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Government of the Republic of Malawi

Ministry of Water Development and Irrigation
National Water Development Programme

Independent Environmental Impact Assessment for the Upgraded Kamuzu Barrage

Final Environmental and Social Impact Assessment
Volume 1 – Main Report

December 2013

SMEC
Celebrating 40 years 1970 - 2010

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List of ESIA Documents

Volume 1: Main Report – ESIA (this Report)

This is the "stand alone" main report addressing the environmental and social impact assessment of the Project and includes a summary of the Environmental Management Plan (EMP) which has been prepared as a separate document. The specialist reports in Volume 2 (Annexe to the ESIA) need only be consulted if a reader wishes to follow-up the specialist studies undertaken to complete the ESIA.

Volume 2: Annex to Main Report

1. Fisheries Report
2. Assessment of Wildlife Impacts
3. Vegetation Assessment
4. Water Quality Assessment

Environmental and Social Management Plan (ESMP)

The ESMP is a stand-alone document which addresses mitigation measures, monitoring and institutional arrangements for the environmental management of the Project. One part of the ESMP is the environmental monitoring program which provides input to management decisions that 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.

Resettlement Plan

The Resettlement Action Plan (RAP) is a separate report to support the ESIA. It identifies resettlement and compensation issues and provides a compensation framework. The findings and recommendations have been included in the Main ESIA.

Abbreviations

AEWA	African-Eurasian Waterbird Agreement
AICC	African Institute of Corporate Citizenship
AIDS	Acquired Immuno-Deficiency Syndrome
ARET	Agricultural Research and Extension Trust
BP	Bank Policy (World Bank)
BOD	Biochemical Oxygen Demand
BoQ	Bill of Quantities
C	Carbon
CADECOM	Catholic Development Commission in Malawi
CARD	Churches Action in Relief and Development
CBO	Community Based Organisation
CEMP	Contractor Environmental Management Plan
cm	centimetre
CPUE	Catch per Unit of Effort
CS	Construction Supervision
dBA	Decibel (A scale)
DO	Dissolved Oxygen
EA	Environmental Assessment
EAD	Environmental Affairs Department (Malawi)
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMA	Environmental Management Act
EMP	Environmental Management Plan
ESCOM	Electricity Supply Corporation of Malawi (Ltd)
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
FAO	Food and Agriculture Organization (UN)
FAQs	Frequently Asked Questions
FCMA	Fisheries Conservation and Management Act
Fe	Iron
GoM	Government of Malawi
GPS	Global Positioning System
GVH	Group Village Head
GWH	Gigawatt Hour
ha	hectare
HIV	Human Immunodeficiency Virus
HRWL	Highest Regulated Water Level
IAPs	Interested and Affected Parties

IUCN	International Union for Conservation of Nature
km	kilometre
kN	kiloNewton
L	Litre
LC	Least Concern
Leq	Equivalent Continuous Sound Level
LLC	Local Liaison Committee
LMLC	Lake Malawi Level Control
LNP	Liwonde National Park
LRWL	Lowest Regulated Water Level
m	metres
mm	millimetres
masl	metres above sea level
MBS	Malawi Bureau of Standards
MCC	Millennium Challenge Corporation
MGDS	Malawi Growth and Development Strategy
MoWDI	Ministry of Water Development and Irrigation
MS	Microsoft
MSEs	Micro and Small Enterprises
MW	Mega Watt
MWK	Malawi Kwacha
N	Nitrogen
NEAP	National Environmental Action Plan
NEP	National Environmental Policy
NGO	Non-Governmental Organisation
NP	National Park
NSO	National Statistical Office
NT	Near Threatened
NWDP II	Second National Water Development Project – Phase II
OD	Operational Directive of the World Bank
OP	Operational Policy of the World Bank
P	Phosphorus
PAP	Project Affected Person
PRA	Participatory Rural Appraisal
PSC	Project Steering Committee
RAMSAR	Convention on Wetlands of International Importance Especially as Waterfowl Habitat
RAP	Resettlement Action Plan
s	second

SADC	Southern Africa Development Community
SE	Supervising Engineer
SIA	Social Impact Assessment
SME	Small and Medium Enterprise
SMEC	Snowy Mountains Engineering Corporation (Australia)
spp	species
SRBMP	Shire River Basin Management Project
STIs	Sexually Transmitted Infections
TCE	Technical Committee on Environment
ToR	Terms of Reference
TSS	Total Suspended Solids
UNDP	United Nations Development Program
USD	United States Dollars
WB	World Bank
WESM	Wildlife Environment Society of Malawi
WHO	World Health Organization
ZAMCOM	Zambezi Watercourse Commission

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    - Health and Sanitation Expert, Mangochi District
    - Water rEsources Board, MoWDI
    - Officer-in-charge of Kamuzu Barrage, ESCOM
    - Operation Manager, Kamuzu Barrage
    - Navigator of Boats, Kamuzu Barrage
    - Operation Manager, Nkula Power Station
    - Senior Power Station Manager, Nkula Power Station
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Executive Summary

Background Information

The Government of Malawi, through the Ministry of Water Development and Irrigation (MoWDI), is currently implementing the National Water Development Project Phase II (NWDP II). Under Phase I of the NWDP, a number of studies were undertaken including: i) Water Resources Development Plan Study to identify future potential sources of water supply, ii) Catchment Rehabilitation and Protection Study, iii) Integrated Water Resources Management Plan for the Lake Malawi and Shire River Study, iv) Songwe River Stabilisation Study and v) Strengthening of the Water Resources Board Study.

The upgrading of Kamuzu Barrage at Liwonde was selected as the best option of a number of alternatives considered under the Integrated Water Resources Management Plan for the Lake Malawi and Shire River Study (also known as the Lake Malawi Level Control - LMLC) to further regulate flows in the Shire River. Upgrading of the Barrage will be undertaken as a sub-project of the Shire River Basin Management Project (SRBMP) financed through the World Bank (WB). The overall program development objective of the SRBMP is to make significant progress in achieving socially, environmentally and economically sustainable development in the Shire Basin.

Rationale

Kamuzu Barrage which became operational in 1965 is reported to have outlived its life of about 25 years. The Barrage was originally constructed in response to low rainfall in the catchment areas of Lake Malawi and the Shire River resulting in lowered lake levels and lack of flow in the Shire River which in turn adversely affected hydropower generation, irrigation, urban water supplies and transport as well as livelihood activities such as *dimba* cultivation and fisheries.

The purpose of upgrading Kamuzu Barrage is to increase water storage capacity upstream (particularly within Lake Malawi) and thereby to help ensure adequate downstream flows in the Shire River to sustain key economic activities. These include hydropower generation (most of Malawi's electricity comes from Shire River hydroelectric plants), water supply (including for the city of Blantyre), existing and proposed irrigation systems, fisheries and traditional *dimba* (flood-recession) agriculture. The remaining natural ecosystems and wildlife (such as in the Elephant Marsh) downstream of the Barrage also depend upon Shire River flows. In previous years of especially low water levels in Lake Malawi, the Shire River has run dry; the Kamuzu Barrage is intended to help prevent (to a certain extent) a recurrence of these low flow situations, which would be disastrous because so many people and businesses now depend upon adequate year-round flows within the River.

Project Description

The Project proponent is the Ministry of Water Development and Irrigation. The Project involves upgrading the existing Kamuzu Barrage which is located on the Shire River at the town of Liwonde. The preferred design option for the Upgraded Kamuzu Barrage involves: refurbishment of the existing Kamuzu Barrage Structure with new gates and raising the existing highest regulating capacity of the Barrage by 40 cm from a Lake Malawi water level of 475.32 masl to 475.72 masl; construction of a new road bridge on the downstream side of the existing Barrage (as part of the same structure); and construction of a floating steel boom upstream of the Barrage to control floating weeds. Erosion protection works will also be constructed downstream of the Barrage. Construction time is estimated at 34 months.

Environmental Setting

Topography

The Kamuzu Barrage is in Liwonde on the Mangochi to Liwonde rift valley plain. Topography of the Project area can be divided into three distinct categories, namely the rift valley floor, the plain north of the Barrage and the hilly forested Machinga Forest Reserve that lies south of the Barrage towards Zomba.

Soils

Sandy soils with coarse grains and light texture with good air circulation are very common in the Project area. Fertile alluvial soils with fine particles and heavy texture are found along the flood plain of the Shire River, Lake Malombe and shores of Lake Malawi. These soils support a variety of crops including maize and rice. There are also hydric soils in the riparian zones of Lake Malawi, Lake Malombe and the Shire

River. These are soils that are formed under conditions of saturation, flooding and ponding long enough in the growing season to create anaerobic conditions in the upper 50 cm of the soil.

Hydrology/ Geology

Flow in the Shire River is determined by the outflow from Lake Malawi and in-flow from the drainage basin downstream of the Lake (Norconsult, 1997). Lake outflows account for all almost all the water entering the Shire River. The Kamuzu Barrage provides flow regulation in the Shire River downstream of Liwonde and limited control of water levels upstream in the Shire River, and Lakes Malombe and Malawi.

Geology at the Barrage site consists of mainly fluvial sandy soils with firm layered residual soils and weathered rock underneath.

Climate

There are three relatively distinct climatic seasons in the Lake Malawi area. Cool and dry weather with south-easterly winds predominates from May till August with air temperatures along the lakeshore dropping as low as 15°C. A short hot and dry period occurs from September to November while the rainy season normally lasts from late November till April. In the rainy period the average temperature is around 28°C and the wind direction is predominantly northerly.

The Upper Shire reach stretching from the outflow of Lake Malawi at Samama to Matope is a relatively dry area with a mean annual rainfall of around 700 mm and average annual temperature of around 22°C. The Middle Shire River area stretching from Matope to Kapichira has a slightly higher rainfall than the upper part with 700-800 mm of rainfall. The mean annual temperature is also slightly higher being approximately 24°C.

Vegetation

The commonest vegetation type in the Project area is miombo woodland (*Brachystegia julbernadia*) occurring on the adjacent Machinga Forest Reserve and other hills in the Liwonde National Park. Hydrophytic plants which include reeds, hippo grass, and other water-loving plants are common along the riparian zones. Six (6) distinct biotic communities were identified as being represented within the Project area during the field assessment, namely:

- Perennial Marshes
- Seasonal Marshes – Uncultivated
- Seasonal Marshes - Under Cultivation (*dambos*)
- Seasonal Flood Plains
- Riverine Woodlands; and
- Dry Bush Savannah

Wildlife

The Project area spans over a variety of habitats from open water, floating meadows, lagoons and reeds, floodplain, grassland, woodland and mixed woodlands. The immediate habitats adjacent to the Shire River and Lake Malombe include wetlands, open grasslands and mixed woodlands. Wetlands and open short grasslands occupy most of the floodplains. The extent of coverage varies from place to place but the Project area being generally flat allows water stagnation during flooding and rain.

There are many species of conservation interest. Records show that a number of protected areas in the Project area now harbour reintroduced species after the previous populations became locally extinct through hunting or habitat loss. Species of key interest include crocodiles, rhinoceroses, roan antelopes, buffaloes, eland, zebra and terrapins (freshwater turtles). There are also species translocated to Liwonde National Park from Kasungu National Park in the north in order save them from local extinction. Wildlife population trends from annual censuses conducted by Liwonde National Park suggest that the populations of most large game species are stable. Important bird species include the globally near threatened African Skimmer which utilises river sand bars and the highly localised Rock Pratincole which utilises emergent boulders in the Shire River channel.

Fishes

Chambo (Tilapia) fish species that include *Oreocromis lidole* and *Oriocromis karongae* are among species of commercial importance. *Opsaridium microlepis* (Mpasa or Lake salmon), a cyprinid and a lacustrine fish species, is the most commercially viable riverine species in Malawi. Mpasa is at the verge of extinction in Malawian natural waters although there appears to be some remnants in Liwonde National Park where it is abundant. Mud fish and others that are not very popular commercially are also found locally.

The fish population of Lake Malawi consists of 500-1,000 species. Of major importance in terms of species diversity is that nearly 100% of the cichlids are endemic to Lake Malawi (i.e. they are found nowhere else in the world). Moreover, many of the cichlid species have a very restricted distribution within the Lake. This is particularly the case among the rock-dwelling mbuna which utilise the rocky shores.

Land Use

Major land uses in the Project area include; agriculture, grazing, human settlement, commercial enterprises, protected areas and tourist/recreational developments such as hotels and lodges along the Lake shore and Shire River areas are used for hotels and cottages.

Livelihoods

Fishing and fish vending are among the major livelihood activities at Kamuzu Barrage as well as at Mangochi and other places on the lake shore. Individuals in these places derive their food and cash income from fishing, processing or selling fish. The most common fish species landed include Usipa, Kampango, Mlamba, Kambuzi, Mcheni and Chambo. Fish catches are generally dwindling.

Settlement

House structures consisting of sun-dried and burnt bricks are common types in rural areas. Most of the houses are grass thatched and a few have iron sheets.

Transport and Communication

Minibuses, pickups and small three tonne trucks are commonly used to transport people as well as goods within and between districts. Bicycles are also commonly used to transport people especially in district centres. The existing Kamuzu Barrage provides an important regional and local transport link across the Shire River.

Ground and mobile telephone services such as Airtel, MTL, and TNM are available in many parts of the Project area though some have weak signals.

Health

The Project area is well serviced by government and private hospitals. There are also health centres in many parts of the rural communities. Malaria is the most common health problem in the area.

Ethnic Composition

Chiyawo and Chingoni are the main local languages. Chichewa is spoken by most people as it is the national language. People of other tribes are those employed by government or doing business in the Project area.

Religion

Most residents in the Project area are Muslims followed by Christians mainly Roman Catholics. Mangochi and Machinga districts are dominated by Muslims comprising more than 50 % of the residents. Conversely, Balaka district residents are predominantly Christians (67%).

Social and Environmental Impacts

Beneficial Impacts

Reliable hydropower generation - The upgraded Barrage will help with the control and regulation of Lake Malawi water levels and flow in the Shire River providing more reliable generation of hydropower. The weed boom will also help to control significant adverse impacts created by water hyacinth weeds in relation to operation of the hydropower plants downstream of the Barrage.

Improved (more reliable) water supply - to towns downstream of the Barrage such as Blantyre and to irrigators including SUCOMA sugar plantation.

Improved transport and communication - The upgraded Barrage will be stronger and wider providing both motorists and pedestrians a more useful, easy and safe access to health clinics, trading centres, markets and other places where they access goods and services. Upgrading the Barrage will enhance the benefits people are currently getting from the existing Barrage including a regional transportation link.

Economic benefits - Besides direct employment, the likelihood of people in the area benefiting economically from the Project through establishment of small scale businesses such as groceries, restaurants, houses for rent, sale of agricultural produce and fish at the local market and by the road side is high. Significant economic benefits will be enjoyed in the Project area.

Employment opportunities - The likelihood that upgrading of the Barrage will create employment opportunities and bring about economic benefits to people in Liwonde, Machinga, Mangochi and the neighbouring districts is also very high. Employment opportunities created will be beneficial both locally and regionally.

Alternative livelihoods - Vending of fish (both fresh and dried) is, at present, the major livelihood activity in the Project area particularly at the Barrage. Increased population as a result of the influx of people and movement of people in the area will bring about different demands for goods and services. The varied demands will provide opportunities for entrepreneurs to venture into new livelihood activities.

Improved Standard of living - Direct cash income from employment by the Project and money realised from rentals, sale of agricultural produce and other commodities will enable people in the Project area and beyond to meet their basic needs and afford essentials such as food, clothing and good houses which will raise their living standards.

Community skills development - The many activities to be undertaken during Barrage upgrading works will likely require the contractor to train some local people as plant operators, technicians, electricians and mechanics, clerks and storekeepers. The acquired skills will benefit the individuals as well as communities in the Project area during and after the Project life.

Adverse Impacts

Soil Erosion/land degradation - Clearing of vegetation and earth moving works during the upgrading of the Barrage (including work at the proposed quarry and borrow areas) will cause localised erosion with sediments contaminating surface water resources including the Shire River. These impacts are expected to be short term and minor with adequate mitigation measures in place.

Air pollution Use of plant and equipment during construction will lead to air pollution. The impact is expected to be short term and minor.

Water pollution - Silt, solid wastes and oil from the construction site may spill into the Shire River contaminating its waters and possibly killing some organisms as well as impacting on downstream water users. Impact is expected to be short term and moderate.

Wildlife – The primary cause of impact to the terrestrial environment resulting from implementation of the Project is associated with changes in regulated flows downstream of the Barrage and changed inundation levels upstream. These impacts will be most pronounced in the low gradient areas of Lake Malawi, Lake Malombe and the Upper Shire River principally on the floodplain and in the River channel.

Increased flooding in the riparian zone during Barrage operation may cause loss of habitats upstream and downstream of the Barrage. Sand banks are utilised by crocodiles and terrapins for nesting and some of these areas may become inundated as a result of higher water levels during the dry season from the refurbished Barrage.

Sand bars in the River channel which are also susceptible to inundation from higher water levels are used as roosting sites by the African Skimmer. Similarly, emergent boulders in the Shire River which provide habitat for the Rock Pratincole may also be inundated as a result of the refurbished Barrage. Impacts are expected to be long term but minor with adoption of Barrage operation safeguards.

Fish – Higher water levels upstream of the Kamuzu Barrage will potentially affect fish habitats, including the highly diverse assemblage of Mbuna cichlid fish species that inhabit shallow rocky waters in Lake Malawi. However, the impact is expected to be minor but long term.

Although the Barrage is a partial barrier to upstream migration of fish, the impact is lessened by the natural barriers in the Shire River created by a series of waterfalls along the Shire River between Liwonde and the Elephant Marsh. Under high flow conditions the Barrage gates are fully opened allowing passage of fish and other organisms.

Vegetation – Riparian floodplain vegetation communities in Liwonde National Park which is located immediately upstream of the Barrage are also susceptible to impacts from prolonged flooding as a result of the refurbished Barrage and its operation. These impacts are potentially long term and moderate to severe. A monitoring program is recommended to assess the impacts and to provide input into Barrage operational rules.

Involuntary resettlement – Resettlement is not expected as a result of the Barrage upgrading. However there will be some temporary and permanent impacts on businesses and structures around the Barrage road approaches, temporary contractor site and upstream along the Shire River between the Barrage and the new weed boom. The RAP for the Project provides a quantitative assessment of compensation and mitigation measures.

Loss of farmland - borrow pits and disposal sites for gravel and other solid wastes (location to be determined by construction Contractor) if located in farm lands will make the land temporarily unavailable for cultivation or grazing. Any compensation for land users is covered in the Project's RAP.

Tourist Facilities –Severe river bank erosion from natural flooding in the Shire River is occurring adjacent to the main accommodation camp in Liwonde National Park such that the Park Service has had to construct river bank protection works (rock gabions) to protect its camp site. Barrage operating rules will minimise any impacts from the refurbished Barrage by controlling opening of gates to avoid sudden or rapid lowering of water levels.

The tourist boat access ramp for Liwonde National Park will be impacted by Barrage construction works and will be replaced as part of the compensation measures outlined in the RAP.

Traffic hazards during construction – increased vehicle movements, especially heavy vehicles will lead to a temporary increased risk of accidents and traffic congestion in the vicinity of the Barrage, quarry site and borrow areas during the construction period. Traffic hazards will be managed by the Contractor through implementation of a Traffic Management Plan.

