.9 MAIN CONSTRUCTION ROAD

The project currently considers that construction traffic will use the road route from Debre Markos-Chagni-Mankush (Guba) to Border, with sections of this road being upgraded. There is currently no alternative route accessing the Border dam site from the Asosa (south) side. In the early part of construction, a bridge across Abbay will be constructed downstream of the dam site. This will 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 Abbay bridge southwards to connect with the existing road network. Currently, this road link is not part of the Border project concept.

An alternative road development therefore arises. Future planning should consider the wisdom of constructing a new road from the south to the Abbay bridge site and using this as the main route for Border construction rather than the Debre Markos-Chagni-Mankush route. If the latter route is still selected, consideration should be given to constructing the southern 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.

This issue is in part also dependent on the sequence of construction of hydropower projects on the Abbay river, assuming a cascade development will take place in due course. For example, if Mandaya is constructed before Border, the southern road link to the Abbay bridge site at Border may be facilitated by Mandaya's road development from Mendi.

8.10 ETHIOPIA-SUDAN ROAD LINK

The report has drawn attention to the possibility and desirability of a future road link between Border and Roseires, although this road link is not proposed for project construction purposes. It has been noted that this link is desirable for local management and coordination of various surveys between Border and Roseires hydropower projects. This recognises that Border 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 Border-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. With this in mind, the detailed routing of the transmission line and its access track may be adjusted from the “minimum distance” route currently proposed.

8.11 WATERSHED MANAGEMENT

There is no alternative to implementing the developing watershed management proposals for the Abbay basin. It appears inconceivable that Border project can proceed without prior and continuing implementation of sustainable watershed management proposals.

8.12 “DO NOTHING” SCENARIO

If Border 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 BORDER

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 Water Resources and Irrigation (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 access 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	MIWR, 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 Border 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 Border and Roseires

There will be need for very close cooperation between managers at Border 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 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 Border 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

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 Border and Mandaya 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.

Some 13,900 people are estimated to be directly affected in the Border project area and about 600 people in the Mandaya 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 Organisational 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.

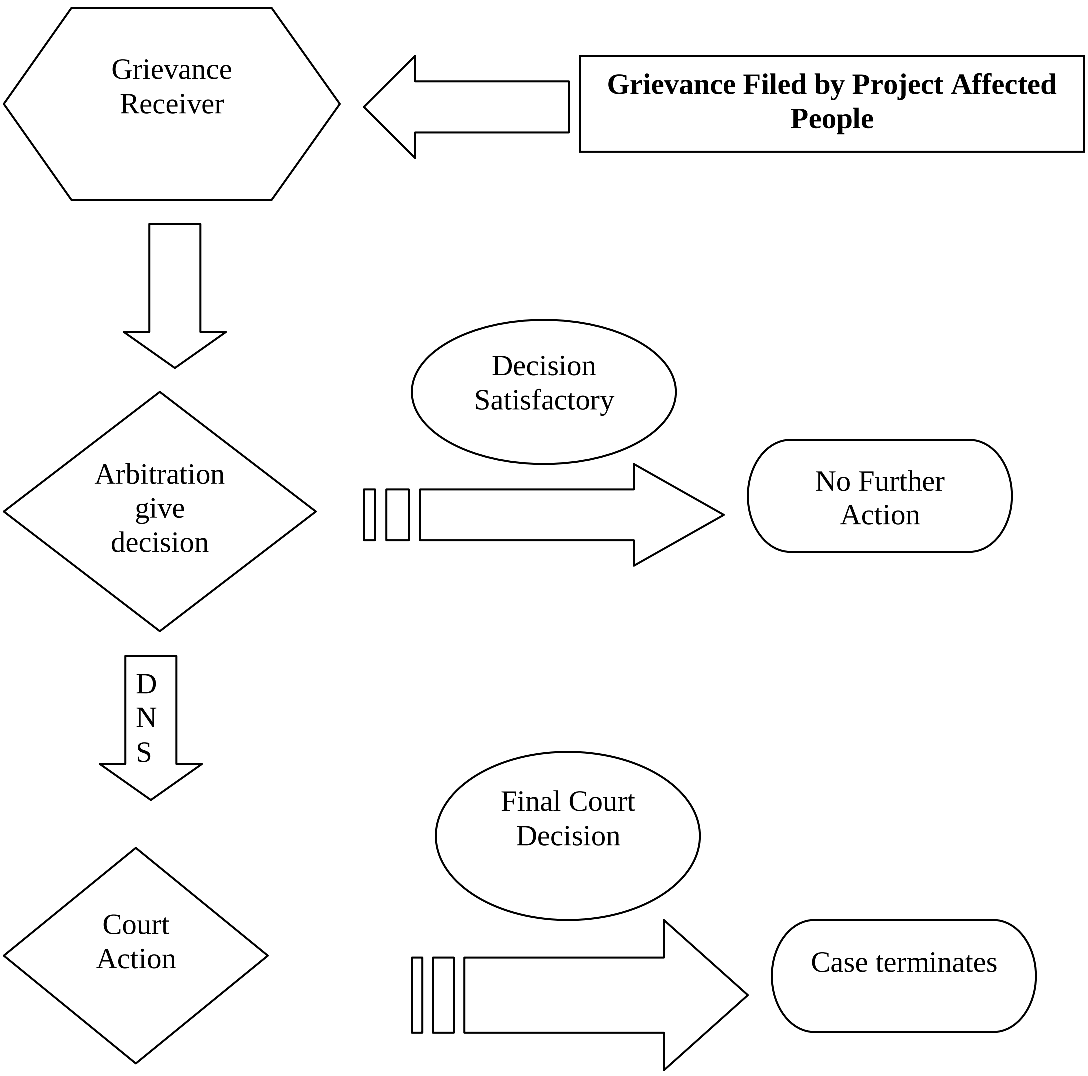
2. **Arbitration Committee:** The Arbitration Committee is next to the Grievance Receiver in the hierarchy to examine the grievance case. The committee members constitute the following.