Health impacts - Borrow pits, if not reclaimed soon after construction works, can fill up with water which provides breeding grounds of water-borne vectors for malaria and, bilharzias. Individuals contract bilharzia as they swim and wash clothes in the stagnant water in the pits. These sites will be rehabilitated in accordance with the Project's ESMP (and included in the Construction Contract) to avoid potential health problems from developing.

Influx of workers and job seekers into the area is very likely to introduce new life styles and increase the incidence of diseases such as HIV/AIDS and other communicable diseases. Drug and alcohol abuse may also increase in the Project area due to increased affluence and higher population. Impacts are likely to be long term but minor provided measures outline in the Project's ESMP are implemented.

Noise and vibrations - The Barrage rehabilitation activities include blasting, crushing and transportation of materials and personnel using heavy vehicles. Machines used in all these undertakings produce noise and vibrations. Impacts are expected to be short term and minor with implementation of mitigation measures under the Project's ESMP.

Environmental Management Measures

The Environmental and Social Management Plan (ESMP) outlined in Section 8 addresses mitigation measures, monitoring and institutional arrangements for the environmental management of the Project. 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 Malawi.

In terms of the riparian environment, there will be a minimal change in the area of habitat inundated and inundation period associated with a 20 cm increase in Barrage height. However, a potentially significant

increase in the area of inundation and inundation period is possible upstream of the Barrage if the height is raised by 40 cm. This would impact the important Perennial Marsh habitat located within Liwonde National Park adjacent to the Shire River. It is recommended that if the Barrage is raised by 40 cm that a Perennial Marsh habitat monitoring program is implemented within the boundaries of the Park and an adaptive management program is adopted whereby the operation of the Barrage is regulated in response to the findings of the monitoring program.

It is also recommended if levels do need to be increased above 475.5 masl then the Barrage should be operated to mimic the seasonal flooding patterns of system i.e. levels of 475.5 masl and above permitted during the wet season only (December–April); maintain levels below 475.5 masl during the dry season (May–October).

This operational regime will also minimise the incidences of prolonged (i.e. greater than existing levels) inundation of Seasonal Floodplain and Marshland habitats downstream of the Barrage. This is significant as this habitat type supports crocodile and terrapin (freshwater turtle) nesting, during the critical incubation period lasting from October to December.

To ensure the effective implementation of the ESMP it is essential that an effective monitoring program be designed and carried out. The environmental monitoring program provides 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.

Section 8 of this ESIA details social and environmental monitoring for the following issues:

- Compliance Monitoring: land acquisition and compensation; water quality; noise levels during construction; soil erosion during construction; vegetation clearing during construction; rehabilitation of work sites; community and worker health; safety during construction; implementation of ESMP;
- Outcome Monitoring: downstream hydrology; operation release strategy; vegetation; wildlife;

In addition to the monitoring, the Contractor for construction of the refurbished Barrage will be required to prepare a Contractor Environmental Management Plan (CEMP) based on the ESMP accompanying the Final ESIA. Contract documents will also include specific environmental requirements from the ESMP.

An environmental training program targeting both the Project proponent and Contractor has also been included in the mitigation measures to improve their capabilities in environmental performance.

Key actions recommended are as follows:

- Revised operating rules for Kamuzu Barrage taking into account environmental requirements both upstream and downstream of the Barrage (prepared by the Design Consultant).
- Implementation of the relocation and compensation program as outlined in the Project Resettlement Action Plan.
- HIV/AIDS awareness campaign for communities and contract workers to mitigate effects of influx of people to the Barrage area.
- Preparation of a disaster preparedness and response plan dealing with flood management as well as Barrage failure.
- Implementation of environmental monitoring plan as outlined in Section 8 of this Report.
- Referral of the ESIA to the Governments of Mozambique and Tanzania in accordance with the SADC revised Protocol on Shared Watercourses;
- Establish a Panel of Experts to oversee construction, Barrage safety and environmental management.

The estimated compensation and monitoring costs required to address the social and environmental impacts associated with the Project is USD 1,413,950. These costs include costs associated with compensation as outlined in the Resettlement Action Plan for the Project.

1 Introduction

1.1 Project Background

The Government of Malawi, through the Ministry of Water Development and Irrigation (MoWDI), is currently implementing the National Water Development Project Phase II (NWDP II). Under Phase I of the NWDP, a number of studies were undertaken including: i) Water Resources Development Plan Study to identify future potential sources of water supply, ii) Catchment Rehabilitation and Protection Study, iii) Integrated Water Resources Management Plan for the Lake Malawi and Shire River Study, iv) Songwe River Stabilisation Study and v) Strengthening of the Water Resources Board Study.

The Integrated Water Resources Management Plan for the Lake Malawi and Shire River Study (also known as the Lake Malawi Level Control (LMLC)) in Phase I was undertaken to investigate alternatives for regulating Lake Malawi level and Shire River system. A number of options including no action option, construction of a high dam at Kholombizo, refurbishment of the Kamuzu Barrage at Liwonde, construction of a new barrage at Liwonde and construction of a pumping barrage at Samama, were proposed. A feasibility study was conducted to assess the option that should be taken to detailed design. The upgrading of Kamuzu Barrage at Liwonde was selected as the best option which is the subject of this ESIA.

The feasibility study indicated that Lake Malawi levels should be maintained between 473.50 masl and 475.50 masl as an acceptable range. It was found that above 476 masl, agricultural lands, property and tourist facility losses were expected. It was further concluded that problems for fisheries and Lake transport were expected at Lake levels below 473.50 masl. At 470 masl negative impacts on commercial fisheries and cichlid fish species were anticipated.

The findings and recommendations of this study partly formed the basis of the preparation of the Water Resources Management Component under NWDP II. The component consists of five subcomponents namely: Water Resources Management Institutional and Technical Support; Water Resources Investment Strategy; Pilot Catchment Management and Development; Lake Malawi Level Control; and, Enabling Legislation for National Water Policy.

Rehabilitation and upgrading of the present lake level control structure, the Kamuzu Barrage at Liwonde will be undertaken within the LMLC subcomponent in NWDP II which is financed through the World Bank. Upgrading of the Kamuzu Barrage will contribute towards reducing risks and further regulating Shire River flows and Lake Malawi levels over a range of droughts and wet climatic sequences, but not for the most severe drought and wet climatic sequences. The effect of the Barrage on the extremes within downstream Shire River flow fluctuations will be very small in comparison with the natural long term and seasonal fluctuations. The Project area is shown in Figure 1.

The overall program development objective of the Shire River Basin Management Program is to make significant progress in achieving socially, environmentally and economically sustainable development in the Shire Basin. The program has a planned duration of 12-15 years. The first phase project will establish coordinated inter-sectoral development planning and coordination mechanisms, undertake the most urgent water related infrastructure investments (such as Kamuzu Barrage upgrading), prepare additional infrastructure investments, and develop up-scalable systems and methods to rehabilitate sub-catchments and protect existing natural forests, wetlands and biodiversity. Future phases will consolidate Basin planning and development mechanisms and institutions, undertake further infrastructure investments, and up-scale catchment rehabilitation for sustainable natural resource management and livelihoods.

The Project Development Objective of the Shire River Basin Management Project (SRBMP) is to develop a strategic planning and development framework for the Shire River Basin and support targeted investments to improve land and water resources management, and associated environmental services and livelihoods in the Basin. The project will: (a) strengthen the institutional capacities and mechanisms for Shire Basin monitoring, planning, management and decision support systems; (b) invest in water related infrastructure that sustainably improves water resources management and development; (c) reduce erosion in priority catchments and sedimentation and flooding downstream, while enhancing environmental services, agricultural productivity and improving livelihoods; and (d) improve flood management in the Lower Shire and provide community level adaptation and mitigation support; and (e) protect and enhance ecological services in the Basin. The upgrading of Kamuzu Barrage should be seen as a component of the SRBMP.

The Project will address the interlinked challenges of poverty and a deteriorating natural resource base in the Shire River Basin to halt the process of environmental degradation and improve the productive potential of natural resources. The Project will promote integrated climate resilient investment planning in the basin, including institutional capacity building to plan and monitor changes in land use patterns at a basin level. Project activities will support strategic planning and implementation of large-scale infrastructure investments; adoption of sustainable land, forest and water management practices to reduce land degradation in production and natural landscapes, to build resilience to climate risk and to improve the productivity and incomes of smallholder farmers in priority catchments. The Project will also improve flood management in the Lower Shire. Project investments will be designed to support the GoM's economic growth and development plans for the basin.

The first phase of the Program will have a duration of five-and-a-half years and is organised in three components: (A) Shire Basin Planning, (B) Catchment Management, and (C) Water Related Infrastructure.

Component A: Shire Basin Planning has the objective to lay the foundation for more integrated investment planning and system operations for the Shire Basin. It will finance development of a modern integrated Shire Basin knowledge base and analytical tools, as well as well-planned structured stakeholder consultation processes, in order to facilitate investment and systems operation planning. This component is critically required to move from the current fragmented approach in investments and systems operation, to a more coordinated and holistic approach based on a shared and sustainable vision for the development and management of the Shire Basin. A modern knowledge base with associated knowledge products will be created along with modelling tools to support this planning. The component will support institutional coordination mechanisms for basin planning and management for the basin's socio-economic development and environmental sustainability. It is organised in four sub-components:

(a) Sub-component A.1: Develop Shire Basin Plan through preparing an inter-sectoral Shire River Basin Plan and strengthening inter-sectoral Shire Basin coordination and management institutions.

(b) Sub-component A.2: Build institutional capacity for coordinated basin management amongst line agencies with responsibilities in the Shire River Basin.

(c) Sub-component A.3: Improve water resources information systems including Flood Forecasting and Early Warning Systems as well as community level early warning systems. These information systems would also be used to refine and update a) the operational regime of the Kamuzu Barrage; and b) the Integrated Flood Risk Management Plan.

(d) Sub-component A.4: Program management, monitoring and evaluation, to ensure efficient and timely delivery of project resources in accordance with the project's objectives.

Component B: Catchment Management has the objective to rehabilitate degraded catchments for sustainable natural resource management and livelihoods through an integrated, participatory approach. Development of community-based natural resource management systems is a long-term process that requires sufficient time to build the necessary capacity and ownership. Since the activities promoted ideally require a longer time horizon than the project duration, this project will institutionalise a successful approach and show early results that will be expanded upon and consolidated through the next phase in the program. There would be three stages at the local micro-catchment level: (i) building conditions for micro-catchment rehabilitation and alternative livelihood development, including community sensitisation, social mobilisation and capacity building to ensure ownership and a strong foundation for subsequent interventions; (ii) implementation of micro-catchment development plans and alternative rural livelihoods; (iii) continuing financial and technical support for catchment rehabilitation and livelihood activities while phasing out project activities.

(a) Sub-component B.1: Build institutional capacity for sub-catchment planning and monitoring.

(b) Sub-component B.2: Rehabilitate targeted sub-catchments, will finance interventions identified in micro-catchment plans prepared under sub-component B.1, including: (i) soil and water conservation for more sustainable and productive agriculture; (ii) forestry and rural energy interventions to restore forest cover and reduce firewood consumption within the sub-catchments; (iii) stream and water control to support improved water management through smaller-scale structures built by community members. Larger infrastructure investments at sub-catchment level will be based on a strategic feasibility assessment.

(c) Sub-component B.3: Alternative rural livelihoods would support demand and market driven income-generating activities, with special targeting of women, youth and landless groups, to gradually decrease dependency on low performance agriculture and unsustainable harvesting of forest and wetland products as sources of income.

(d) Sub-component B.4: Ecosystem Management would strengthen management of remaining natural habitat blocks in the middle and lower Shire (such as Liwonde NP) to protect and enhance the delivery of environmental services (such as watershed protection, flood attenuation, biodiversity conservation, carbon sequestration and as a basis for generating revenues from tourism).

Component C: Water Related Infrastructure has the objective of developing the water resource by enhancing the infrastructure platform for multi-sectoral growth in the basin and to mitigate risks posed by droughts and floods. Development of critical infrastructure is essential to overcome annual and long-term variability in water resources availability for communities, environment and economic sectors. The Shire Basin has a unique resource base as it is the outflow of one of the largest Lakes in the World; with very complex climate response dynamics; and at the same time virtually the entire economy of the country is based on this resource making improvements to water resources management a must. The component will build on the basin planning carried out under Component A, and the priorities as set out in the national Water Resources Investment Strategy prepared in 2011. The component is organised in three sub-components.

(a) Sub-component C.1: Kamuzu Barrage will support the construction and construction supervision of the Kamuzu Barrage upgrade at Liwonde.

(b) The sub-component will finance the activities of the National Dam Safety Review Panel to review the quality of the engineering and construction. Separately, the sub-component is currently financing the implementation of the Environmental and Social Management Plan, and Resettlement Action Plan; on the basis of the independent Environmental and Social Impact Assessment (ESIA), conducted at design stage.

(c) Sub-component C.2: Flood Management in the Lower Shire in collaboration with other initiatives, to support the implementation of the Integrated Flood Risk Management Action Plan for the Lower Shire (see Component A). It will also support greater community involvement in the implementation process.

(d) Sub-component C.3: New Water Investments within the Shire basin will support feasibility and design studies for additional water related infrastructure works.

1.2 Scope and Objectives of the ESIA

The objectives of the ESIA as outlined in the ToR for the Consultancy are to:

1. Identify probable biophysical , socio-economic and health and sanitation impacts that the Project will have on aspects of the physical (receiving) and social environment, and to analyse and determine the significance of these impacts;
2. Identify, analyse, discuss and compare the proposed project with feasible alternatives (including the " Without Project" situation), and justify the selected alternative;
3. Identify measures required to prevent, minimise, mitigate or compensate for adverse impacts and for social and environmental enhancement;
4. Prepare an Environmental and Social Management Plan (ESMP) that describes in detail mitigation measures to be carried out, costing, scheduling and assigning responsibility for such measures, a detailed monitoring process and schedule and a description of any training support that may be required;
5. Conduct public consultation with affected stakeholders throughout the EIA process.

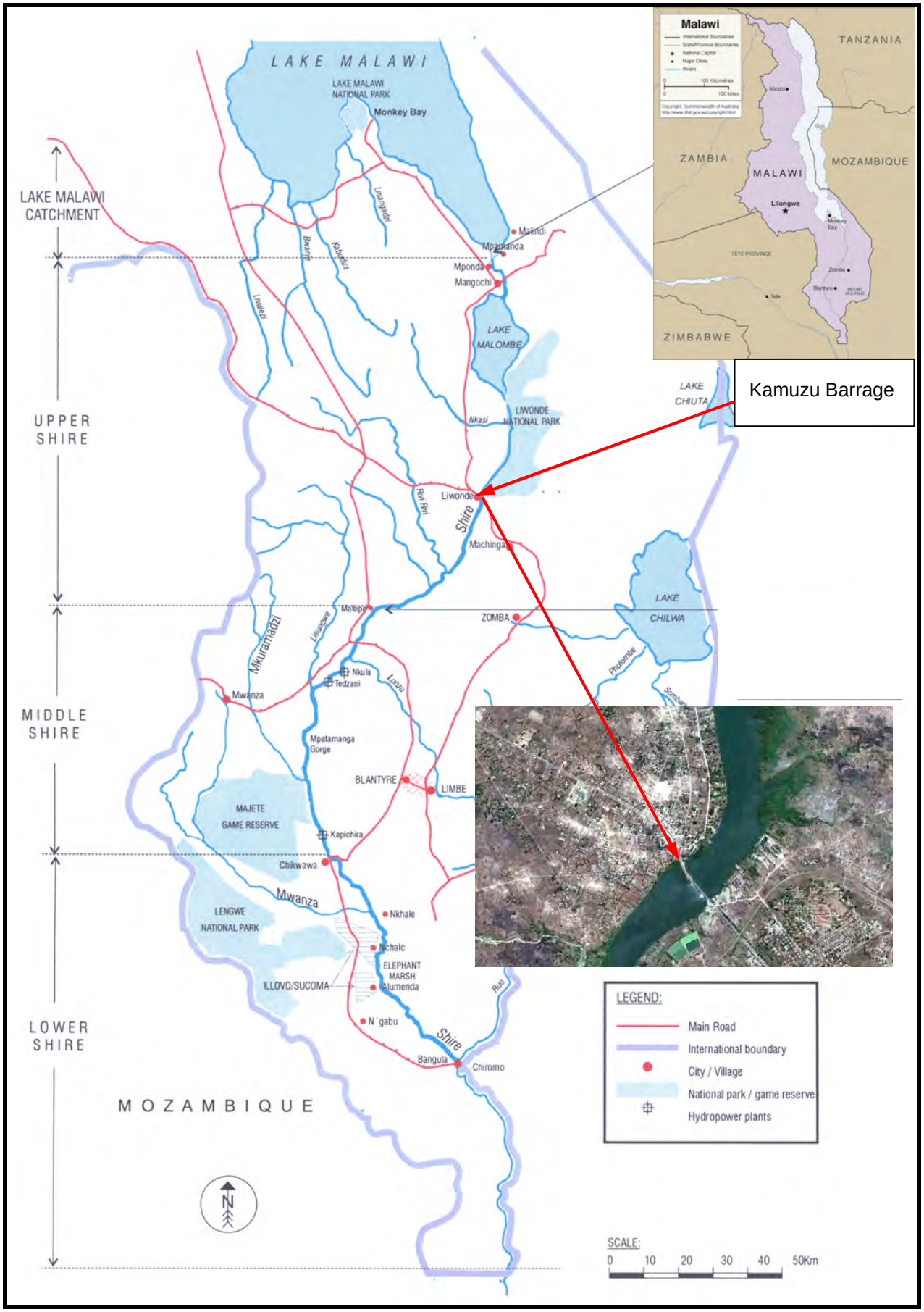


Figure 1. Project Location Map and Environmental Setting

1.3 ESIA Resourcing and ToR

The Ministry of Agriculture, Irrigation and Water Development contracted Snowy Mountains Engineering Corporation (SMEC International) of Australia to undertake a Consultancy for the environmental component of upgrading Kamuzu Barrage. The Contract for Consultancy Services was signed on 25th May 2011 between the Client (Ministry of Irrigation and Water Development) and the Consultant (SMEC International of Australia). The date for commencement of services was 8th June 2011. The time period for the Consultancy Services was originally 10 months.

The Consultancy Service requires the consultant to carry out a detailed Environmental Impact Assessment (EIA) for the upgrading of Kamuzu Barrage at Liwonde under Lake Malawi Level Control subcomponent, in accordance with the requirements of Malawi's EIA process and to World Bank standards. The Ministry of Agriculture, Irrigation and Water Development intends to incorporate all practical and cost-effective measures into the Project in order to avoid or minimize negative environmental impacts, capture environmental benefits and, overall, to ensure sound environmental management.

A list of the Consultant's staff and their positions is presented in Appendix 1.

As stated in the Terms of Reference (ToR), the purpose of the EIA is:

- To provide the Ministry of Agriculture, Irrigation and Water Development with advice on how the detailed Project may be designed and planned to avoid or mitigate negative impacts and to better capture anticipated environmental benefits; and
- To prepare an Environmental and Social Impact Assessment (ESIA) report acceptable to the Environmental Affairs Department of Malawi and the World Bank.