   - 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 Border 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 Owner, 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 Owner, responsible for implementing mitigation works in relation to river morphology, river crossings and conversion of flood recession agriculture to pumped irrigation in Sudan (MIWR); 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 BORDER

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 Border dam site, and at access roads, quarries, borrow areas in relation to Border, 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 by measurements. 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 Border 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 Border and its impact on Roseires and further downstream. As mentioned earlier, decisions on future road communications between Border 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.

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 Border

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 • Exacavation 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 Border reservoir	▪ Observations, made by boat and land access
▪ New and existing springs, boreholes and shallow	▪ Levels and flows	▪ Around Border 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	▪ Border 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	▪ Border Dam and downstream	▪ Checking records of past operations; checking equipments and schemes are operational
▪ Border gauging station	▪ Water level , flow and sediment concentration	▪ Border gauging station	▪ Checking records of past monitoring; checking equipment is operational ▪ Continuing measurements and calibrations
▪ Border and Roseires reservoirs	▪ Full aquatic/limnological surveys – all hydro-biological aspects	▪ Border 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	▪ Border and Roseires reservoirs	▪ Surveys, synchronised if possible
▪ Reservoir sedimentation	▪ Hydrographic survey	▪ Border 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 Border project and Roseires reservoirs, contributing information to the power station management's department(s)	▪ exchange of data and information	▪ Border 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	▪ Border, 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 Border 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 Border 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 ETB and USD 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)

4) ***Compensation for Recession Agriculture:*** Compensation for lost production from recession agriculture (In addition to maize and sorghum, etc., vegetables, tobacco, and others)

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 (wild fruits, fish, gold panning and wild honey, etc.).

7) ***Feluco Transport:*** Compensation for lost income of Feluco operators (local ferrymen's income) for transporting people and animals across the river.

8) ***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 area.

9) ***Compensation for houses/assets:*** Cost of replacing houses/assets (store, schools, health facilities, etc.) lost in the reservoir area

10) ***Compensation for infrastructure:*** Compensation for loss of infrastructure: bridges, bailey bridges, ford and road.

11) ***Compensation of for loss of arable land in construction areas:*** Compensation for construction activities at access roads and working areas outside of the reservoir area.

12) ***Fisheries study/outreach program:*** Fisheries development outreach support (taking into account present and future fishery potential through study, training and capacity building)

13) ***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.

14) ***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)

15) ***Generic BMP 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)

16) ***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)

17) ***Water Quality Monitoring:*** Cost of checking water quality in the reservoir and downstream of the tailrace outlet, over and above the contractor's obligations.

18) ***Monitoring of Construction Work:*** Monitoring/auditing construction and adherence to the EMMPs. EMU.

19) ***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.

20) ***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 Authority of Benishangul Regional State).

21) ***Community Gain:*** Contribution to water supply, schools/education, veterinary services, etc to be decided by the resettled people from the direct impact zone.

22) **Cost 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).