The Consultancy was supervised by the Program Manager, National Water Development Program within the Ministry of Water Development and Irrigation (MoWDI). The consultant reported to the Director of Water Resources in the MoWDI. The Client also assigned counterpart staff from within the MoWDI to work with the Consultant.

1.4 Report Content

The ESIA Report is arranged in two volumes, a main report (Volume 1) and an annex to the main report (Volume 2) containing the specialist reports as outlined in the table of contents to this report. This report is arranged as follows:

Chapter 1: Introduction

Chapter 2: Outlines the policy, legal and administrative framework for implementation of the Project.

Chapter 3: Provides a description of the Project and its objectives.

Chapter 4: Describes in detail the methodologies employed in undertaking the ESIA study including collecting baseline environmental and social information.

Chapter 5: Provides a description of the baseline environment impacted by the Project.

Chapter 6: Considers alternatives to achieving the Project objectives and also considers a "do nothing" option.

Chapter 7: Identifies the social and environmental impacts from the Project.

Chapter 8: Summarises the environmental and social management plan which is a separate stand-alone document. It lists the mitigation measures developed to minimise any adverse impacts and maximise Project benefits

Chapter 9: Lists the key actions to be implemented, summarises the compensation and monitoring costs and outlines the recommendations of the ESIA.

Chapter 10: Lists the reference material used in undertaking the ESIA study.

2 Policy, Legal and Administrative Framework

The MoWDI is committed to conduct its activities with full compliance to the requirements of national regulations and its obligations under international conventions and treaties, giving due consideration to international best practices and policies. This ESIA Report has been developed taking into consideration the laws and decrees of the Republic of Malawi and International Standard Policies including those of the World Bank, African Development Bank and other acknowledged international standards.

2.1 The Constitution of the Republic of Malawi, 1995

The Constitution of the Republic of Malawi, 1995, is the supreme law of the land. It contains, among other things, principles of national policy in section 13. The section sets out a broad framework for sustainable environmental management at various levels in Malawi. Among other issues, the section provides for environmental issues under Principles of National Policy. Section 13 (d) of the Constitution provides that the state shall actively promote the welfare and development of the people of Malawi by progressively adopting and implementing policies and legislation aimed at managing the environment responsibly in order to:-

a) Prevent the degradation of the environment;

b) Provide a health living and working environment for the people of Malawi;

c) Accord full recognition to the rights of future generations by means of environmental protection and the sustainable development of natural resources;

d) Conserve and enhance the biological diversity of Malawi; and

e) Enhance the quality of life in rural communities with the ultimate aim of attaining sustainable development.

The Constitution further provides for a framework for the integration of environmental consideration into any development programs. The implication of this provision is that Government, its cooperating partners and the private sector have a responsibility of ensuring that development programs and projects are undertaken in an environmentally responsible manner.

The Constitution Further provides the basis for and against land acquisition. Section 28 (2) of the Constitution of the Republic of Malawi states that “No person shall be arbitrarily deprived of property” and section 44 (4) states that “Expropriation of property shall be permissible only when done for public utility and only when there has been adequate notification and appropriate compensation, provided that there shall always be a right to appeal to a court of law for redress. The activities of the proposed Project will result in some people losing their land and property. As such provisions of section 44 (4) must be taken into consideration even before the inception of the Project.

In line with principles of national policy under section 12 of the Constitution, public participation is required for projects of this nature. This principle is based on the presumption that while organised society delegates its affairs to public institutions it retains the right to have an input in decision making and enforcement processes. The public must have unimpeded right to ensure that accepted standards are enforced. In that way institutions will not assume they are exclusive custodians of power and will ensure accountability in their actions.

Even though the principles of national policy in section 13 of the Republican Constitution are directory in nature, the state has a constitutional responsibility of ensuring that all programs and projects are undertaken in an environmentally sustainable manner in order to achieve the above policy objectives. Further, the Republican Constitution in section 146 establishes local government authorities and gives them the responsibility of, among other things, promoting infrastructural and economic development, through the formulation and execution of local government plans. It is therefore imperative that this project will have to be managed with the requirements of the national constitution in mind.

2.2 Legislative Framework

2.2.1 Environment Management Act, 1996 and EIA Guidelines, 1997

The Environment Management Act (EMA) is described as a framework piece of legislation on environmental management, protection and conservation. The Act contains general provisions on protection, management, conservation and sustainable utilisation for almost all forms of environmental media.

The Act provides for Environmental Impact Assessment (EIA) under Part IV. It further gives power to the Minister to publish in the Gazette the type and size of projects that shall not be implemented without an EIA. A prescribed list of projects for which EIA is mandatory is given in Malawi's Guidelines for EIA, 1997. Environmental Impact Assessment is mandatory for the rehabilitation of the Kamuzu Barrage at Liwonde. The Act requires that every developer implementing a project requiring an EIA must submit to the Director of Environmental Affairs a project brief, stating the matters provided for under section 24(2). If the Director is satisfied that there is sufficient information in the project brief, he will require the developer in writing to conduct an EIA in accordance with prescribed guidelines and submit to the Director an EIA report giving the particulars stipulated in section 25(1).

Upon receipt of the EIA report the Director must invite written or oral comments from the public and may conduct public hearing or require the developer to redesign the project or conduct a further EIA or recommend to the Minister to approve the project subject to such conditions as the Director may impose. In making the decision whether or not to recommend to the Minister to approve the project or impose any conditions, the Director shall take into account any likely impact of the project on the environment and the actual impact of any existing similar project on the environment. Finally, it should be noted that no licensing authority can issue any license under any written law unless the Director certifies either that the project has been approved by the Minister under EMA or that an EIA is not required.

Part IV of the EMA makes provision for pollution control that is, both air and water pollution. With regard to water pollution, the EMA prohibits discharging of any pollutants into the environment. It further makes it a duty of every person to prevent the discharge of any pollutant into the environment otherwise than in accordance with it and to comply with such general or specific directions of the Minister or Director for preventing, minimising or cleaning up, removing or disposing of any pollutant discharged into the environment. Although the provision requires that any discharge of pollutants be in accordance with the EMA, nowhere has the EMA made provision to that effect. However the EMA goes on to provide that where any person discharges any pollutant into the environment otherwise than in accordance with it, he or she may be required by the Minister to clean up, remove or dispose of the pollutant in such manner and within such period as the Minister shall direct.

The consultant therefore carried out an EIA study to determine the potential positive and negative environmental and social impacts that could arise during project implementation, but more so to come up with an Environmental Management Plan (EMP) to enhance the positive impacts; and prevent, reduce and or mitigate the negative impacts. The EIA for the proposed project is in compliance with the requirements of the Act and the Guidelines. Furthermore, the Director may, in consultation with a lead agency, also carry out or cause to be carried out periodic environmental audits of the project.

2.2.2 Land Act (1965)

The Land Act, 1965, mainly deals with issues of ownership, land transfer, use of land, and compensation. It recognises that every person has a natural dependency on land and that it is therefore important that Government provides for secure and equitable access to land as a multipurpose resource and an economic assert by defining issues of security of tenure. The Land Acquisition Act outlines procedures to be followed for land acquisition by individuals or Government. The procedures include the steps to be undertaken for government to acquire land starting from issuance of formal notices to persons with existing land interests to payment of compensation for land ownership transfer. This has implications on the proposed Project in that all land required permanently for the construction footprint should be acquired following formal land acquisition procedures and that people who will lose property (either temporarily or permanently) or who will be displaced should be fairly compensated.

Further, under section 14 of the Act, the Minister has power to re-enter for breach of conditions contained or implied in a lease. The developer will work closely with the local community and will inform them and where

required, obtain consent from chiefs, headmen, area councillors and local authorities for the construction works.

2.2.3 The Lands Acquisition Act (1971)

The Lands Acquisition Act (Cap 58:04) and the Public Roads Act (Cap 69:02) set out in detail, the procedures for acquisition of customary land and freehold land. The processes and procedures for proclamation of the land required permanently in this Project in the construction footprint area should follow the steps as provided for in the existing Lands Acquisition Act (Chapter 58:04) Sections 3-11.

Land for this Project will be acquired from individuals. There will be a need to make sure that procedures set out in the Act are followed to ensure that landowners are fairly and equitably compensated.

2.2.4 Forestry Act (1997)

The Act deals with the management of indigenous forests on customary and private land; forest reserves and protected forest areas; woodlots and plantation forestry and also crosscutting issues including law enforcement and fire management. The Act among other things seeks to protect trees and other resources in forest reserves, conserve and enhance biodiversity, protect and facilitate management of trees on customary land, promote community involvement in the conservation of trees, promote sustainable utilisation of timber and other forest produce and protect fragile areas such as river banks and water catchment. Rehabilitation of the Kamuzu Barrage and construction of diversions and the new bridge downstream will result in destruction of riverine vegetation on the river banks and in the water due to alternative crossing of the watercourse during construction.

Construction of diversions will have to undertake measures to protect riverine vegetation on the river banks and in the water, trees within the diversions and limit the cutting down of trees to where it is absolutely necessary in consultation with relevant authorities and communities.

2.2.5 Water Works Act, 1995

The Act has some potential to effectively address the issue of water pollution and pollution from water effluents discharged into water systems. It provides for the establishment of water Boards and water-areas and for the administration of such water-areas and for the development, operation and maintenance of waterworks and waterborne sewerage sanitation systems in Malawi and for matters incidental thereto. The Water Works Act gives these Water Boards various powers and duties in connection with water supplies and waterborne sewerage sanitation in their respective water areas.

Firstly, the Act imposes a duty on the Water Boards to provide a supply of portable water sufficient for the domestic purposes of the inhabitants within their respective water- areas. This presupposes a supply of fresh and clean water, free of pollutants because only clean water can be safely used for household purposes.

The Act also empowers Water Boards to make by-laws for the regulation of the use and the prevention of pollution and the prevention of pollution of gathering grounds, waterworks and water therein.

The Act prohibits people from throwing, emptying into public sewers any:

a) Matter likely to injure the sewer or drain, or to interfere with free flow of its contents, or to affect prejudicially the treatment and disposal of its contents; or

b) Chemical refuse or waste steam; and

c) Petroleum spirit or carbide of calcium.

The rehabilitation works of the Kamuzu Barrage at Liwonde will have the potential to interfere with, pollute or foul the water of Shire River. This Project will need to comply with the relevant provisions of this Act. The developer needs to ensure that the Shire River is not polluted or that any noxious matter is carried into the river.

2.2.6 Water Resources Act (1969)

The management of water resources has to contend with two distinct though related issues: provision of a wholesome supply and the removal and disposal of contaminated liquid wastes and in that regard has a

bearing on waste management. The Water Resources Act, 1969 is the major statute dealing with management of water resources.

The Act specifically deals with control, conservation, apportionment and use of water resources of Malawi. The Act further prohibits any person to divert, dam, store, abstract or use public water for any other purpose except in accordance with the provisions of this Act. The Act under Section 16 (i) makes it an offence for any person to interfere with, alter the flow of or pollute or foul any public water. The Act defines pollution or fouling of public water to mean the discharge into or in the vicinity of public water or in a place where public water is likely to flow, of any matter or substance likely to cause injury whether directly to public health, livestock, animal life, fish, crops orchards or gardens which such water is used or which occasions, or which is likely to occasion, a nuisance.

The activities of the proposed Project will have the potential to interfere with, alter the flow of or pollute or foul the water of Shire River. It is worth pointing out that no offence is committed if a discharge is, inter alia, under the authority of the Act or any other written law as under the Water Resources (Water Pollution Control) Regulations made pursuant to section 24 of the Act, the Board is given powers to consider applications for a Ministerial consent to discharge waste or effluent into public water.

Under section 6 of the Act, the right to use public water may be limited if the use may cause damage to natural resources of the area or in the vicinity. On the current Project, section 16 of the Act should be considered. It provides that it is an offence for any person to interfere with or alter the flow or pollutes or fouls any public water. Polluting or fouling public water is defined as discharging any matter or substance likely to cause injury to public health, livestock, animal life, fish, crops or gardens.

Further, under the Regulations, persons are not allowed to discharge into public water any water of less purity or any matter that might affect the river or fish. The developer therefore will have to ensure during the whole lifecycle of the Project that the Act and the Regulations are not contravened.

2.2.7 Occupational Safety, Health and Welfare Act, 1997

This Act aims at consolidating the law regarding the preservation of public health. In pursuance of this objective, the Act makes provision for the control and provision of water pollution generally and also the use of public sewers so as to prevent pollution. In this respect, the Act imposes a duty on every local authority to take all lawful, necessary and reasonably practicable measures for preventing any pollution dangerous to health of any supply of water which the public within its district has a right to use and does use for drinking or domestic purposes.

The imposition of such a duty on the local authorities is mainly meant to ensure access to clean drinking water to members of the public, which is a facet of public health. Where drinking water has been polluted, the Act also imposes a duty on the local Assemblies to take reasonable and lawful measures aimed at purifying such polluted water. This places a daunting task on the local assemblies which, though costly, is important if members of the public are to be safeguarded from waterborne diseases which may be contained in polluted water.

In order to recoup expenses that might have been incurred in the process of preventing water pollution or indeed purifying water that has already been polluted, the Act empowers the local authorities to take any necessary measures, including legal proceedings against any person polluting any such supply or polluting any stream so as to be a nuisance or danger to health.

The Act under Part X requires developers to provide adequate sanitary and health facilities near the barrage where the campsite will be located to avoid harmful effects of waste on public health. This is important for the proposed Project as the developer is likely to build a camp site close to the barrage where different construction materials will be stored and subsequently some workers will reside on the site.

Further, section 82 prohibits persons from passing certain matters into public waters. The matters include petroleum spirit and any substance that may cause injury to public health.

The developer will have to comply with the requirements of this Act by designing waste disposal facilities in accordance with the anticipated volumes of waste. The Project will further ensure that measures to prevent diseases and pollution dangerous to human health and to any water supply are taken into account.

The Occupational Safety, Health and Welfare Act is important in safeguarding the health and welfare of all workers. The developer will have to ensure that there is adequate protection for the workers who will be on site as required by the Act.

2.2.8 The Employment Act, (2000) and Labour Relations Act, (1996)

The two Acts regulate employment matters i.e. minimum wage, fair labour practices, non-discrimination, prohibition (in some cases) of employment of children. When employing people for the implementation of the Project activities, the developer should ensure that provisions of this Act are taken care of.

2.2.9 Town and Country Planning Act (1990)

This Act makes provision with respect to town and country planning. It regulates land use planning and physical developments in Malawi. Generally, land use control plays a major role in environmental management through physical planning, zoning, and the creating of protected areas.

The Act creates the public office of the Commissioner for Town and Country Planning and it also creates the Town and Country planning Board. Section 20 provides for the development of a National Physical Development Plan in order to contribute to a balanced pattern of development and economical use of resources. The Act requires developers to obtain development permission from the local Planning Committee. The Planning Committee considers the foreseeable impacts of the proposed development; noise, air, water, ground pollution, and any detrimental effect; traffic; and the contribution of the project to the economy before granting any development permission.

This therefore means that the rehabilitation works for the Kamuzu Barrage needs to be approved by the Planning Committee for Liwonde Town Council. The approval will only be given if the developer satisfies the requirements under the Act including the zoning restrictions. Under section 52 and 53 of the Act, the Minister may declare any area a special area for the purpose of protecting the natural environment of the land or water from the harmful effects of development.

The Act regulates land use planning and physical developments in Malawi. It seeks to promote orderly physical planning in an attempt to optimise use of and service infrastructure and protect and conserve fragile ecosystems in space. This is achieved by guiding physical developments through provision of planning permission following appropriate scrutiny by local planning committees or the Commissioner for Physical Planning. Section 40 of the Act regulates development by prescribing screening for environmental and socio-economic implications for large scale development projects before planning permission is granted. Since the proposed Project is large scale, it will have to undergo screening before permission is granted, hence need for the EIA.

2.2.10 National Parks and Wildlife (Amendment) Act, 2004

The most relevant Section is Part IV under which an EIA can be requested for any Government or private activity which may have an adverse effect on wildlife species or community. Part V of the Act establishes National Parks and Wildlife Reserves while Part VI lists protected species of plants and animals.

2.2.11 Fisheries Conservation and Management Act (1997)

The principal legislation regulating fisheries management is the Fisheries Conservation and Management Act (FCMA), 1997 which replaced the Fisheries Act of 1974. The FCMA was enacted to make provision for regulation, conservation and management of fisheries of the country. The Act provides for mandatory monitoring and control of pollution of various water bodies from toxic chemicals/substances including persistent organic pollutants. The Act further provides for penalties for both pollution and failure to remove pollutants. Under Section 43, the Act prohibits pollution of rivers, streams and lakes. The works for the rehabilitation of Kamuzu Barrage at Liwonde if not well managed will pollute the water of the Shire River and may affect fish, fish spawning grounds and other aquatic life. The Project should ensure that it does not engage in acts or omissions that may adversely affect fish in the river.

2.2.12 Public Roads Act (1989)

This Act under Part II — Compensation, contains a detailed compensation scheme. Section 44 provides for the assessment of compensation, payable under the Act regarding the land or surface rights of an owner or

occupier. Section 45 provides for the compensation for which land becomes public and specifically states that in the case of customary land compensation shall be in respect of disturbance.

Section 46 outlines matters to be taken into consideration and matters to be disregarded in assessing compensation. Section 47 outlines the procedure to be followed when pursuing claims for compensation and section 48 provides for procedure before compensation boards. Sections 49 and 50 respectively deal with appeals to the High Court and state that there shall be no further appeal from the High Court. The provisions of this Act must therefore be strictly observed by the contractor. Furthermore, in this Project, diversions from the existing bridge to the bridge to be constructed downstream are part of the overall designs for barrage rehabilitation.

2.2.13 Malawi Bureau Standards Act (1972)

The Malawi Bureau of Standards (MBS) is a statutory organisation established by the Malawi Bureau Standards Act (1972). It is charged with the preparation and promulgation of national standards. Formulation of standards is done through Technical Committees whose membership covers representatives from industry, government, non-governmental organisations, professional bodies, consumers and other interested parties. Current Technical Committees include one for environmental protection and pollution Control.

2.3 Relevant Policies, Plans and Strategies

Several Malawi sector-specific policies, plans and strategies may be touched upon by the proposed development and its broader implication. The relevant policies, plans and strategies are discussed below.

2.3.1 National Environmental Action Plan (NEAP), 2004

The NEAP was prepared in 1994 in response to Agenda 21 that required signatories to the 1992 Rio Declaration to prepare an action plan for integrating environmental issues into socio-economic development programs. The NEAP was updated in 2004. The objectives of the NEAP are to:

a) Document and analyse all major environmental issues and measures in order to alleviate them;

b) Promote sustainable use of natural resources in Malawi; and

c) Develop an environmental protection and management plan.

Key issues that NEAP identified and are relevant to this Project include:

a) Soil erosion;

b) Water resources degradation and depletion;

c) Threat to fish resources; and

d) Threat to biodiversity.

In order to protect the environment from further degradation; the NEAP outlines actions that need to be considered to ensure adequate environmental protection. The actions relevant to the establishment of the Project in question include:

a) EIAs will be required for any development that may affect fragile ecosystems; and

b) Government will ensure that workers in hazardous workplaces are supplied with the appropriate protective equipment and undergo pre-employment medical examinations and regular check-ups.

2.3.2 National Environmental Policy, 2004

The National Environmental Policy (NEP), 2004, aims at narrowing the gap between the degradation of the environment and depletion of the natural resources on one hand and development on the other. The Policy promotes sustainable social and economic development through sound management of the environment and natural resources. The policy seeks, among other things to:

a) Secure for all persons now and in the future an environment suitable for their health and well-being;

b) Promote efficient utilisation and management of the country's natural resources and encourage, where appropriate long-term self-sufficiency in food, fuel wood and other energy requirements;

c) Facilitate the restoration, maintenance and enhancement of the ecosystems and ecological processes essential for the functioning of the biosphere and prudent use of renewable resources;

d) Integrate sustainable environment and natural resources management into the decentralised governance systems and ensure that the institutional framework for the management of the environment and natural resources supports environmental governance in local government authorities;

e) Enhance public education and awareness of various environmental issues and public participation in addressing them; and

f) Promote local community, NGO and private sector participation in environment and natural resources management.

In as far as water resources are concerned, the NEP's overall objective is to manage and use water resources efficiently and effectively so as to promote its conservation and availability in sufficient quality and acceptable quality. In order to realise this objective, the NEP lays down a number of guiding principles. With regard to water pollution, the NEP states that the precautionary approach to water quality management shall be pursued with a focus on pollution minimisation and prevention. Further, the NEP advocates for the incorporation of the polluter pays principle in water policy and legislation so as to ensure that costs of unsustainable water utilisation and management are borne by the party responsible for such acts.

In the NEP, there are strategies on environmental planning and environmental impact assessment, audits and monitoring, among others. On environmental planning, the objective is to ensure that national and district development plans integrate environmental concerns, in order to improve environmental management and ensure sensitivity to local concerns and needs. On EIAs, the objective is to regularly review and administer the guidelines for EIAs, audits, monitoring and evaluation so that adverse environmental impacts can be eliminated or mitigated and environmental benefits enhanced.

In line with the environmental policy (on planning and EIAs, among others), the developers must integrate environmental concerns during the whole cycle of the project i.e. planning, design, and implementation. The rehabilitation works of the Kamuzu Barrage at Liwonde will have a potential to pollute the water of Shire River. The implication of the policy is that the Project has to put in place measures to reduce adverse impacts arising from the activities of the Project and that implementation of the activities of this Project has to take sustainability issues on board.

2.3.3 National Land Policy, 2002

This is the principal policy that guides the land management and administration issues in Malawi. The policy introduces major reforms intended for land planning, use, management and tenure. It provides clear definition of land ownership categories (Section 4), and addresses the issue of compensation payment for land (Section 4.6).

Of relevance is the fact that the policy provides for Land use Planning and Development, and Environmental Management. On land use planning, the policy provides that land allocation should be done in a manner as to obtain effective use and at the same time pay attention to the built environment and welfare of community. To achieve this policy objective, a comprehensive National Land Use and Physical Development Management Policy shall be developed.

On environmental management, the policy aims at lending support to the policies and strategies that are already in place. One of the serious problems identified in the policy is the management of solid and liquid waste, protection of sensitive areas, development in fragile areas, and coordination of multiple land use.

The policy also has provisions for environmental management covering issues related to both urban and rural management of solid and liquid waste, protection of sensitive areas, agricultural resource conservation and land use, community forests and woodland management, over-dependence on fuel wood, forest programs, co-ordination of multiple land use, water resources and wetlands, lakeshore environmental management and mining and minerals. Of particular importance is section 9.8.1 (c) which states that development activities in fragile ecosystems such as wetlands, game reserves, forest reserves and critical habitats will only be permitted after the appropriate authority has conducted an environmental impact assessment. The proposed rehabilitation works of the barrage will require construction of a bridge downstream to allow traffic cross the Shire River during the rehabilitation. This will result into construction of diversions from the existing road

structure to direct traffic to the new bridge. The diversion will pass through privately owned land, dimba farms and some fragile land. As such, section 4.6 on compensation will guide the developer on how to deal with compensation matters for the temporary or permanent loss of land access, property and displaced persons.

2.3.4 National Water Policy (2004)

Malawi's policy on water resources management requires that:

a) Water should be managed and used efficiently and effectively in order to promote its conservation and future availability in sufficient quantity and acceptable quality; and

b) All programs related to water should be implemented in a manner that mitigates environmental degradation and at the same time promotes the enjoyment of the asset by all.

For a long time rivers have been used as a cheap and convenient repository for human and industrial waste. Recently they have come to be recognized as the basis of unique ecosystems worthy of protection in their own right. If the water is to continue to perform this and other many important roles in a sustainable manner then unrestrained disposal of materials into the aqueous environment poses an unacceptable threat.

Section 5.2.1 to 5.2.14 provides strategies for the prevention of pollution and the maintenance of water quality. Activities of the barrage rehabilitation if not managed properly will significantly degrade water of the Shire River. This Project will therefore have to ensure that it abides by the provisions of this policy in order to avoid the deterioration of water quality as a result of the Project's activities.

2.3.5 National Forestry Policy (1997)

The policy aims at promoting sustainable contribution of national forests, woodlands and trees towards the improvement of the quality of life in the country by conserving the resources for the benefit of the nation and to the satisfaction of diverse and changing needs of Malawi population, particularly rural smallholders. The policy prevents unnecessary changes in land-use that promote deforestation, or endanger the protection of the forests which have cultural, biodiversity or water catchment values. It also discourages development activities in gazetted forests unless proven to be environmentally friendly for which suitable inter-sectoral and local consultations will be conducted.

Above all, the policy advocates for the carrying out of environmental impact assessment where actions are likely to have significant adverse impacts on important forests and other resources. Rehabilitation of the Kamuzu Barrage and construction of diversions and the new bridge downstream will result into destruction of riverine vegetation on the river banks and in the water due to alternative crossing of the watercourse during construction.

Construction of diversions will have to undertake measures to protect riverine vegetation on the river banks and in the water, trees within the diversions and limit the cutting down of trees to where it is absolutely necessary in consultation with relevant authorities and communities.

2.3.6 National Parks and Wildlife Policy (2000)

The goal of the National Parks and Wildlife Policy (2000) is to ensure proper conservation and management of wildlife resources in order to provide for sustainable utilisation and equitable access to the resources; and the sharing of benefits arising from the use of the resources for both present and future generations. One of the objectives of achieving this goal is to ensure adequate protection of ecosystems and their biological diversity through promotion and adoption of appropriate land management practices that adhere to the principle of sustainable development.

2.3.7 National HIV AIDS Policy

The National HIV AIDS Policy (2003) provides technical and administrative guidelines for the design, implementation and management of HIV/AIDS interventions, programs and activities at all levels of the Malawi society. It offers guidance on critical intervention areas, among them social and economic support for people living with HIV/AIDS; their full integration into the response, going beyond the typical token representation; provision of care and support for treatment to achieve a better quality of life for all Malawians living with HIV/AIDS; and protection of their human rights and freedoms.

The goals of the National HIV/AIDS Policy are to:

1. Prevent the further spread of HIV infection;
2. Mitigate the impact of HIV/AIDS on the socioeconomic status of individuals, families, communities and the nation.

The Policy is implemented through the National Aids Commission (National Aids Commission, 2003).

2.3.8 The Malawi Growth and Development Strategy

The Malawi Growth and Development Strategy II (MGDS II) is the overarching strategy for Malawi for the five years from 2011/12 to 2015/16. The overriding philosophy is poverty reduction through sustainable economic growth and infrastructural development. The MGDS identifies six key priority areas for the country to achieve economic development. The areas are agriculture and food security; irrigation and water development; transport infrastructure development; energy generation and supply; integrated rural development; prevention and management of nutrition disorders, HIV and AIDS.

The MGDS will accelerate the attainment of the Millennium Development Goals. The MGDS therefore aims at maintaining a balance between the economic and social sectors of the economy.

The MGDS is built around five thematic areas namely sustainable economic growth; social protection; social development; infrastructure development, and improved governance.

In translating the Millennium Development Goals, the MGDS recognize that managing natural resources is an essential aspect of environmental sustainability. Further, on sub-theme four of theme one (sustainable economic growth), the MGDS recognises that sustainable use of natural resources contributes to many of the goals in the MGDS. This includes fisheries, wildlife, forestry, and environmental protection. Efforts in environmental protection will focus on improving compliance with environmental and natural resource management laws.

The developer has to comply with the strategies in the MGDS on the conservation of the environment during the Project.

2.3.9 WHO Standards

The World Health Organisation (WHO) is the directing and coordinating authority for health within the United Nations system. It is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends.

WHO standards relevant to Kamuzu Barrage Refurbishment Project include:

- standards for drinking water
- standards for heavy metals
- standards for wastewater
- standards for heavy metals in soil
- standards for water quality parameters

WHO also develops global guidelines such as the WHO Guideline on HIV/AIDS which are also relevant to the Project.

2.4 Private Sector Capacity

Construction Contractors for the Project will be appointed through international competitive bidding and contract documentation includes environmental monitoring and management requirements. Such requirements are standard practice and most international contractors are aware of the need to carry them out. However, the level of adherence is often dependent on the environmental monitoring and management expertise of the Supervising Consultant and the relevant sectoral agency, which in this case is MoWDI.

It is important therefore that Contractors are provided with detailed environmental monitoring and management plans and that Contractor staff are given on-site environmental training by the supervision consultant and MoWDI throughout the construction period.

2.5 World Bank

The World Bank provides guidance on EIA requirements through the Environmental Assessment Sourcebook (World Bank 1994) which includes sectoral guidelines. In particular, Vol. 2 of the Sourcebook dealing with Sectoral Guidelines for Environmental Assessment of Energy and Water Projects provides a detailed analysis of the potential environmental impacts associated with hydropower generation including dams and transmission structures. It also addresses environmental monitoring and management issues and identifies typical mitigation measures.

The World Bank EIA process is implemented through a set of Operational Safeguards Policies/Procedures (OP/BPs) whose primary objective is to ensure that Bank operations avoid, minimise or mitigate any adverse social or environmental impacts. The following WB Safeguard Policies/Procedures have been considered for Kamuzu Barrage ESIA as a technical reference.

OP/BP 4.01 Environmental Assessment (January 1999)

Ensures that appropriate levels of environmental and social assessment are carried out as part of project design. It also deals with the public consultation process, and ensures that the views of project-affected persons/groups and local NGOs are taken into account. It outlines the contents of environmental assessment reports and environmental management plans for Category "A" projects.

Comment: This Safeguard Policy is relevant because of the nature and size of the Project and its potential to cause significant adverse impacts including loss of land and other private assets and impacts on businesses.

OP/BP 4.04 Natural Habitats (June 2001)

Supports the conservation of natural habitats and the maintenance of ecological functions as a basis for sustainable development. The Bank does not support projects that involve the significant conversion or degradation of critical natural habitats.

Comment: This Safeguard Policy is relevant because operation of the upgraded Kamuzu Barrage will, to some extent affect critical natural habitats (particularly Liwonde National Park), along with some threatened animal species.

OP/BP 4.36 Forests (November 2002)

Aims to reduce deforestation and enhance, through sustainable economic development, the environmental and social contribution of forests. The Bank does not support projects which involve significant conversion or degradation of critical forest areas or related critical natural habitats.

Comment: This Safeguard Policy is relevant because operation of the upgraded Kamuzu Barrage is likely to affect forest and woodland areas, particularly within Liwonde National Park.

OP/BP 4.11 Physical Cultural Resources (July 2006)

Cultural property is defined to include both remains left by previous human inhabitants (e.g. middens, shrines) and unique natural environmental features such as canyons and waterfalls. The Bank does not support projects that will significantly damage non-replicable cultural property and assists only those projects that are sited or designed so as to prevent such damage.

Comment: This Safeguard Policy is relevant because construction activities (related to quarry and borrow areas) might reveal important cultural resources that would be permanently affected by the Project.

OP/BP 4.12 Involuntary Resettlement (December 2001)

The World Bank's involuntary resettlement safeguarding regulations and requirements are triggered when a project leads to the involuntary taking of land resulting in:

- relocation or loss of shelter;
- loss of assets or access to assets;
- loss of income sources or means of livelihood, whether or not the affected persons must move to another location;
- involuntary restriction of access to legally designated parks and protected areas resulting in adverse impacts on the livelihoods of the displaced persons.

The overall objectives of Operational Policy 4.12 (the Bank's policy on involuntary resettlement as defined above) are:

- to avoid or minimise involuntary resettlement, by exploring "all viable alternative project designs;
- where population displacement is unavoidable, to conceive and execute resettlement activities as sustainable development programs;
- that displaced persons should be meaningfully consulted and should have opportunities to participate in planning and implementing resettlement programs; and
- to assist displaced persons 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.

OP/BP 4.12 requires that displaced persons are provided prompt and effective compensation at full replacement cost for losses of assets attributable directly to the project; provided assistance (such as moving allowances) during relocation; and provided with residential housing or housing sites. The policy also requires that taking of land and related assets may take place only after compensation has been paid and, where applicable, resettlement sites and moving allowances have been provided.

OP/BP 4.12 identifies three categories of affected persons:

- those who have formal legal rights to land, including customary and traditional rights recognised under the laws of the country;
- those who do not have formal legal rights to land, but have a claim to such land or assets provided that such claims are recognised under the laws of the country or become recognised through a process identified in the resettlement plan." This is further explained: "Such claims could be derived from … continued possession of public lands without government action for eviction (that is, with the implicit leave of the government)"; and
- those who have no recognisable legal right or claim to the land they are occupying.

People described in (a) and (b) above should be compensated for the land they lose, as well as provided with other agreed-upon assistance whereas those described in (c) above should be provided with resettlement assistance in lieu of compensation for the land they occupy as well as other assistance as necessary, if they have occupied the area prior to an agreed cut-off date for entitlements. All three cases should be provided with compensation for loss of assets other than land.

Comment: This safeguard Policy is relevant since the Project will result in loss of land and other private assets as well as temporary loss of access to business premises.

OP 7.50 Projects on International Waterways

This Safeguard is relevant to the Project since it conforms to at least one defining criteria:

- The primary water source Lake Malawi forms a boundary between three countries (Malawi, Mozambique and Tanzania);

Comment: The underlying requirement in the Operational Policy is for communication of project design and implementation features to the boundary states – in this case Mozambique and Tanzania - so that they can conduct reviews and transmit specific concerns, or lack thereof, to the Government of Malawi. The SRBMP of which Kamuzu Barrage Upgrading is a component, has been referred to Mozambique and Tanzania in accordance with this directive.

OP 4.37 Safety of Dams

Safety of Dams requires competent and periodic inspection of both new and existing dams to ensure that risks from failure are acceptably low and that measures are in place to deal with structural failures.

Comment: This safeguard Policy is triggered. However, since the proposed dam wall size is less than the threshold for large dams the requirements are less stringent. Generic dam safety measures designed by qualified engineers are usually considered adequate for small dams.

OP 17.50 Disclosure

This Policy details the Banks requirements for making operational information available to the public. The Bank reaffirms its recognition and endorsement of the fundamental importance of transparency and accountability to the development process. In addition, timely dissemination of information to local groups affected by the projects and programs supported by the Bank, including nongovernmental organisations, is essential for the effective implementation and sustainability of projects.

Beyond these Safeguards Policies, and because of its cross-cutting dimensions, the World Bank requires due consideration to gender dimensions. Though OP 4.20 Gender and Development is not a Safeguards Policy per se, its' main objective is "to reduce poverty and enhance economic growth, human well-being, and development effectiveness by addressing the gender disparities and inequalities that are barriers to development". This objective is closely aligned with the development objective of the Shire River Basin Management Project.

2.6 International Agreements

Malawi is party to a number of internationally acceptable policies, conventions, treaties and protocols in order to augment the national policies and laws. International laws and probably their institutions serve as the principal framework for international co-operation and collaboration between members of the international community in their efforts to protect the local, regional and global environment. This is due to the fact that most environmental problems have a trans-boundary effect hence require a concerted effort to manage them. It is therefore apparent from the foregoing, that international environmental laws assist in capturing and building consensus between nations on goals for environmental protection, resource conservation and sustainable use.

Malawi, just like other States will become bound to the provisions of an international agreement/law, only if it signs and submits instruments of ratification in respect of a particular agreement. The international environmental instruments relevant to the EIA study which Malawi signed or ratified are listed in Table 1.

TABLE 1. INTERNATIONAL ENVIRONMENTAL INSTRUMENTS SIGNED AND RATIFIED BY MALAWI

Name of Convention / Protocol	Date of Entry into Force	Date Malawi Ratified	Project Relevance
African Convention on the Conservation of Nature and Natural Resources	15.09.1968	14.04.1973	The Convention requires the contracting States to undertake and adopt measures necessary to ensure conservation, utilisation and development of soil, water, flora and fauna resources in accordance with scientific principles and with due regard to the best interests of the people. The Convention has implications to the Project in that the refurbished Barrage has potential effect s on the soil, water, flora and fauna resources of the Shire River system.
Convention on Wetlands of International Importance especially as Waterfowl Habitat (RAMSAR)	02.02.1971	14.03.1997	The RAMSAR treaty provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Malawi has only one wetland listed under RAMSAR – Lake Chilwa

Name of Convention / Protocol	Date of Entry into Force	Date Malawi Ratified	Project Relevance
			however this wetland is not affected by the Project.
SADC revised Protocol on Shared Watercourses	22.09.2003	31.05.2001	The Protocol is aimed at fostering closer cooperation for judicious, sustainable and co-ordinated management, protection and utilisation of shared watercourses and advance the SADC agenda of regional integration and poverty alleviation. The Protocol is relevant to the Project as Lake Malawi is a shared water body between Malawi, Mozambique and Tanzania. Also the Shire River flows into Zambezi River and any activities on the Shire River which will have any impacts on the waters of Shire River will also have impacts on the Zambezi River.
SADC Protocol on Forestry	3/10/2002	2003	The Protocol applies to all activities relating to development, conservation, sustainable management and utilisation of all types of forests and trees, and trade in forest products throughout the SADC Region. The Project potentially impacts on riparian forests along the Shire River system.
SADC Protocol on Fisheries	8.08.03	24.09.02	The objective of this Protocol is to promote responsible and sustainable use of the living aquatic resources and aquatic ecosystems of interest to State Parties. The implication of the Protocol on the Project is that the activities of the Project have to ensure that they do not have significant adverse effect on the living aquatic resources and aquatic ecosystems of interest to Malawi.
Zambezi Watercourse Commission (ZAMCOM)	2005	-	The objective of the Commission "is to promote the equitable and reasonable utilization of the water resources of the Zambezi Watercourse as well as the efficient management and sustainable development thereof." The Protocol is relevant to the Project since the Shire River flows into the Zambezi River.

3 Project Description

3.1 Location and Justification

Kamuzu Barrage was constructed across the Shire River at Liwonde on the Zomba to Lilongwe road approximately 230 km south-east of the capital city of Lilongwe (Figures 2 and 3). The latitude and longitude of the Barrage structure is 15°03'38"S and 35°13'8"E. It is located on the upper Shire River downstream of Lakes Malawi and Malombe and within Balaka and Machinga Districts (Figure 4).

The Barrage was originally constructed in response to low rainfall in the catchment areas of Lake Malawi and the Shire River resulting in lowered lake levels and lack of flow in the Shire River which in turn adversely affected hydropower generation, irrigation, urban water supplies and transport as well as livelihood activities such as dimba cultivation and fisheries for those living adjacent to the two Lakes and the Shire River.