23) **Transmission Lines**: Compensation for impacts of project transmission lines from Border to Debre Markos and Hasaheisa/Rabak.

Table 11.1 : Border Environmental Cost Estimate - ETB

No.	Item	Text Reference	Units	Quantity	Unit Cost ETB	Capital Cost (ETB)	Recurrent Cost Lump Sums (ETB) Constr. Phase	Recurrent Cost Lump Sums (ETB) Oper. Phase
1	Reservoir Clearing (included in Civil costs)	Table 6.3	ha	51,600	4,605	237,618,000		
2	Technical Environmental Optimization	See note	LS			1,800,000		
3	Compensation for annual crop	Table 6.8	ha	4,172	23,283.20	97,137,510		
4	Compensation for recession agriculture	Table 6.8	ha	2,400	27,015.00	64,836,000		
5	Compensation for grazing land	See note	LS			900,000		
6	Compensation for lost Natural Resources	Table 6.11	LS			236,230,900		
7	Income lost Feluco transporters	Table 6.10	Yr	10	211,700	2,117,000		
8	Implementation of livelihood safeguard program	See note	LS			27,000,000	12,873,600	1,800,000
9	Compensation for houses/assets	Table 6.4	LS			16,128,990		
10	Compensation for infrastructure lost (bridge, road, etc)	Table 6.9	LS			108,290,000		
11	Compensation for arable land in construction areas	Table 6.5	LS			23,640,060		
12	Fisheries study/outreach program	See note	LS			1,800,000	0	180,000
13	Health centre (project employees & locals)	See note	LS			4,500,000	11,160,000	0
14	Replanting	See note	ha	400	2,601	1,040,400		
15	Generic BMP for disturbed areas	See note	ha	400	7,200	2,880,000		
16	Conservation initiatives (provisional sum)	See note	PS	6	675,000	4,050,000		
17	Water quality monitoring	See note	LS			0	30,000	40,500
18	Monitoring of construction work	See note	Year	5	270,000	1,350,000	540,000	0
19	socio-economic monitoring	See note	Year	5	180,000	900,000	900,000	0
20	Institutional capacity building program	See note	LS			4,500,000	900,000	450,000
21	Community gain (Social Service Proposed)	Table 6.12	LS			70,423,037	1,800,000	900,000
22	Post construction environmental audit	See note				65,520,000	0	0
23	Compensation for Transmission Lines	Table 6.7	LS			35,189,568		
	Sub-Totals (excluding reservoir clearance)					770,233,465	28,203,600	3,370,500
	Contingency at 10%					77,023,346	2,820,360	337,050
	Grand Total							**881,988,321**

Table 11.2 : Border Environmental Cost Estimate in USD

No.	Item	Capital Cost (USD)	Recurrent Cost (USD) Construction Phase	Recurrent Cost (USD) Operation Phase
1	Reservoir Clearing (included in Civil Works)	25,800,000	0	0
2	Technical Environmental Optimization	195,440	0	0
3	Compensation for annual crop	10,546,961	0	0
4	Compensation for recession agriculture	7,039,739	0	0
5	Compensation for grazing land	97,720	0	0
6	Compensation for lost Natural Resources	25,649,392	0	0
7	Income lost Feluco transporters	229,859	0	0
8	Implementation of livelihood safeguard program	2,931,596	1,397,785	195,440
9	Compensation for houses/assets	1,751,248	0	0
10	Compensation for infrastructure lost (bridge, road, etc)	11,757,872	0	0
11	Compensation of assets lost due to construction	2,566,782	0	0
12	Fisheries study/outreach program	195,440	0	19,544
13	Health centre (project employees & locals)	488,599	1,211,726	0
14	Replanting	112,964	0	0
15	Generic BMP for disturbed areas	312,704	0	0
16	Conservation initiatives (provisional sum)	439,739	0	0
17	Water quality monitoring	0	3,257	4,397
18	Monitoring of construction work	146,580	58,632	0
19	socio-economic monitoring	97,720	97,720	0
20	Institutional capacity building program	488,599	97,720	48,860
21	Community gain (Social Service Proposed)	7,646,367	195,440	97,720
22	Post construction environmental audit	7,114,007	0	0
23	Compensation for Transmission Lines	3,820,800		
	Sub-Totals (excluding reservoir clearance)	83,630,128	3,062,280	365,961
	Grand Total (USD) including 10% contingency			**95,764,200**

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 Border dam 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.