Kamuzu Barrage which became operational in 1965 is reported to have outlived its life by about 25 years. The major concerns for its safety and operation include the following. There are no energy dissipation works downstream of Bays 4 to 14. Limited inspections through divers have confirmed the occurrence of scour / erosion up to 2 metres depth immediately downstream of the sheet pile. The scour hole if it develops significantly can endanger the safety of the Barrage structure. 10 to 20 mm wide cracks have been observed on the upstream side of some of the pillars. The submerged portion of the Barrage has never been inspected and condition of the submerged part is unknown. Some of the gates are no longer fully functioning.

Figure 2. Downstream view of Kamuzu Barrage on the Shire River, Liwonde.

Figure 3. Kamuzu (Liwonde) Barrage road deck.

Different ways of securing and further regulating the water flow in the Shire River have been suggested and studied. The most recent of these studies is the Lake Malawi Level Control Study – Phase I and II which analysed different types of interventions to further regulate flows in the Shire River. One alternative dealt with the option of upgrading the existing Barrage at Liwonde.

The purpose of upgrading Kamuzu Barrage is to increase water storage capacity upstream (particularly within Lake Malawi) and thereby to help ensure year-round downstream flows in the Shire River to sustain key economic activities. These include hydropower generation (most of Malawi's electricity comes from Shire River hydroelectric plants), water supply (including for the city of Blantyre), existing and proposed irrigation systems, fisheries, traditional flood-recession agriculture, and other human uses. The remaining natural ecosystems and wildlife (such as in the Elephant Marsh) downstream of the Barrage also depend upon Shire River flows. In previous years of especially low water levels in Lake Malawi, the Shire River has run dry. The Kamuzu Barrage is intended to help prevent (to a certain extent) a recurrence of these extreme low flow situations, which would be disastrous because so many people and businesses now depend upon adequate year-round flows within the River. Upgrading of the Barrage also includes a new weed boom to improve weed control (mainly water hyacinth).

3.2 Description of Proposed Works

The detailed design for the Upgraded Kamuzu Barrage is being undertaken in two phases under a separate design consultancy. The first phase which includes a review of Feasibility Studies and design optimisation for Kamuzu Barrage has been completed. The second phase involves preparation of detailed designs and tender documents and has been undertaken parallel to the social and environmental studies for the Project.

The preferred design option for the Upgraded Kamuzu Barrage involves: refurbishment of the existing Kamuzu Barrage structure including replacement of the existing 14 radial gates with new ones; raising the height of the maximum regulating level of the Barrage from the existing highest regulated water level (HRWL) of 475.32 masl by up to 40 cm (corresponding to a Lake Malawi level of 475.72 masl); construction of a new road bridge immediately downstream of the existing Barrage (connected to the existing structure); and construction of a floating steel boom and weed collector upstream of the Barrage to control floating weeds (NORPLAN 2013). Project layout is shown in Figure 5. The proposed works and activities which will be carried out in phases as described in the following Sections.

The Barrage refurbishment works described in the following Sections is based on the Design Consultant's report (NORPLAN 2013). The design includes:

- Upgraded Kamuzu Barrage, including erosion protection
- Upgraded weed collection system

Detailed drawings and Bill of Quantities of all works are shown in the Bidding Documents for the Upgraded Kamuzu Barrage as prepared by the Design Consultant.

3.2.1 Present Regulation Control Range of Existing Barrage

The existing Kamuzu Barrage has a control range between 473.5 masl and 475.32 masl so that once water levels fall below 473.5 masl then the gates are fully opened and water levels above 475.32 will also require fully open gates. The water levels refer to Lake Malawi Water Levels. The corresponding water levels at the Barrage vary depending on flow and Lake Malawi Water Level. The highest corresponding regulated water level at the Barrage is approximately 0.10 m lower than the mentioned Lake Levels.

3.2.2 General Description of Barrage Design

The final design of the upgraded Kamuzu Barrage includes the following main components:

1. The barrage is extended downstream with a new road bridge
2. Energy dissipation structure, erosion protection, at a length of 20 m is constructed between new pillars and further downstream.
3. New gates are installed at the location of the existing gates
4. The existing bridge is divided into two lanes:
    a. Upstream part, footbridge
    b. Downstream part, operation space
5. Upgraded approach roads to the Barrage

3.2.3 New Road Bridge

A new bridge with a gross width of 10.3 m will be constructed downstream of the existing gates. The bridge includes a 7.5 m wide roadway and a 2 m wide footpath.

The bridge rests on pillars with the same spacing as of the existing Barrage.

3.2.4 Erosion Protection - Energy dissipation

The bathymetric survey of the area downstream of the existing Kamuzu Barrage showed partly intensive scour, depending on properties of the underground, which consists of fluvial sediments and residual soil decomposed from basically gneiss basement rock formation. It is evident that improved scour protection / energy dissipation is required.

The design of the downstream erosion protection has gone through different proposed designs. The final proposal is a standard shape energy dissipation basin with an ogee crest inlet part and a 20 m long basing. The construction extends 20 m downstream of the bridge pillars and the total length from existing concrete structures is 32.8 m. The transition between concrete and undisturbed river bottom will be protected with rip-rap.

A roller bucket was constructed downstream of gates 1-3, in 1972. The roller bucket does not work properly for energy dissipation, but the long downstream concrete slab gives proper erosion protection for the three gates. Significant scour has been identified just downstream of the concrete slab. The design will be unchanged if the quality of the structures is satisfactory. Unfortunately detailed drawings of the construction, with reinforcement drawings and foundation conditions are not available, and it is proposed to check further after dewatering the area.

3.2.5 New Gates and Stop Logs

The scope of work will include:

- Existing gates shall be dismantled and 14 new gates in a box construction shall be installed.
- Gate numbers 1 - 3 will have the same principal design as gates 4 - 14, but on the top they will have flushing gates, w x h = 4 m x 2 m. This will allow for flushing of weeds and trash with minor use of water.
- The existing wire hoist for operating gates will be replaced by a two-sided chain hoist with the same principal layout as the existing wire hoists.
- Control cabinet for local operation near each gate.
- Equipment in operation centre.
- Emergency power supply–a diesel generator will be installed to provide an emergency power supply for operation of the Barrage when mains power is unavailable.

The following equipment is expected to be in good condition and shall be used for the new gates:

- Bearing axle;
- Stainless steel guides;
- Stainless gate sill;
- Lock for securing the gates in open position.

Stop logs

The existing stop log groove upstream of the gates will be maintained for further use, while a new guide will be installed downstream of the gates to allow for more easy maintenance of the gates in the future. The “stop logs” are designed as welded steel gates, 9.3 m wide and 2.5 m high. Two of these “gates” is then required to close one opening.

3.2.6 Existing Bridge Upgrade

The exiting bridge will be divided in two separate lanes:

- a 3.6 m wide operation bridge; and
- a 3.5 m wide footbridge for bicycles and pedestrians.

The two lanes will be divided by a fence/rail.

Construction work includes drilling the riverbed for pillars for the new road bridge including 130 bored piles. Excavation and concrete works will be required for foundation, erosion protection, pillars and bridge structure involving 25,000 m^3 of excavation/fill and 5,000 m^3 of concrete.

There will also be phased construction of temporary earth / rock-fill coffer dams (6 in total requiring 11,000 m^2 of steel sheeting and 80,000 m^3 of fill) upstream and downstream of the existing Barrage to facilitate refurbishment of the Barrage including construction of the new road deck.

3.2.7 Road Upgrading

The existing approach roads will be upgraded and elevation increased to increase the freeboard of the earth fill dams. The design includes:

- Main road, with net width 7.3 m at elevation 477.5 masl
- Upstream and downstream pedestrian walks, 3.0 m and 2.1 m wide respectively

The extent of the upgrading reaches the checkpoint to the west to and including the first junctions on the east side. Heavy road compacting machines will be used to strengthen/compact the ends of the Barrage.

3.2.8 Traffic during Construction

One of the main advantages of the selected option for final design, compared to earlier studies, is that all traffic will be able to continue using the existing road bridge practically undisturbed during construction of the civil structures.

All construction traffic to the downstream working area will be on the cofferdams and on the new bridge. The installation of the new gates will be from the new bridge, while the new hoists for operation of the gates will partly be from the old bridge.

There will be a need for traffic management during construction to safely manage transportation of equipment, materials and work force since there will be increased traffic in the Project area as the contractor transports equipment and materials (including new weeds boom and Barrage gates) to and from the site during the upgrading work.

3.2.9 New Weed Removal Device

3.2.9.1 General

The existing weed collecting boom is located some 200 m upstream of the Barrage and the weeds are collected using the Kapichira weed harvester. The boom is installed perpendicular to the river and most of the weeds are trapped in the middle of the river. A completely new setup for the boom and the weeds removal arrangements will be implemented. The main goal for revised design of the weeds boom arrangement is:

- Utilise the river flow to transport the weeds along the boom to the riverbank;
- Convenient arrangement for taking the weeds onshore.

Due to the bends of the river the main flow and velocity is slightly to the left bank when flow approaches the Barrage. Hence the boom will not be perpendicular to the river, but aligned as much as possible along the main direction of flow.

The existing weeds boom and the east and west anchors will be removed after the new boom is installed.

3.2.9.2 New Steel Boom

The proposed boom design is originally a design developed for timber booms in rivers, but the same design has successfully also been used in African Rivers exposed to water hyacinths and other weeds.

3.2.9.3 Anchors

The main forces from the boom will be taken by the upstream, northwest bank, anchor. The anchor must resist a load of about 1,000 kN, which requires a major concrete construction at the river banks.

3.2.9.4 Weed Landing Arrangement

The weed handling area is shifted from the western river bank to the eastern (right) bank. One of the main challenges is to design the arrangement for handling and landing of the weed and reeds as easy as possible.

To take the weed from the water onshore, a hydraulic rake is proposed. The rake/grab is based on the principles of a hydraulic trash rack cleaner, which could load the weeds directly onto waiting trucks or leave it for dewatering in a concreted area.

The rake shall reach at least 20 m out from the shore and some degree of freedom should be left with the supplier to allow them to use standard trash rack cleaner design.

3.2.10 Quarry and Borrow Areas for Construction Materials

Borrow areas and a quarry will be required where the contractor will source construction materials including sand and quarry stone, weathered rock and gravel for the Project. Four potential sites (as shown in Figure 4) have been identified: Naliswe River, 6-8 km west of Liwonde towards Balaka (river sand); the existing Naliswe quarry, 14 km west of Liwonde towards Balaka (quarry stone); Molipa borrow area, 24 km east of Liwonde towards Nsanama (an existing source of weathered rock / coarse gravel); and, Chabwera borrow areas, 2-4 km east of Liwonde (also an existing source of weathered rock / gravel material).

3.2.11 Temporary Work Camp and Plant Area

Work camp and plant area - the contractor will establish a temporary camp for Project administration and workers residence. The proposed site is located upstream of the Barrage on the left (east) bank of the Shire River (Figures 5 and 6).

3.2.12 Permanent Operation Centre

This will include construction of a permanent store, workshop and office building with provision to house the Marine Police premises as shown in Figures 5 and 6. It will include a new permanent control and administration building (single story 9.6 m x 20.1 m).

3.2.13 New Hydrological Monitoring System

A new hydrological monitoring system will be installed for lake level monitoring, discharge monitoring and downstream flow monitoring and operational support system in order to enable an efficient optimization of requirements from the consideration of downstream water users as well as environmental and sociological considerations.

3.2.14 Construction Workforce

With regard to the construction workforce it is envisaged that there will be between 200 and 250 workers on the Project during the various stages of construction. Out of these about 100 will be unskilled workers who will most likely come from the local area, another 100 will be skilled workers (technicians and artisans, drivers, plant operators etc.) who will be Malawian and may come from other areas of the country while about 50 will be expatriate from elsewhere (i.e. the region or abroad) whose special skills will be required from time to time so they will all not be there during the whole construction period. However up to ten expatriate employees (for the Consultant and the Contractor) will be on site for almost all the time.

3.2.15 Management of Storm Water, Wash Water and Effluent on Construction Sites

Discharge of any pollutants from construction sites into the neighbouring environment, such as chemicals and fuels, as well as untreated sewage effluent shall be prevented. It is required that the Contractor comply with all relevant laws and regulations in Malawi concerning water provision, sanitation, and wastewater discharge when planning its worker's camp, other buildings, sanitation infrastructure, etc on site.

Drainage structures (channels, ditches, sumps) shall be constructed to effectively drain runoff from work sites. These will be designed by the Contractor once appointed. Particular care shall be taken to ensure that facilities are capable of dispersing maximum predicted rainfall.

3.2.16 Equipment

Key equipment which will be used for the Project includes the following. The minimum number required is in brackets:

- Excavators/Wheel loaders (2)
- Trucks (3)
- Bulldozer (1)

- Concrete batch plant, 10 m3/hr (1)
- Concrete aggregate processing plant (1)
- Concrete Trucks (3)
- Sheet Piling Rig (1)
- Drilled Piling Rig (2)
- Drilling Rig (1)
- Mobile crane (1)
- Vibro roller compactor, min 8 tons (1)

3.3 Operation and Maintenance Activities

Only a small permanent workforce is expected to be employed to undertake the operation and maintenance activities once the Barrage has been refurbished. They will be located in a permanent administration building located on the left bank of the Shire River just upstream of the Barrage (Figure 6).

3.4 Area of Project Impact

In general the study area will include the following areas which will benefit from the Project, or which may be directly affected in a negative way, by any of the components of the Project (see Figures 1 and 4). Specifically, the study area will include:

- The upstream environment as far as Lake Malawi and its foreshores which will be affected by the operation of the upgraded Kamuzu Barrage;

  It has been empirically established the Barrage only influences a small range of Lake Malawi water levels within the natural variation of the Lake (approximately one metre annually and seven metres over the recorded history of Lake levels) and hence the variations that would be caused due to raising the height of the Barrage by 40 cm would be much less than the natural variations. Impacts on Lake Malawi are therefore expected to be minimal. There will however be more frequent inundation of land upstream of the Barrage (especially during the dry season) as a result of the 40 cm increase in water level at times within Lake Malawi.

  Although people living along the shoreline of Lake Malombe experience variations in water levels more than for Lake Malawi, increasing the regulating capacity of Kamuzu Barrage is not expected to have a significant impact. However, operation of the Barrage could cause a significant impact. Because of the relative shallowness of Lake Malombe's foreshores, a sudden drawdown could strand irrigation pumps, make foreshore access difficult and impact on fisheries (especially during the breeding season), which would impact on the livelihoods dependent on the Lake's fishery.
- The land resources and the people who may be affected by construction activities (construction Footprint) as these relate to the refurbishment of the Barrage, the new weed boom, new temporary and permanent roads, and other ancillary work sites including material storage and handling sites, worker camp etc;
- Farmers, hydropower stations and other water users downstream of Kamuzu Barrage dependent on regulated flow releases from the Barrage.

  The Barrage influence is mainly dependent on a selected flow regime rather than the elevation of the Barrage. Different release strategies will have differential environmental and social impacts, although given the river profile and the fact that many tributaries with much more pronounced hydrographs enter the system downstream, the impact of the main stem is negligible (this also why the Barrage cannot be used to a great extent for flood control), and hence minimal adverse impact is expected downstream of the Barrage.

- The Shire River environment downstream of the Barrage to the extent that river flow releases from the Barrage impacts on fish, wetlands, riparian habitats and water quality.

3.5 Project Implementation

Construction time is estimated at 34 months with the bidding and contract phase to take approximately six months prior to this. Construction will be sequenced to minimise disruption to transport across the Barrage. The proposed work schedule is shown in detail in Chapter 15 of the detailed design report (NORPLAN and Associate, 2013).

It is proposed that construction management and construction supervision will be undertaken by a Consultant appointed through a tendering process.

3.6 Project Cost

Cost estimates for all construction activities, materials and construction supervision is USD 45.4 million based on the final design and the Bills of Quantity and the Price Schedules included in the Bid Documents prepared by the Design Consultant in July 2012.

This excludes environmental and social management costs including RAP implementation) totalling USD 1,391,982 as outlined in this document (see Section 9.2).

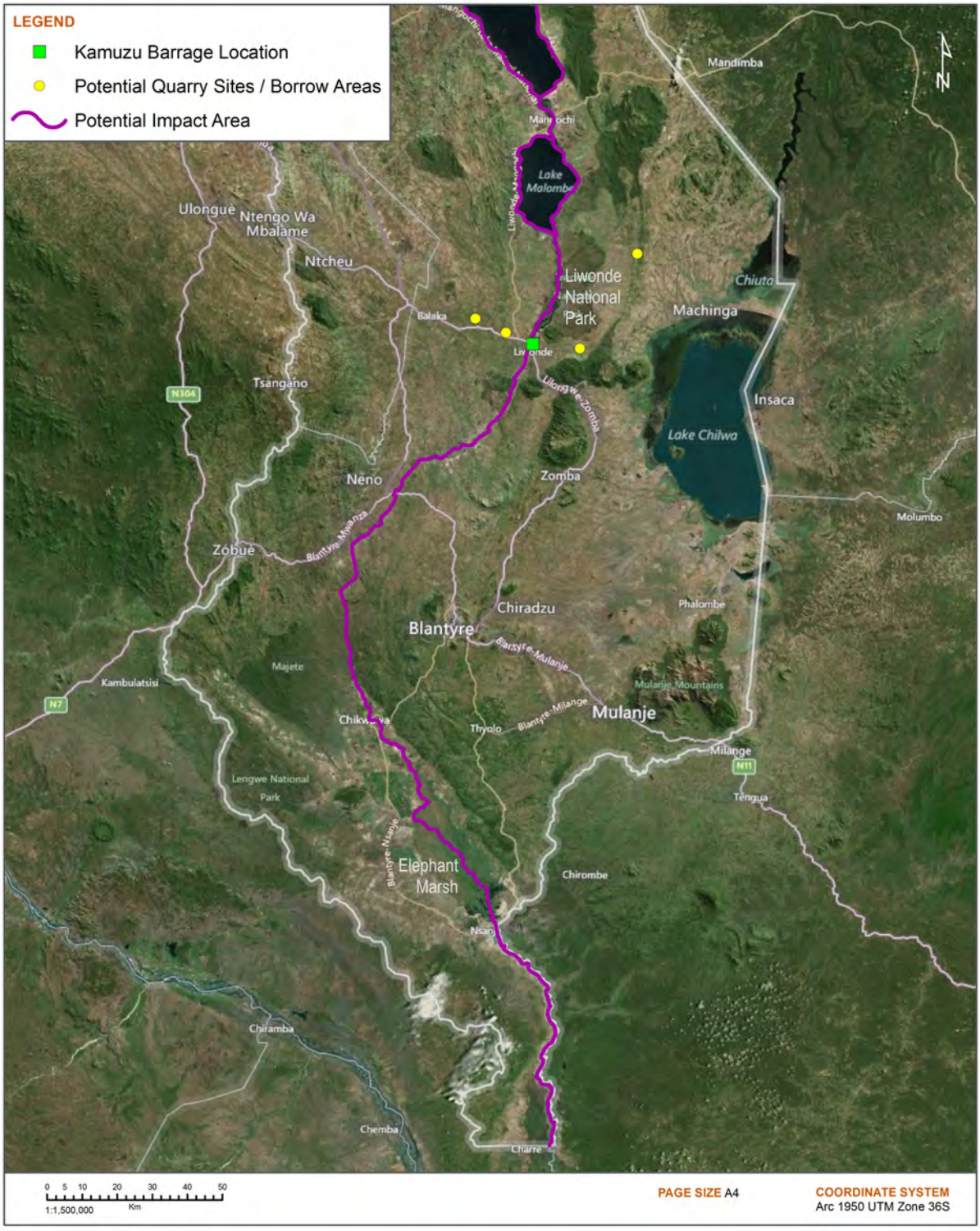
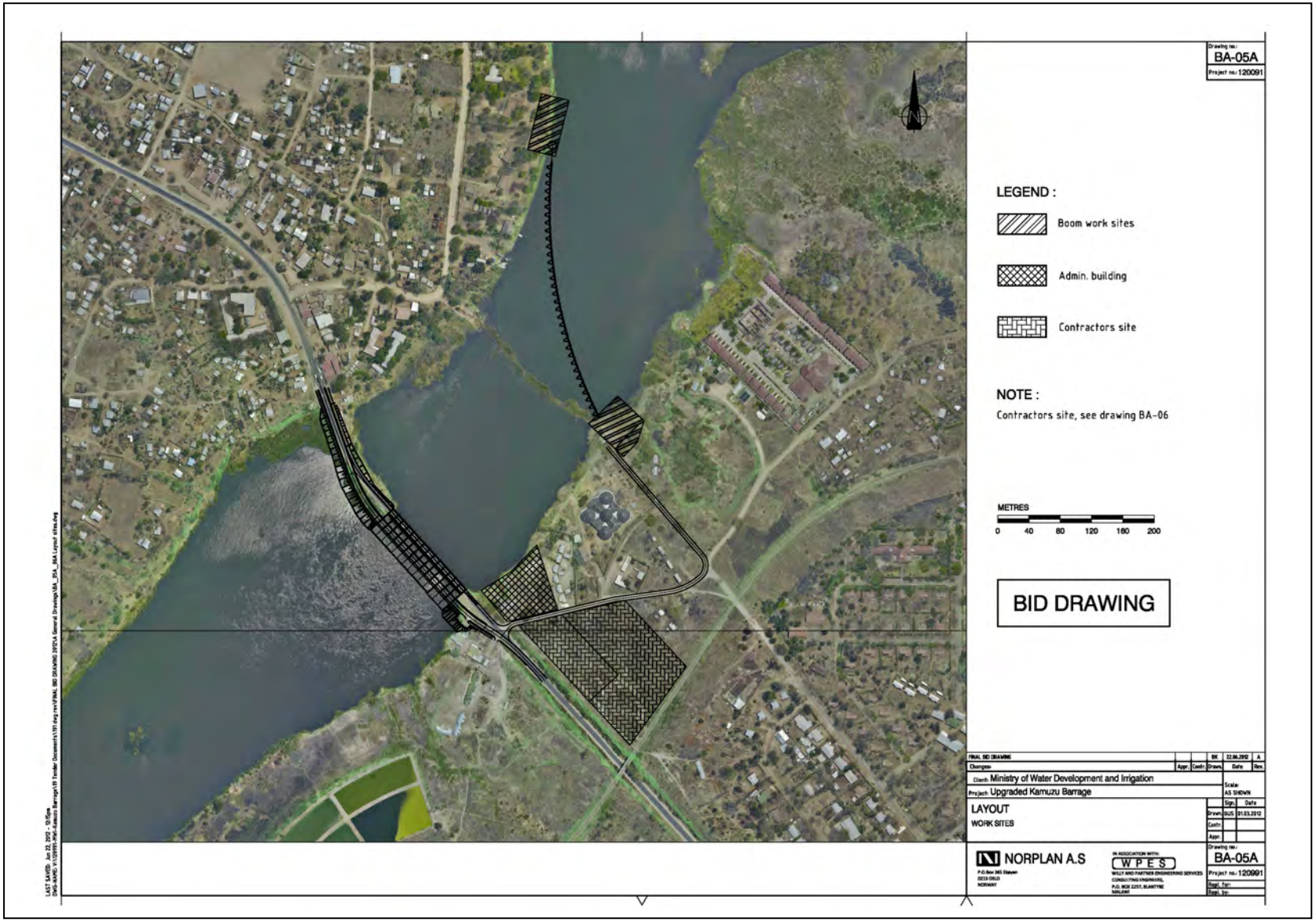
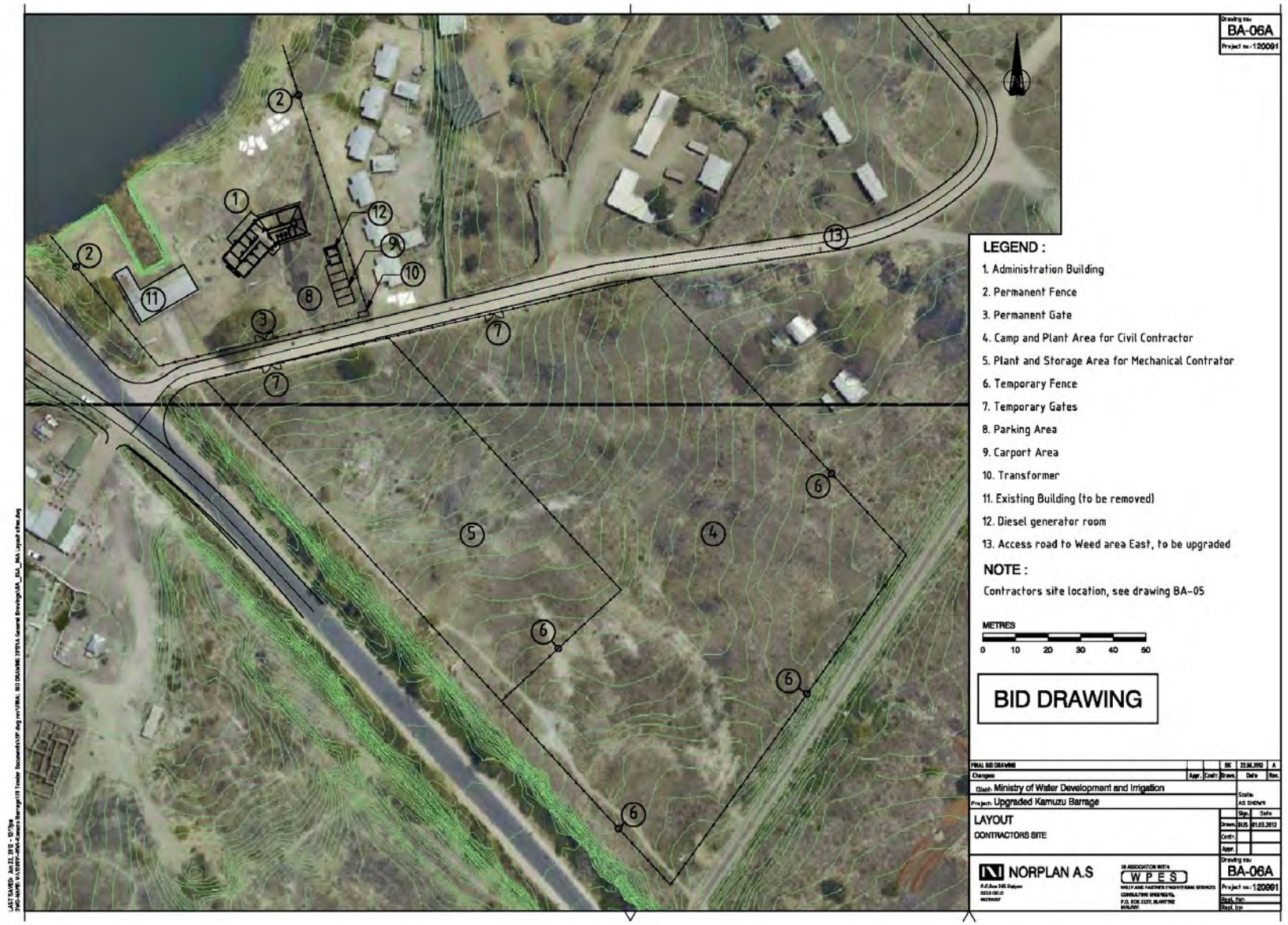


Figure 4. Area of Project impact



Source of map: Design Report (NORPLAN and Associate, 2012a).

Figure 5. Location of Barrage work sites



Source of map: Design Report (NORPLAN and Associate, 2012a).

Figure 6. Detailed layout of Contractors sites

4 Methodology

4.1 Source of Information and Data Analysis

The following methodologies have been formulated on the basis of:

- Relevant documents, including World Bank directives, guidelines and other documents; relevant national and local legislation, policy papers and guidelines of Malawi.
- Available survey plans and related reports from the feasibility study and design / tender documents from the Design Consultant.
- Practical considerations including timeframe for EIA, and the accessibility of the study area.

Wherever possible, the Consultant has made use of 1:250,000 and 1:50,000 vegetation cover, forestry, topographical and geological maps, soil maps, aerial photographs and satellite imagery and previous survey work undertaken as part of the Feasibility investigation. High-resolution colour aerial photography from the southern tip of Lake Malawi, along the shoreline of Lake Malombe and along the Shire River downstream to Chigaru was also made available during the course of this study, through the Project Design Consultancy.

4.2 Environmental/Biophysical Aspects

4.2.1 Source of Information

- Preliminary site visit and consultations with local officials and affected people.
- Detailed site survey.
- Interviews with government authorities, relevant institutions and NGOs.
- RAP investigations.
- Previous environmental studies in the area including the Feasibility Study EIA prepared in 2003 and numerous reports available for Liwonde National Park and Lake Malawi.

Data were obtained from both primary and secondary sources, including an environmental factors survey for discussion with selected samples of local residents and Project affected persons (PAPs) who have knowledge of the local ecosystem and its exploitation by traditional methods.

4.2.2 Survey Methodology

An in-depth investigation of the bio-physical environment was undertaken including the services of an ecologist, plant taxonomist and fisheries specialist who carried out the following tasks:

- Description of vegetation types using aerial photography, satellite imagery and field transects;
- Description of aquatic environment in Lakes Malawi and Malombe and the Shire River based on Fisheries records from the Fisheries Research Station at Monkey Bay and the Malawi College of Fisheries at Mangochi, field sampling and interviews with local fishers and Malawi Fisheries Department staff;
- Description of species composition and biodiversity;
- Listing of any endangered, rare, or vulnerable species using the International Union for Conservation of Nature (IUCN) classification (Red Data List);
- Estimation of the ecological significance of biota at the regional, national and global level (if significant);
- Assessment of the sensitivity of terrestrial and aquatic ecosystems to the proposed Project intervention in order to identify variables which are likely to experience change;

- Assessment of impacts and changes that may be induced by the Project, and identify mitigation measures to avoid or lessen the negative (adverse) impacts;
- Identified environmentally sensitive areas in addition to Liwonde National Park and Lake Malawi and assess the area's sensitivity to negative effects from construction and operation of the Barrage and associated structures;
- Characterise the biological resources within the zones of influence of the Barrage and associated structures;
- Interview traditional users of the local natural environment who have first-hand information.

4.2.3 Water Quality

Reconnaissance survey

In order to ensure a good representative sample, a reconnaissance survey was first undertaken which was instrumental for subsequent activities including sampling design, equipment, and resources required for the water quality assessment. Further details are provided in the Water Quality Report in Volume 2 of the ESIA.

Sampling design

A sampling design was developed based on the findings of the reconnaissance survey.

For purposes of comparisons of scientific data analysis, sampling was done during the dry and rainy seasons (October and December).

Water samples were analysed for Coliform bacteria, Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), pH, Total Suspended Solids (TSS) and Turbidity, Electrical Conductivity, Nitrate, and Phosphate, Chlorophyll "a", Hardness, and Sulphates.

Literature review

Documents related to the study were reviewed with a focus on those that capture studies undertaken within the Project catchment area.

4.2.4 Terrestrial and Aquatic Wildlife

A combination of techniques including secondary sources and primary data were used to collect wildlife information for assessing potential impacts of the Project on wildlife. Considerable secondary information on wildlife was available from Liwonde National Park, Department of National Parks and Wildlife, Feasibility Study reports, Majete Wildlife Reserve, Grey literature and Malawi Government website. Primary data was also collected from site visits and included direct observation, transects, interviews and discussions. During field visits all wildlife encountered was recorded. For interviews and discussions some guiding questions were prepared to facilitate the conversation. Details of questions asked can be found in Section 1.2 of the Wildlife Report in Volume 2: Technical Reports of the ESIA.

4.2.5 Vegetation and Land Use

Conducting vegetative studies over the extensive study area with a diverse range of habitat types is challenging. The most effective and efficient means of surveying the area is by remote sensing supported by targeted field verification. The methodology used by the Consultant is summarised in Figure 7. Further details are provided in the Vegetation Assessment Report in Volume 2 of the ESIA.

Vegetation types within the Project Study Area have been classified using remote sensing and image classification techniques. This involved the conversion of spectral raster data into a set of classifications that represent surface vegetation types seen on the remote sensing imagery (in this case high resolution colour aerial photography from the Design Consultant).

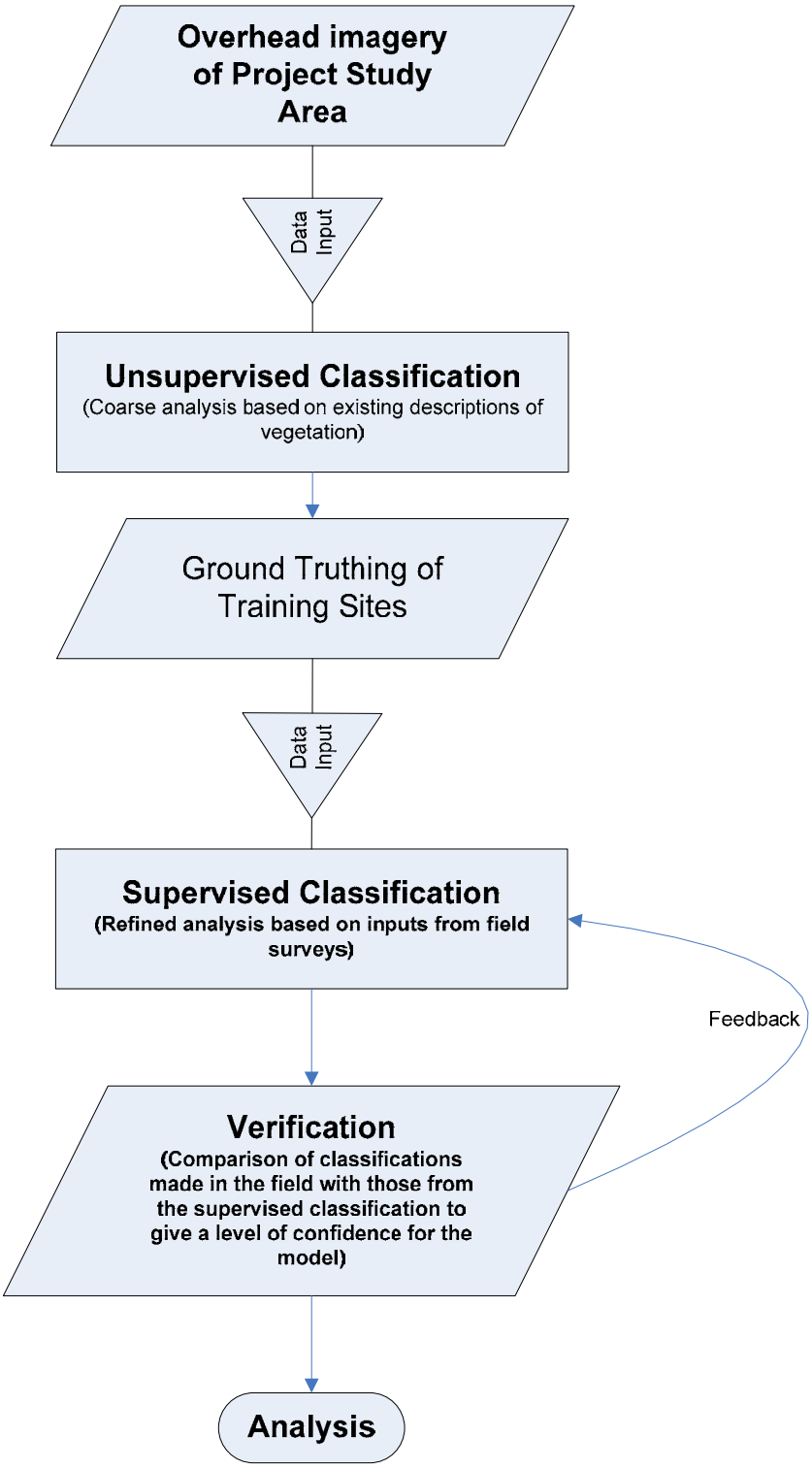


Figure 7. Steps in the vegetative classification process

4.2.6 Fish Resources

The fish assessment was based on:

- Desk top study including literature search at Fisheries Research Station (Monkey Bay) and at Malawi College of Fisheries (Mangochi);
- Field survey consisting of fish sampling using seine netting for length frequency and catch per unit effort (CPUE) analysis;

- Interviews with fishers and Fisheries Department staff and analysis of fish catches.

Further details are provided in the Fisheries Report in Volume 2 of the ESIA.

4.2.7 Data Analysis

The data collected has been validated by experts in the EIA team. The main outputs involved:

- Identifying environmentally sensitive areas to assessing the area's sensitivity to negative effects from construction and operation of the Barrage and associated works.
- Assessing impacts and changes that may be induced by the Project, and identifying mitigation measures to avoid or lessen the negative impacts.

4.3 Social Aspects

4.3.1 Social Impact Assessment

The Consultant's proposal contains details on the recommended approach and methodology for conducting the Social Impact Assessment (SIA) component of the ESIA, based on international best practice. In summary, the primary aim of the SIA was to identify, in advance, the potential social consequences of the proposed Project, so that social issues of operational relevance inform Project design. The SIA was guided by the following principles:

- Implementation as an integral part of Project preparation and not as a freestanding operation.
- Identification of a range of relevant stakeholders so that their views can be taken into account in the final Project design.
- Identification of the key social issues (constraints and opportunities) to be taken into account in Project preparation.
- Full community participation to enhance (a) the legitimacy of the overall investigation; (b) the social development potentials of the Project; and (c) the capacity of affected persons to collaborate in the subsequent implementation of the ESMP and RAP.
- Identification of appropriate participation, delivery, mitigation and impact management mechanisms and procedures for incorporation into the ESMP.

4.3.2 Resettlement Planning

The Resettlement Action Plan (RAP) for the Kamuzu Barrage upgrading was completed based on the Resettlement Policy Framework for NWDP II and the following tasks:

- establishment of a participatory framework (institutional arrangements);
- information collection and database development;
- impact assessment;
- identification of mitigation measures; and
- report preparation.

Community meetings and smaller discussion groups were the main components of the participatory framework. Information was also collected through a census (percentage coverage determined from field work), sample socio-economic survey and focus group discussions. Household-level information was captured into a Microsoft (MS) Access database.