In order to make some allowance for additional works, management and monitoring in Sudan and Egypt, a total provisional sum of USD 125.4 million has been included with the Ethiopian costs for these and included in project costs for assessment in the project model for investment planning and modelling (Module 6). With an estimate of USD 25.8 million for reservoir basin clearance, these environmental costs represent some 10% of the estimated overall project cost.

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 3.10	Border Project Cost		1,481
7.5.1	Potential sale **value of the electricity** generated at Border - firm energy only	158 / year	
7.5.2	The annual sale of the **uplift of energy** in Sudan	37 / year	
7.5.3	**River morphology changes**, river training works	-	Not assessed
7.5.4	**Incremental fisheries production**	Not assessed	-
7.5.5	**Additional irrigation with regulated flows**	Not assessed	
7.5.6	**Reduction in flooding – health services, urban, property, infrastructure**	<52 / year	-
7.5.6 Table 7.14 Table 7.15	**Reduction in flooding – mitigation for reduction of recession agriculture** Benefits and costs 434,700 feddan conversion	Not assessed	1,739 (capital and annual combined) 2.9 (annual energy)
7.5.7	**Reduction in reservoir sedimentation**. Benefits claimed in energy uplift above	-	-
7.5.8 7.5.9 Table 7.16	**Reduction in reservoir sedimentation**. Foregone agricultural production	230 to 316 / year	-
7.5.8	**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	-

Text Reference	Project and Downstream Impacts	Benefit USD million	Cost USD million
7.5.8 Table 7.17	**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	-
7.5.8	**Reduction in reservoir sediment loads at abstraction points and irrigation schemes** Higher costs of water purification	Not assessed	-
7.5.8	**Reduction in reservoir sediment loads at abstraction points and irrigation schemes** Pump damage	Not assessed	-
7.5.9	**Reduction of sediment loads** Use of artificial fertilizers	-	Not assessed
7.5.10	**River crossings on Blue Nile** Navigation benefits and pedestrian/livestock river crossings	Not assessed	Not assessed
7.5.11	**Reduction in evaporation at HAD** Additional water supplies Foregone energy	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 Border 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 Border project. It was suggested that the mechanism for the Border project contributing to watershed management could be through its financial support from energy sales. Thus, a watershed management cost requires to be incorporated in Border 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 1,200 MW Border project (6,011 GWh/year) is very substantial. Screening the project by considering the land area flooded (574 km^2) and the numbers of people displaced (13,905) by the reservoir for each installed MW suggests that Border is reasonably favourable in comparison with 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.