Impact assessment and the identification of mitigation measures were undertaken as part of the SIA process. Mitigation measures were identified with community input. Affected individuals were requested to indicate their compensation preferences.

Report preparation was according to the standard outline/table of contents as detailed in OP/BP 4.12 (Involuntary Resettlement) of the World Bank.

4.3.3 Socio-economic Survey Methodology

The main methods used for the social impact assessment and resettlement planning are summarised below:

Review of secondary data: This included review of the Feasibility Study EIA and other Project documentation; of published information on demographic, socio-economic and poverty indicators in the area/country; of other developments in Malawi that involved land acquisition and population displacement; and of country and international guidelines on compensation and resettlement planning.

Remote and field investigations to determine anticipated impacts and losses: aerial photography and satellite imagery of the Project area were used to determine the magnitude of expected losses associated with refurbishment of the Kamuzu Barrage. Field investigations were undertaken to confirm the expected losses. A formal asset recording and verification exercise, incorporating official valuation of assets by a government valuer from the Ministry of Land, Housing and Urban Development (MLHUD) was undertaken as the basis for the negotiation of final compensation packages. For the other Project components anticipated losses were estimated through the interpretation of available drawings, maps and aerial photos, and field investigations.

Consultation with affected communities and other interested parties: this included community meetings, focus group discussions and interviews with a number of affected community groups and interested parties.

Field checklists and questionnaire surveys: This entailed the following:

- village checklists –completed for villages directly affected by the Project (including upstream and downstream areas);
- socio-economic survey – completed for a sample of 520 households and other stakeholders directly affected by the Project (including upstream and downstream areas);
- compensation and resettlement survey – completed for households and other groups such as tourist facility owners whose assets will be affected by the Project.

4.4 Public Consultation and Disclosure

4.4.1 Stakeholder Consultation and Participation

Environmental and socio- economic impact assessment cannot give meaningful results if the stakeholders including the direct and indirect affected people are not consulted. The EIA study ToR required the Consultant to carry out public consultations so that stakeholders' concerns and interests were incorporated in the Project design. This was also important during the development of the ESMP so that the responsibilities of each stakeholder were well defined.

The aim of the public consultation and participation process was to solicit public views and concerns on the Project, explore ways of avoiding or minimising all concerns and reach a consensus that all concerns have been adequately addressed. The Consultant's core strategic approach was to encourage full participation in Project implementation by national, district and local authorities and community stakeholders, from the commencement of the Consulting Services.

The Consultant's public consultation specialist, in consultation with MoWDI Counterpart staff, identified various stakeholders that included: communities that are directly or indirectly affected; non-governmental organisations; government departments and agencies that have a stake in the Project.

Persons and organisations consulted included:

- People who are affected by the Project, both those who are potential beneficiaries and/or those who are potentially disadvantaged;
- Officials from relevant ministries and government agencies;
- Officials from local administration in the Districts of Salima, Mangochi, Balaka, Machinga, Zomba, Blantyre, Chikhwawa and Nsanje: relevant bureaus and departments, municipalities and community associations. The selection of districts that were consulted for the Project was based on proximity to the Shire River, Lake Malombe and Lake Malawi (and likely to be impacted). Neno and Mwanza Districts were not included in the detailed consultation because they are unlikely to be affected by

the Barrage refurbishment since the Shire River in these areas is characterized by a deeply incised river channel with numerous falls such that any changes in flow regime from the Barrage will not result in inundation of riparian areas suitable for agriculture, forestry or other resource use activities. However, the District Commissioner for Mwanza was invited and attended the Workshop presentation on the Draft EIA Study;

- Village Headmen who are familiar with the local communities and with their social and economic environment. They would also know the places and sites of religious and/or cultural importance that may be affected by the Project;
- Women, youth and vulnerable groups as local users of natural resources;
- Religious leaders;
- Local / national NGOs.

The full list of Interested and Affected Parties (IAPs), including Non-government organisations (NGOs) which were consulted during the preparation of the ESIA is provided in Appendix 2. Details on consultation including dates of meetings, attendees and minutes of meetings are provided in Volume 2 – Record of Consultation of the RAP.

4.4.2 Consultation and Participation Methods

The consultation methods for the consultation and participation process varied depending on the stakeholder and the information sought. Generally, Participatory Rural Appraisal (PRA) methods were applied that allowed for a wider participation of stakeholders within a short period of time. The consultation methods included:

- Public and community meetings;
- Individual Consultation;
- Focus group discussions (5- 25 persons);
- Random socio-economic household survey. A sample of households and other stakeholders directly affected by the Project (including upstream and downstream areas);
- Compensation and resettlement assessment and survey was completed for households and other groups such as tourist facility owners whose assets will be affected by the Project.
- Stakeholder Workshops at the beginning of the EIA study to help scope the study and develop the ToR; and another Workshop towards the end of the EIA study to present the draft findings (see Section 4.4.2.1).

This varied approach ensured that there was an open and interactive communication between stakeholders, that minority groups, women, youth and other vulnerable groups were fairly represented, and that there was a framework for effective disclosure to all relevant stakeholders.

Public consultation and participation formed an integral part of the process used for gathering data, understanding community and individual preferences, selecting Project alternatives, and designing viable and sustainable mitigation and compensation plans. It was included in the planning and design phases as well as during implementation. This included meetings with local government, which were held prior to field survey work being undertaken in order to brief relevant stakeholders about the Project objectives and activities. Particular attention was paid to local attitudes towards the Project; to compensation preferences and mitigation measures, as well as to the long-term monitoring of the Project.

4.4.2.1 Workshops

Two workshops were held as part of the environmental assessment process. The first was on environmental scoping and development of ToR for the EIA study for the Upgraded Kamuzu Barrage. It was held on Monday 12th September 2011 in Lilongwe. Details including list of attendees are included in Appendix 3.

The EAD requires preparation and submission of a Terms of Reference (ToR) for the EIA study to the Director for review and approval. The Terms of Reference (ToR) describe the purpose and structure of the proposed ESIA report. The Consultant prepared the EIA Terms of Reference based on the Stakeholder Workshop and submitted it to EAD on behalf of the Project proponent (MoWDI) for review and approval.

Following presentation of a draft outline for the ESIA by the Consultant Team Leader, Workshop participants were divided into 3 groups to provide comments and further suggestions on social and environmental issues which the Consultant needed to address in preparation of the ESIA. Group comments are shown in Appendix 3. These comments were incorporated into the revised ToR.

The second workshop involved a much broader audience and was held on 20th September 2012 within the Project area at Liwonde. The Consultant presented the draft findings of the EIA study and the Workshop provided Project stakeholders with the opportunity to ask questions and raise any further issues with respect to the social and environmental issues of the Project. The list of attendees and details of questions/discussion raised during the workshop are presented in Appendix 4.

4.4.3 Communication Strategy Formulation

The Social Expert will assist the client in the formulation of the communication strategy that will further strengthen the public consultation process during resettlement planning. The development of the communication tools (e.g. press releases and Frequently Asked Questions - FAQs) will remain the responsibility of the Client.

4.4.4 Disclosure

The Environmental Affairs Department of Malawi fully supports and requires public consultation to be undertaken as part of the environmental assessment process. To this effect, the Department has included Guidelines for Public Consultation as an Appendix (Appendix G) to its Environmental Impact Assessment Guidelines.

To further aid disclosure within Malawi, the Executive Summaries for the Final ESIA and RAP Reports will be translated into Chichewa.

With respect to disclosure requirements of the World Bank, the Client will make available the ESIA and RAP reports to the World Bank for review and comment and public disclosure in accordance with the Bank's Operational Policy 17.50 on Disclosure.

5 Description of the Environment

The following descriptions are based on previous studies including the Lake Malawi Level Control Study (Norconsult 1997 and 2003) and the Design Consultant's Environmental and Social Assessment Report (NORPLAN 2011) as well as field work undertaken as part of the environmental study for this Report.

Quantification and mapping of vegetation types and wildlife habitat was based on high resolution aerial photography of the Project area provided by the Project Feasibility Design Consultant. Socio-economic descriptions are based on the socio-economic survey and stakeholder consultations undertaken by the environmental study Consultant.

5.1 Physical Environment

5.1.1 Project Setting

The existing Kamuzu Barrage was constructed across the Shire River at Liwonde on the Zomba to Lilongwe road. The upgraded Kamuzu Barrage will be in the same location, extending the existing structure (piers) downstream to support the second road bridge, while gates will be refurbished in the same location, using the existing bearings.

The Kamuzu Barrage is in Liwonde on the Mangochi to Liwonde rift valley plain. Generally topography of the Project area can be divided into three distinct categories which include the rift valley floor, the plain north of the Barrage and the hilly forested Machinga Forest Reserve that lies south of the Barrage towards Zomba.

5.1.2 Geology and Seismicity

Geology at the Barrage site consists of mainly fluvial sandy soils with firm layered residual soils and weathered rock underneath.

According to the Project Design Report (NORPLAN 2012) major fault zones related to the formation of the Great Rift Valley cross Malawi longitudinally along the Lake Malawi and Shire River. Malawi has experienced major earth quakes in the Northern and Southern parts of the country, whereas no major earth quakes have been recorded in the Project area in the central regions. However, no maps showing relevant seismic risk parameters, which are necessary for earth quake design calculations, are available for Malawi.

The Design Consultant engaged a specialist from the geophysical section of the University of Addis Ababa, Ethiopia to undertake a seismic hazard risk assessment. The earth quake design for the Barrage will be based on the seismicity study and also on the geotechnical conditions of the site (the latter yet to be finalised).

5.1.3 Soil Resources

Sandy soils with coarse grains and light texture with good air circulation are very common in the Project area. Fertile alluvial soils with fine particles and have heavy texture are found along the flood plain of the Shire River, Lake Malombe and shores of Lake Malawi. These soils support a variety of crops including maize and rice.

There are also hydric soils in the riparian zones of Lake Malawi, Lake Malombe and the Shire River. These are soils that are formed under conditions of saturation, flooding and ponding long enough in the growing season to create anaerobic conditions in the upper 50cm. of the soil.

5.1.4 Climate

There are three relatively distinct climatic seasons in the Lake Malawi area. Cool and dry weather with south-easterly winds predominates from May till August with air temperatures along the lakeshore dropping as low as 15°C. A short hot and dry period occurs from September to November while the rainy season normally lasts from late November till April. In the rainy period the average temperature is around 28°C and the wind direction is predominantly northerly.

The Upper Shire reach stretching from the outflow of Lake Malawi at Samama to Matope is a relatively dry area with a mean annual rainfall of around 700 mm. The average annual temperature is around 22°C.

The Middle Shire River area stretching from Matope to Kapichira has a slightly higher rainfall than the upper part with 700-800 mm of rainfall. The mean annual temperature is also slightly higher being approximately 24°C.

5.1.5 Water Resources

The water bodies and catchment area influenced by the Project include Lake Malawi and the Shire River water systems (Figure 8). Lake Malawi has a catchment area at the Lake outlet of about 126,500 km^2, consisting of:

- 64,372 km^2 drainage area in Malawi
- 26,600 km^2 drainage area in Tanzania
- 6,768 km^2 drainage area in Mozambique, and
- 28,740 km^2 of Lake surface

The Shire River forms the only outlet of Lake Malawi. The Shire River runs through the southern part of Malawi. Its lower part, below the junction with the Ruo River, forms the border with Mozambique. A few kilometres further downstream of the southern border of Malawi the Shire discharges into the Zambezi River. The Shire River catchment, below the Lake and excluding the Ruo catchment, covers an area of 18,945 km^2.

Although Malawi lies within the tropics the topography is so varied, and the range of altitude so great, that climatic conditions are complex with many gradations between dry and wet and hot and cold.

Figure 8. Lake Malawi and Shire River Water Systems

The Project area has been defined as the reaches/areas of the Shire River, Lake Malombe and Lake Malawi that may experience permanent or temporary changes in water levels as a result of the proposed upgrade of the Kamuzu Barrage at Liwonde. The Project area covers a distance of approximately 275 linear kilometres from the lower reaches of Lake Malawi to the Elephant Marsh on the Shire River (Figure 8). Upstream of the Barrage the area affected is within the riverine ecosystem and lake foreshores (Lakes Malombe and Malawi) that are inundated by existing Lake level fluctuations. Downstream of the Barrage, regulated flow from the Barrage is restricted to the River channel.

The Project area is naturally divided in to four major zones, namely:

1. Lake Malawi – Southern arms
2. Upper Shire River – from Samama to Matope (including Kamuzu Barrage)

3. Middle Shire River - from Matope to Kapichira
4. Lower Shire River – Kapichira to Mozambique border (including the Elephant Marsh)

Lake Malawi

Lake Malawi is the southernmost and third largest of the East African great lakes. It is approximately 560 km long and 75 km across at its widest point. Maximum depth is around 700 m. The Lake is located at an altitude of about 475 m and experiences marked seasonal variations in wind, temperature and precipitation. The depth of the Lake falls off quickly from the shore and depths of more than 200 m are found close offshore. In the south-eastern arm, where the Lake discharges its excess water in to the Shire River, the fall-off in depth is less striking and large shallow sandy areas occur. The Lake and in particular the southern part supports important fisheries both artisanal and semi-industrial. The Lake has been included on the UNESCO World Heritage List due to its unique fish biodiversity, represented by the several hundred different "mbuna" cichlid species. These species are almost exclusively found around rocky substrates, mostly around Lake shorelines and islands.

Upper Shire River

The Upper Shire River is defined as the river channel from its outflow at Lake Malawi at Samama down to Matope and includes Kamuzu Barrage. For this 100 km stretch the River flows down an extremely gentle gradient, the water level at Liwonde being only 2 m lower than the Lake exit (the gradient is even less with the Barrage in operation). The flat landscape and reduced stream velocity cause the River to meander, creating a network of pools and channels, and to flood adjacent land in the rainy season (Figure 9).

The area is relatively dry with mean annual rainfall of around 700mm (contrasting with over 2,000mm on the nearby Zomba Mountain). The rainy period is from November to April when more than 90% of the rain falls. May to October constitutes the dry season. Mean annual temperature is around 22°C.

The landscape of the Upper Shire takes its character from the Great African Rift Valley, which runs north-south in a 15-35 km wide trough. The valley consists of plains and gentle foot-slopes, which rise to an altitude of approximately 700 m. To the west the Rift Valley merges into uplands and hills around 1,100 m, while an escarpment delimits the eastern boundary several hundred metres high guarding and extensive area of uplands and hills.

The area is underlain by basement complex rocks of pre-Cambrian and Cambrian age. Extensive faulting since Mesozoic times led to the formation of the Rift Valley, which itself is filled with unconsolidated sediments of lacustrine, fluvial and colluvial origin.

Soils are generally well drained, yellowish brown to reddish brown, medium to fine textured and are deep if developed in alluvium. In the lowest areas, soils have been modified by flooding and sedimentation, giving rise to considerable localised variations.

Much of the Upper Shire Valley and the lakeshore plain areas where soils have reasonable drainage are dominated by woodland savannahs. Apart from Liwonde National Park, most of the areas of semi-deciduous riverine forest have been cleared for cultivation. Some areas of Mopane (*Colophospermum mopane*) woodland survive, mostly in association with other trees and shrubs.

Middle Shire River

The Middle Shire, from Matope to Kapichira, drops over 370 m in elevation over a distance of about 90 km. The gradient is gentle but gradually increases. Beginning around Matope, the River falls below the surrounding land and is flanked by alluvial terraces. This section also contains a series of cataracts (Kholombidzo, Nkula, Tedzani, Hamilton and Kapichira – Figure 10). Additional River characteristics are meanders, rapids flanked by islets and abandoned river channels. Several tributaries join the main channel, the most important being the perennial Lisungwe and Mkurumadzi Rivers.

The Valley is relatively dry with annual rainfall in the order of 700-800 mm. Mean annual temperature is approximately 24°C.

The Middle Shire Valley forms the floor of the Great African Rift Valley and consists of undulating but rugged and densely dissected country. The Rift Valley is separated from the African surface by a scarp zone of broken terrain incorporating an altitude gain of several hundred metres.

The area is largely underlain by Precambrian metamorphic rocks (basement complex) consisting of gneisses and granulite. Soils in general are moderately deep, well drained, brown and medium textured with weathered rock in the subsoil and grave and stones throughout the profile.

Population pressure in Middle Shire Valley has resulted in the natural vegetation only appearing in areas deemed unsuitable or very marginal for cultivation. The remnants of the natural vegetation may be classed as woodlands and savannahs.

Figure 9. The Upper Shire River at Mangochi.

Figure 10. The Middle Shire River at Kholombidzo Falls.

Lower Shire River

Downstream of Kapichir the Shire River Valley widens in to a flat alluvial plain. For about 150 km the Shire River meanders over this plain.

The area is relatively dry, recording rainfall of 700-1,000 mm annually. Dry spells lasting several weeks are not uncommon during the period of the rainy season. Highest mean monthly temperatures fall into the range of 27°-30°C during the rainfed crop growing season.

The Lower Shire Valley is a continuation of the Rift Valley, as noted in the preceding sections. The floor of the Rift Valley is flanked by escarpments associated with the major fault lines which follow a south-east to north-west trend. Relief is dominated by the Chikwawa-Thyolo Escarpment to the east, the Majete Escarpment to the north-west, the Nsanje Hills to the south-west and the Lower Shire uplands to the west. Altitude in the Lower Shire Valley ranges from 50 m to 200 m, while to the north-west and south-west the land rises to nearly 1,000 m.

The hills and uplands surrounding the Lower Shire Valley predominantly consist of basement complex rocks, gneisses and granulite. The Valley itself is characterised by Tertiary unconsolidated sediments. Soils in the Valley are deep, medium to fine texture, brown to very dark in colour and have a drainage ability, which varies from good to very poor.

The upper reaches of this section host large areas of commercial sugar cane agriculture, whilst the lower reaches are dominated by the seasonally flooded Elephant Marsh with its attendant market garden agriculture and artisanal fisheries. The natural vegetation of the Valley has been largely removed or extensively disturbed by cultivation. Seasonally waterlogged areas adjacent to the Shire River support productive grass vegetation.

5.1.5.1 Hydrology of Lake Malawi and the Shire River

5.1.5.1.1 Lake Malawi

The level of Lake Malawi normally exhibits an annual fluctuation of about one metre between the low dry season and the high level at the end of the rainy season. In addition, the Lake has in geological and historical times exhibited a pattern of cyclical fluctuation. From the evidence of writings of early travellers it is inferred that the Lake level was very low in 1830, very high in 1857-63, falling in 1875-78, high in 1882, very low in 1890, but rising in 1892-95.