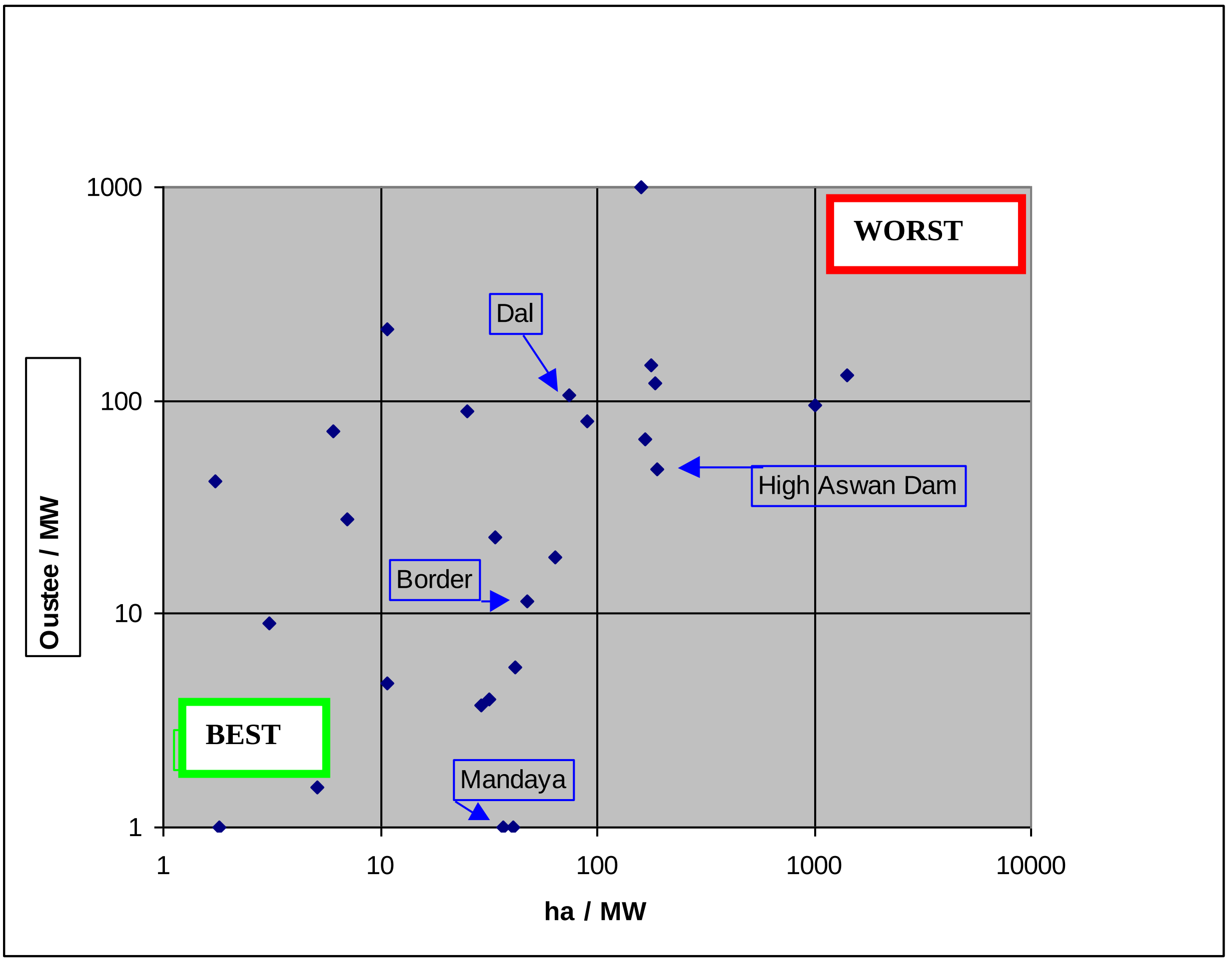


Figure 12.1: Hydropower Efficiency Ratios

Taking a global view, with an index of 11.6 people per installed MW it is concluded that Border is among the few remaining potential major hydropower project sites in the world where development would disturb relatively few people directly.

12.1.2 Downstream energy generation uplift

Border 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 1,658 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 Border 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 Border and Mandaya in Ethiopia and Dal in the Nubian desert in Sudan. Border's evaporation losses for each unit of electrical energy are five times less than at Dal.

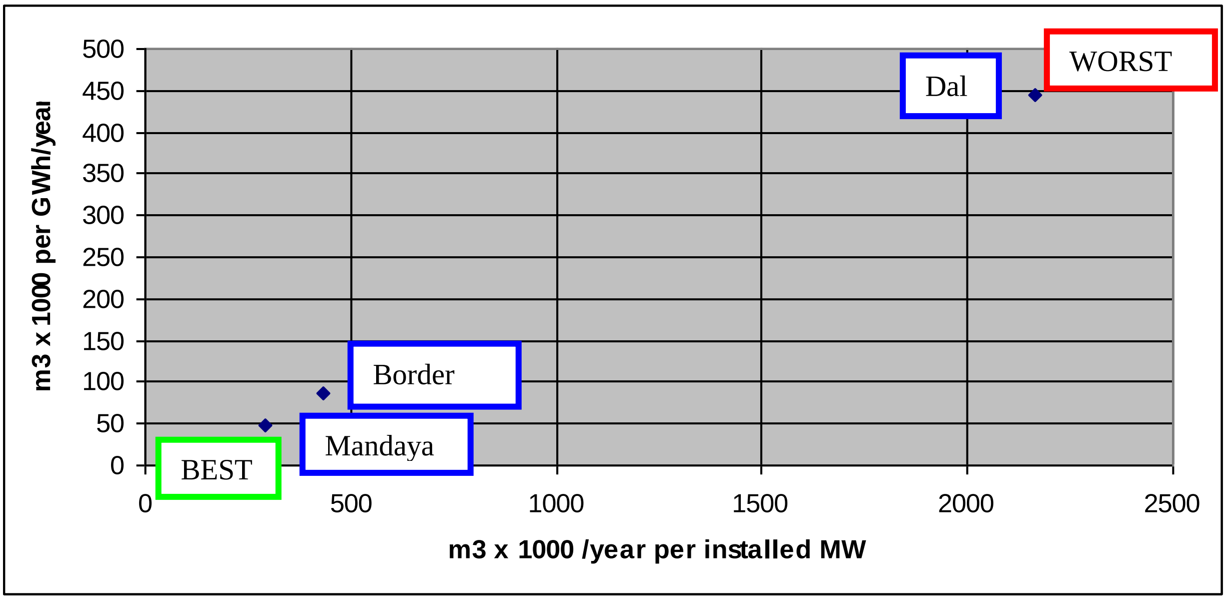


Figure 12.2 : Hydropower Efficiency Ratios of Annual Evaporation Losses for Installed Capacity and Annual Energy

12.1.4 Conclusions on Preliminary Screening

It is concluded that development of Border 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 Border 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 Border 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 Border project may be regarded as medium for the size of project and it will 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 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 Border 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 Border area have revealed few sites of interest and none in the project area itself. There is only one road in the reservoir area (a short length near the dam site) which is testimony to its isolation and suggests that the valley has been inhospitable for settlement in the past. One of the reasons for this may have been the presence of tsetse fly. 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 Border 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 Border reservoir is relatively small (14.5 billion m^3) in relation to mean annual flow (49 billion m^3). First filling may be achieved in a single season but will necessarily cause 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 Border may be filled without causing water supply shortages for public water supply and irrigation. Explicit simulations have not been carried out in relation to determining downstream impacts (because they are believed to be relatively small and short lived) but will be required in future studies. They should use agreed data sets and variants of these 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, and of regulation in the operational period, will require examination in future. However, as it appears from parallel planning studies, that Border would be developed in the Abbay hydropower cascade after Mandaya, studies will need to reflect its timing and any prior developments upstream.

12.2.7 River Morphology

With retention of most of the sediment load in Border 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 Border reservoir behaviour and turbined releases and spillway flows suggest that the annual flood of the Blue Nile and Main Nile will be reduced in some years and barely affected in others. This would have some benefits for reducing urban flooding and related disruption along the Blue and Main Nile in some years but this flood relief, though welcome, would be infrequent. On the other hand, Border would seriously impact on recession agriculture in some years. 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. Border would spoil farming and livelihoods dependent on the annual flood in some years. 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 Border project. It is also concluded that this conversion would need to be implemented before first filling of Border begins in order to prevent hunger and hardship for the affected communities.

12.2.9 Secondary benefits in Sudan

The secondary benefits of the Border project in Sudan result from the project raising dry season flows 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 Border.

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 Border will impact on livelihoods and the local economy, and power generation at Aswan to some extent. 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 Border 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 Border project when it becomes operational.

12.2.12 Dam Safety

Border's 90 m high dam is large by most dam standards. 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 Border 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 Border project is expected to take six 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 in Ethiopia downstream of Border dam site 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 Border 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 Border 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 gauging 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 Border 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 Border 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 Border, 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 Border project.

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APPENDICES

Appendix	**Contributors to Initial Environmental Impact Assessment of Mandaya and Border Hydropower Projects**
Appendix	**Record of Environmental Consultations on Mandaya and Border Projects**

Appendices 4.1 to 4.7: Aquatic ecology baseline data

Appendix 4.1	**List of phytoplankton species from samples in Abbay river taken near Abagole and at Mandaya dam site in March 2007**
Appendix 4.2	**List of phytoplankton species from samples in Abbay river at Bure-Nekempte bridge in January 2007**
Appendix 4.3.	**List of fish species collected from Abbay river on 21 and 22 March 2007 at Abagole, downstream of Mandaya dam site**
Appendix 4.4	**Fishes of the Abbay river at Bure-Nekempte bridge (NFLARR/EARO, 2003) (Date of sampling 20-24/03/1992)**
Appendix 4.5	**Fishes of the Beles River at Babizenda (Source: Zeleke Berie, 2007)**
Appendix 4.6	**Fishes of the Abbay River at a location 35 km SWW Mankush (11o14’N 34o59’E) (Source-JERBE, 2000)**
Appendix 4.7	**Fishes of the Dabus River at the bridge along Nekempt-Assosa road (9o 46’ N 34o 48’30’’E) (Source: NFLARR/EARO, 2003)**
Appendix 4.8	**List of contacted people and organizations**
Appendix 4.9	**Participants of Focus Group Discussion (FGD) at different localities in the project area**
Appendix 4.10	**A Nurse’s View**
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**
Appendix 5.2	**Flood Damages in Sudan**
Appendix 6.1	**Border Hydropower Project – CO_2 Emission**
Appendix 6.2	**Settlements impacted by Border reservoir**
Appendix 6.3	**Note on compensation procedures in Sudan and Egypt**

Appendix

Contributors to Initial Environmental Impact Assessment of Mandaya and Border Hydropower Projects

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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 Adam,** Ministry of Irrigation and Water Resources	Go through simulations of Mandaya. Recession agriculture 50,000 feddan 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.

<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>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. 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>
</table>

Consultations in Khartoum 13th to 19th March 2007		
Meeting Date	**Person/Agency**	**Environmental issues raised and discussed in Khartoum**
19/03/07	**Eng. Abdulla Elsadile Elamein,** Nile Water Department	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 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

Consultations in Cairo 25th March 2007

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.

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

Green algae (Chlorophyceae)

- *Staurastrum* Sp.
- *Cosmarium* Sp.
- *Pediastrum* Sp.
- *Scenedesmus* Sp.
- *Comphosphaeria aponina*
- *Treubaria* Sp.
- *Closterium*

Blue Green algae (Cyanophyceae*)*

Anabaenopsis Sp
Lyngbya
Anabaena

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^o 46’ N 34^o 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

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
40	Dr Babikan	ENTRO, Environmentalist	

No	Name of contacted people	Organization and responsibility	Address
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 4.9

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	,,	,, ,,
16	Sanun Marid	,,	,, ,,

No	Name of the Participants	Occupation	Administrative location
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 4.10

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 and Border hydropower projects.

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

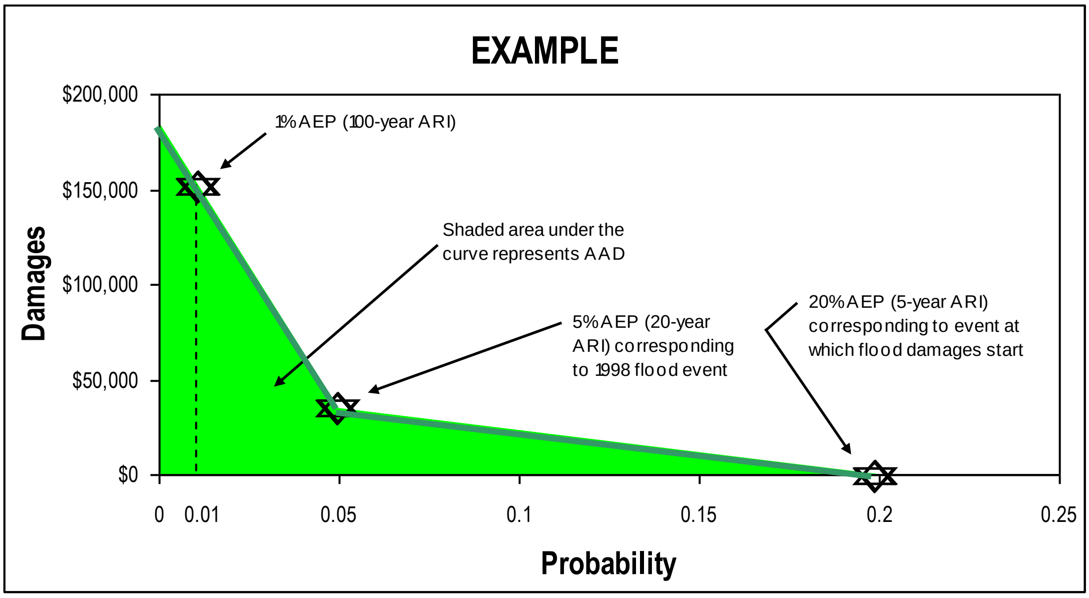
[1] The annual exceedance probability (AEP) is the inverse of the annual recurrence interval (ARI) expressed as a percentage. Hence the 1% AEP event is the same as the 100-year ARI event.

Dongola); and

- 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

1. BORDER HYDROPOWER PROJECT – CO_2 EMISSION

1.1 INTRODUCTION

The proposed Border 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 BORDER 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 Border 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	3,082,000m^3
- Rock excavation	1,416,000m^3
- Roller compacted concrete	3,326,000m^3
- Conventional concrete	1,358,000m^3
- Reinforcement steel	58,000 tons
- Diesel fuel	69,000 tons
Electro-mechanical equipment	
- Steel	10,280 tons

Based on the volume of roller compacted and conventional concrete and other construction activities such as grouting, shotcreting, etc. a cement requirement of about 874,000 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 3,500,000 GJ.

The weight of reinforcement steel, hydraulic steel structures and steel for the electro-mechanical equipment totals about 68,000 tons. It takes approximately

40 GJ of energy to produce one ton of steel. Therefore, the energy input into steel and equipment is about 2.7 million GJ.

The energy requirement for the excavation, transport and placing of soil and rock material is covered under the diesel fuel requirements of 69,000 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 312,000 tons of coal and 179,000 tons of gas would be needed. The burning of these fossil fuels would ultimately lead to a CO_2 emission of approximately 490,000 tons.

The burning of 69,000 tons diesel fuel will result in a CO_2 emission of about 223,000 tons. The total emission of CO_2 associated with the construction of the Border hydropower project will thus be approximately 714,000 tons.

1.2.2 CO2 Emission caused by the Biomass with the future reservoir

The Border hydropower project will inundate a gross area of about 580 km^2, which, after exclusion of the existing river channel, will result in a net area of about 50 km^2 of land. The biomass of savannah woodland is in the order of 50 t/ha dry weight and, based on this assumption a total biomass of about 2,975,000 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:

$$180\ g\ C_6H_{12}O_6 + 192\ g\ O_2 = 264\ g\ CO_2\uparrow + 108\ g\ H_2O$$

$$1\ t\ C_6H_{12}O_6 + 1.07\ t\ O_2 = 1.47\ CO_2\uparrow + 0.6\ H_2O$$

Using the same relationship on the total estimated quantity of biomass affected by the Border hydropower project the decomposition of the biomass in the reservoir area could lead to a maximum CO_2 emission of about 890,000 tons, assuming that 70% of the woodland was used cut and as fuelwood, substituting for other sources and reducing deforestation elsewhere in Ethiopia.

1.2.3 The Total CO2 Emission of the Border Hydropower Project

Approximately 714,000 tons of CO_2 will be produced with the construction of the Border hydropower project. The maximum potential CO_2 emission associated with the aerobic decomposition of the biomass located in the reservoir (assuming that 70% of the biomass is harvested for use as fuelwood) is estimated to be approximately 890,000 tons. Thus the implementation of Border hydropower project will lead to a total CO_2 emission of about 1,600,000 tons.

1.3 CO2 EMISSION BY EQUIVALENT THERMAL POWER PLANTS

This section quantifies the CO_2 emissions resulting from generating the same average energy as Border 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 Border hydropower project would amount to 6,012 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 4.2 million tons of CO_2 would be discharged to the atmosphere annually.

Table 4: Approximate CO_2 Emission of equivalent Thermal Power Mix

Plant Type	Annual Energy GWh	CO_2 Million tons
Coal-fired steam	3,006	2.9
Gas-fired combined cycle	3,006	1.3
Total	**6,012**	**4.2**

It is noted that the CO_2 emission of 4.2 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 Border 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 2.6 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 Border hydropower project will produce an average of 6,012 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 residual 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 Border will be some 890,000 tons.

Generating the same energy by burning fossil fuels (equal proportions of lignite, coal, oil and gas) would release into the atmosphere some 4.2 million tons of CO_2 every year. Over a period of 50 years, the assumed commercial life of Border, this annual CO_2 emission would result in a total of 210 million tons of CO_2. Consequently the generation of hydro-electric energy at Border will result in CO_2 emissions 130 times less than if the same energy were generated by burning fossil fuels.

Appendix 6.2

Settlements impacted by Border reservoir

No	Woredas	Kebele	Sub-Kebele	HH size	Infrastructure Affected			Other
					Road	Clinic	Schools	
1	Guba				76 km	3	7	3
		Babizenda	Beles	50				
			Gechitu ?	50				
			Jadia	50				
			Amri ?	50				
			Tengro	50				
			Degdig	50				
			Mesasha ?	50				
		Yarenja	Bercha	50				
			Gomer	50				
			Bergne	50				
			Kefa-Kakna	50				
			Kefa-Belewa	50				
				600				
		Funguso	Yabetal	50				
			Kumbulo	50				
			Honda	50				
			Rebu Gebeya	50				
			Buan ?	50				
			Almia	50				
			Aymer	50				
				350				
		Bamza	Yageter ?	50				
			Bamza	50				
			Bamza Dara	50				
				150				
2	Sirba Abbay					1	1	
			Awele Bezu	60				
			Abbay Endamo	60				
			Adinkish	500				
			Affiaballa	500				
			Gomhor	20				
			Alabiot	20				
				1160				
	Wonbera[2]							
			NA	**521**				
	Grand Total			**2781**				
	Total Pop affected (estimated)			**13,905**				

[2] Population and households of Wonbera were estimated on the basis of population density in the woreda.

Appendix 6.3

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.