The factors determining the fluctuation are the run-off from its large catchment, half of which originates in the high rainfall areas of southern Tanzania, the rainfall directly on the Lake surface and the loss through evaporation. The residual water, the so called "freewater", is either used to change the volume of the Lake or is released into the Shire River. The evaporation is the conservative factor, leaving the water level to be heavily dependent on changes in rainfall pattern – in particular on the rainfall directly on the Lake. Representative data on Lake rainfall and evaporation are not available. An indicative water balance for the Lake, based on hydrological and meteorological data from the period 1953/54 to 1973/74, has been presented in a Government of Malawi – UNDP/WMP Project report. Calculated into average annual flow figures the balance showed:

- Inflow from catchment: 595 m^3/sec
- Rainfall on the Lake: 1,230 m^3/sec
- Lake evaporation: 1,467m^3/sec
- Free water (combined Lake outflow and change in Lake volume); 358 m^3/sec

Lake Malawi is a nutrient poor, clear lake (oligotrophic). The production of phytoplankton which forms the base of the food chain, and consequently influences the total fish production, is limited by the storage of nutrients. The influx of nutrients from the catchment runoff is mostly lost into a stratified anoxic layer originating at a depth of approximately 250 m. Some mixing and mobilisation of nutrients occurs in the cool winter season (May – August), due to south-easterly trade winds. In the shallower south-eastern part of the Lake, the entire water column is mixed in the cool season and nutrients in bottom sediments are returned to the water column. The existence of internal upwelling under the influence of the strong southerly winds also helps in mixing the water and hence maintaining the productivity of the south-east arm of the Lake. This leads to a much higher annual biological production in this part of the Lake compared to the northern segment.

5.1.5.1.2 Lake Outflow and Upper Shire

The flow of the Shire River is primarily determined by two components: the outflow from Lake Malawi; and the inflow from the drainage basin downstream of the Lake. Of these, the outflow from the Lake is the dominant component. In the dry season, Lake outflow accounts for virtually all the water entering the Shire River. Evaporation from Lake Malombe accounts for an average annual loss of about 20 m^3/sec. The Kamuzu Barrage provides some flow regulation capacity and is used to secure the base flow needed for hydropower generation.

The long term variations in Lake levels, and thus the outflow, have caused periodic changes in the flow characteristics of the Shire on a historical time-scale. The River ceased to flow altogether in 1915 and only gradually regained its regular flow in 1934-37 when the water level in Lake Malawi rose to the height whereby it was able to break through the sand and sediment bars that the tributaries had built up in the Upper Shire. From the early 1950s until mid-1970s, the River flow at Liwonde was maintained at annual average levels fluctuating between 200 m^3/sec and 600 m^3/sec. The Kamuzu Barrage was completed in 1965 for the purposes of storing water in the upper part of the River to maintain a minimum flow of at least 170 m^3/sec downstream. In the period from the mid-1970s and through the 1980s the Lake level increased and the average annual flow was recorded at between 400-800 m^3/sec. In the early 1990s, however, the whole of south-eastern Africa experienced serious droughts and a dramatic fall in the Lake level and a reduction in Shire River flow resulted.

The lowest water level in 40 years was recorded in December 1995, when the lake level reached 473.0m with a resulting downstream water flow (measured at Liwonde) of 129 m^3/sec. This flow was well below that required for maintaining hydropower production at the plants in the Middle Shire.

An additional factor that affects the outflow is the status of silt and sand deposits in the river bed of the Upper Shire River. As a result of the modest slope of the whole upper course, sand bars are able to form, preventing some of the water from flowing downstream. A reduced initial outflow from the Lake, due to low Lake levels, will further exacerbate the problem. A high River flow enables the breaking through of barriers and the flushing of sand and sild downstream.

Some of the siltation changes are a result of the dynamics of the main River, but the major problems are caused by the seasonal tributaries and their discharge points in to the Shire. Silt transport by the tributaries

has increased in recent times due to poor land-management and the intensification of agriculture in the catchment area (Shela, 2000; Norconsult and Associates 2003; and NORPLAN 2011a).

The relatively nutrient rich water exiting the Lake is further enriched as it flows downstream. The erosive force of the Shire River and tributaries add to the concentration of nitrogen and phosphorus available for plant growth. Some of these nutrients will be used by planktonic algae in the Shire River and others will be used to promote the growth of reed and wetland species, including floating or submerged plants. The water hyacinth (*Eichhornia crassipes*), a noxious floating plant, has recently established itself in the area and is benefiting from the nutrient rich water in some of the more sheltered parts of the Shire River.

5.1.5.1.3 Lake Malombe

Lake Malombe is effectively an extension of the Upper Shire, located approximately mid-way between the outflow and Liwonde and downstream of Mangochi (Figure 11). Typically, the length of the Lake is about 30 km with a maximum width of about 15 km. The depth averages about 7 m, with a maximum of around 17 m. It is claimed that the depth has decreased in recent years. The existence and dimensions of the Lake are totally dependent on the discharge of the Shire River. Large seasonal fluctuations in Lake size are common and records exist of a total dry-out in the years the Shire River ceased to flow in its upper course. Lake Malombe causes flooding in its vicinity according to local residents. The flooding depth can reach as high as 0.5 m and the duration of the flooding could be as long as three to six months.

Due to its shallow depth, the water in Lake Malombe is comprehensively mixed at all times of the year; the nutrients are efficiently recycled and the productive zone extends right to the bottom. Additionally, the Lake profits from the inflowing nutrient rich water. Surface runoff reaching the Lake further contributes to the productivity levels. Indicators of the nutrient rich (eutrophic) character are high levels of chlorophyll “a” and the low transparency of the Lake water.

Commercial sand mining and fishing are common practices at Lake Malombe. Malaria is a common disease on the flood plains of the Lake. When floods recede farmers make use of the regained land for cultivation of maize. During inundation, they grow rice. Although the government is encouraging residents to pump water from the Lake using heavy duty pumps for irrigation development, there is only one known irrigator who uses pumping. In case of flood disaster, which was observed some years back, the government has a flood contingency plan. Land around Lake Malombe is covered under the Green Belt Initiative, a Government-supported plan for expanding irrigation in selected areas of Malawi. Under this plan, 800 ha of irrigation (the Kobole Scheme), is planned around Lake Malombe.

Figure 11. The shallow shoreline of Lake Malombe

Figure 12. The Elephant Marsh in the Lower Shire River.

5.1.5.1.4 Middle Shire

Proceeding downstream the River is fed by a number of tributaries, most of them seasonal. The flow regime of the River here, therefore, exhibits greater variations between peak flows and low flows than the upper part. Typically – in normal Lake outflow periods – the rainy season flow is about one-and-a-half to three times the magnitude of the dry season flows. Although flood episodes of local origin are important, a significant proportion of peak average flow is due to higher lake levels towards the end of the rainy season. A

comparison of Shire flow discharge at Liwonde and that at Maganga (2.5 km downstream of Kapichira falls) indicates that the Middle Shire tributaries contribute about 30% of the Shire water in the rainy season, and less than 10% in the dry season.

5.1.5.1.5 Lower Shire

The Lower Shire is slow flowing over a flat flood plain. During periods of high water level it overflows the area termed Elephant Marsh, creating a large wetland with a multitude of channels and pools (Figure 12). The Elephant Marsh in its downstream portion is also heavily influenced by the Ruo River running from the east at the Malawi – Mozambique border. In some years, the Ruo might even have a greater impact on the water table in the Marsh than the Shire River itself. Downstream of the Ruo River confluence is another extensive wetland area which is known as the Ndinde Marsh.

5.1.5.2 Major Water Users

The major water users from the Shire River downstream of Lake Malawi are Mangochi Town, Blantyre City, Nkula Hydropower plant and SUCOMA Sugar Estates. Major water users who are licensed by the Water Resources Board of the MoWDI are Demeter Irrigation; Cattle feedlot, Illovo Irrigation (SUCOMA Sugar Estates) and Blantyre Water Board.

The daily demand for water supply at Mangochi is estimated at 8,000 m^3/day and is predicted to increase to 12,000 m^3/day in 20 years. The system loss at Mangochi water supply is estimated at 21%.

The main water management problem faced by the irrigation interests in Lower Shire is at present the heavy silt content of the water. Continuous mechanical removal of silt from the intake channel is needed to maintain irrigation operations on the SUCOMA Sugar Estates.

5.1.5.2.1 Nkula Power Station

Nkula Hydropower station has eight units with a total installed capacity of 124 MW. Nkula A is equipped with three units with a total installed capacity of 24 MW whereas Nkula B is equipped with eight units with a total installed capacity of 100 MW. The annual energy production varies from 581 GWH to 650 GHW. Nkula A uses 72.0 m^3/s of flow in total whereas Nkula B uses 200 m^3/s in total. The rated head for generating power is 57 m.

There are two barrages side by side serving both hydropower stations. The water conveyance structures consist of tunnels and penstocks. The barrage is equipped with sector or radial gates which are very old and leakage was observed. There are also automatic raking machines in order to clean the trash rack at the inlet to the tunnel.

As per the information from the Power Station Manager, siltation upstream of the barrage is a very serious problem which they have to deal regularly in order to avoid the clogging of the intake to the tunnel. The siltation has become problematic in the last 12 years. There is a dredger equipped with a stirrer and a suction pipe which removes the silt to a nearby dumping site. The silt is ejected into this dumping site which is divided into parcels of land with dykes.

5.1.5.2.2 Blantyre Water Pumping Station

The Blantyre Water Board Pumping station (Walker's Ferry) is located very close to Nkula Hydropower station. It draws water from Shire River and its intake is located upstream of the Nkula Barrage. The maximum daily production is 85,200 m^3/day when all pumps operate for 24 hrs. The pumping station is equipped with eight pumps. Four of the pumps have a discharge capacity of 460 m^3/hr per unit. The rest each have a discharge capacity of 1,440 m^3/hr. The Clear water output is 80,952 m^3/day. There are eight pumps for supplying the clear water to the city through a head of 700 metres over a distance of 37 km. A pressure break tank is located at Chileka. The Distribution reservoirs are all located in the City and a conventional water treatment plant is also located nearby. It has its own water quality laboratory. The treatment plant includes pre-settling tanks, flocculation tanks, dosing chamber etc.

According to the Production Supervisor, siltation at the intake is a huge problem since it clogs their intake. Hence, they have on standby a leased dredger to remove the silt so that the intake to the pumping station receives clear water.

5.1.5.2.3 SUCOMA Sugar Plantation

A command area of the Sugar Plantation is estimated at 14,000 ha. A mixed type of irrigation is used which includes sprinkler and surface irrigation. Almost half of the irrigation area is under sprinkler and the rest under surface irrigation. The main canals have a discharge capacity of 1.7 m^3/s.

They are currently licensed to abstract 23.6 m^3/s of water from Shire River and additional surface water from Mwanza River. They have a plan to expand the irrigation but they found out that water is a limiting factor. For example, they faced a serious shortage of water recently and they had to lodge their complaint to the Water Resources Board. The irrigation scheme is also a bulk consumer of power. Their demand stands now at 23 MW.

The SUCOMA Sugar Estates are also facing a very serious problem with sedimentation in their irrigation canals. To reduce the growing problem of a heavy sediment load in the Shire River and its tributaries, the Shire River Basin Management Project (SRBMP) will finance interventions to rehabilitate targeted sub-catchments through (i) promoting soil and water conservation for more sustainable and productive agriculture; (ii) forestry and rural energy interventions to restore forest cover and reduce firewood consumption within the sub-catchments; (iii) stream and water control, including check-dams and small earth dams to support improved water management through smaller-scale structures built by community members.

5.1.5.3 Kamuzu Barrage at Liwonde

The Kamuzu Barrage provides flow regulation in the Shire River downstream of Liwonde and limited control of water levels upstream in the Shire River, and Lakes Malombe and Malawi.

The Water Resources Board is responsible for the Operation and Management of the Barrage. The Barrage is currently operated in order to satisfy the requirements of ESCOM at Nkula hydropower station and the downstream cascade of hydropower stations. The peak demand for power and hence flow is from 5:00 p.m. to 8:00 p.m. Flow releases from the Barrage are not used for peak power generation but are used to supply reliable average flow for baseload power generation. Peaking is achieved through the use of the ponds at the hydropower stations (balancing low flow and peak demand).

The operating discharge from the existing Kamuzu Barrage is 340 m^3/s as computed from the rating curve. However, it is not certain whether the flow in the Shire River channel is as large as 340 m^3/s as predicted by the rating curve. In 2002/2003, ESCOM was operating at only 170 to 180 m^3/s. The SRBMP will support the improvement of rating curves and establishment of an improved realtime hydromet system for the Shire River.

Kamuzu Barrage at Liwonde is furnished with 14 sector gates. The gates are numbered from one to fourteen starting from the left bank looking in the downstream direction. Gates 1 to 4 are provided with a downstream apron and they are constructed in such a way that when they are fully opened the whole demand downstream of the Barrage will be met. Gates 5 to 14 are not provided with stilling basins and they are constructed as reserves. Over the years, considerable downstream erosion has caused scouring immediately downstream of the Barrage of at minimum two metres depth, which in mid to longer term might affect the stability of the structure. Currently, Gate 8 is not functional and is in a closed position.

The gates are operated using motors installed on each gate. There is no crane for lifting the gates. No provision is made for stop logs. Leakage is observed on most of the gates.

Floating weeds are becoming a serious problem to the operation of the gates and more importantly for downstream hydropower installation where they cause considerable downtime for repair and maintenance, hence weeds are removed at the Barrage. Weed removal costs ESCOM as high as MWK 60 Million per year. There is a standby weed harvesting machine which is regularly operated to remove the weeds although it is not completely effective (ESCOM 2009).

Siltation is believed to be occurring and the river bed is now aggrading. The estimated aggradation is about 1.5 m from its original bed elevation.

An operational Lake Level range exists in the interval of which regulated or controlled discharge is released downstream of the Kamuzu Barrage. A constant capacity is released when the lake levels are in the operation range. Outside of this range, the gates are fully opened and the flow in the Shire River follows the natural rating curve.

The existing Kamuzu Barrage is only capable of regulating Lake Malawi levels when they are between 474.30 masl and 475.32 masl. The proposed upgrading has the objective of increasing the highest regulated water level (HRWL) from 475.32 masl to 475.52 masl (Scenario 1), and from 475.32 masl to 475.72 masl (Scenario 2). This brings about 20 cm and 40 cm increase in the HRWL respectively.

5.1.6 Water Quality

Further details on water quality are provided in the Water Quality Specialist Report in Volume 2 of the ESIA. Nineteen water quality parameters were measured at five sampling sites from the Shire River around the Kamuzu Barrage. These were biochemical oxygen demand (BOD), chlorophyll "a", conductivity, dissolved oxygen (DO), depth, hardness, nitrate, nitrogen, pH, phosphorus, salinity, Secci depth (transparency), sulphate, temperature, total dissolved solids (TDS), total suspended solids (TSS) and turbidity, Zooplankton and Faecal Coliform. Water quality data for the sampling undertaken during the wet and dry season are reproduced in Appendix 5.

Results showed that all five sampling points had faecal pollution (118±3.2 CFU/100ml, mean) but did not have high phosphorous (20.6±0.18µg/l, mean) and nitrate levels (0.16±0.04mg/L, mean). However, the rainy season values were higher than those of the dry season, showing the impact of rain and runoff from the catchment to the river system. Also those points that were close to the Kamuzu Barrage and at the outlet of Lake Malombe had high concentrations of coliform counts (124±2.2CFU/100ml, mean) and those sampling points within the stream catchment area and resorts and lodges gave higher concentrations of Phosphorous (24±2.6 µg/l, mean) and Nitrates (0.22±0.02mg/L, mean) than the rest, probably due to the nature of pollution emanating from the lodges and resorts.

Water quality analysis results further showed that Chlorophyll "a", hardness, P, Secchi depth and Turbidity increased as one moves from the downstream side of the Barrage to the upstream side of the barrage and the ESCOM weed trapper. This could be because as the water passes through the Barrage there is good mixture with oxygen and also water flow is increased hence most of the substances are oxidised whilst on the upstream side of the Barrage water flow is reduced hence increasing the residence time for water. This causes substances to accumulate as described by Wetzel (2001).

A combination of phosphorous and nitrogen is very crucial in relation to aquatic primary production. Excessive concentrations of the two nutrients will lead to eutrophic state of the water which may be manifested by macrophytes growth (aquatic weeds) rather than in the growth of phytoplankton. The effect of eutrophication can be highly detrimental to water quality and severely limit the uses for which the water is meant. In relation to concentration of the phosphorous and nitrogen, the water of the Shire River is basically within the oligotrophic category - water with low primary production due to low nutrient content, often more clear with high drinking quality (Class I water quality in Table 2).

TABLE 2. STANDARD GUIDELINES FOR WATER QUALITY FROM UNECE

Variable	Class I	Class II	Class III	Class IV	Class V
DO (mg/L)	> 7	7- 6	6-4		<3
BOD (mg/L)	< 5	5-10	10-20	21-30	>50
Phosphorous (µg/L)	<15	15-40	40-75	75-190	>195
Total Nitrogen (µg/L)	<300	300-750	750-1500	1500-2500	>2500
Chlorophyll "a" (µg/L)	<4.00	4-15	15-45	45-165	>165
Hardness (mg/L)	<20	-	-	-	>80
Turbidity (NTU)	<5	-	-	-	>20

Source: (UNECE, 2003)

Class I; Oligotrophic, Class II; ά- mesotrophic, Class III; ß-mesotrophic, Class IV; ά-Eutrophic

Previous studies conducted between 1994-1997 (GoM, 2003, Table 3) on selected water quality parameters show higher readings of Total Dissolved Solids and Electrical Conductivity and lower Turbidity (among other parameters) in comparison to the current findings. Increase in turbidity by close to three fold indicates the increase in pollution over the years. However, although there are these differences, the water quality was still in the oligotrophic category in both situations.

TABLE 3. MEAN CONCENTRATION OF SELECTED WATER QUALITY PARAMETERS FOR THE SHIRE RIVER (1993-1997)

PARAMETER	YEAR				
	1993	1994	1995	1996	1997
Conductivity (µS/cm)	382	475	320	297	321
TDS (mg/L)	151	300	155	158	170
Nitrate (mg/L)	<0.1	4.1	<0.1	<0.1	<0.1
Sulphate (mg/L)	<0.1	14.4	4.6	5.2	4.4
Hardness (mg/L)	80	82	92	84	94
Turbidity (NTU)	7	84	10	10	25
TSS (mg/L)	11	36	12	12	28

Source: GoM, 2003 (most recent available at time of ESIA preparation).

5.2 Biological Environment

The Project footprint (i.e. that area where effects from the Project are likely to occur) includes Lake Malawi, Lake Malombe, and the Shire River from Lake Malawi outlet to the Barrage, and downstream to the Elephant Marsh and confluence with the Zambezi River. Further details on vegetation, wildlife and fisheries are contained in the Specialist Reports in Volume 2 of the ESIA.

5.2.1 Vegetation

The vegetation descriptions for the wider Project have been given according to basic landscape types. Within the wider Project area the major zones are:

1. Southern Lake Malawi
2. Mangochi – Lake Malawi – Lake Malombe Zone
3. Lake Malombe to the Kamuzu Barrage
4. From the Kamuzu Barrage, downstream as far as the Kholombidzo Falls
5. From the Kholombidzo Falls to the bottom of the series of rapids and waterfalls on the Lower Shire
6. Lower Shire and Elephant Marsh

Within each major zone, there are vegetation zones that are described according to their location on the landscape and the hydrological regime created by the mountains, hills and escarpments of the Great African Rift Valley, from the north, right down to the hills and escarpments of the lower Shire River.

The basic land systems and associated vegetation within the area influenced by the Project are described as follows:

Southern Lake Malawi, with special emphasis on the Lake Malawi National Park

This section has been described according to information taken from the FAO (1989 – 1992) reports, verified by rapid assessment by a Land Use/Botany specialist (Norconsult, 2003) and reassessed by a second rapid assessment as part of the current study.

- Wetter hills and escarpments
- Dry hills and escarpments
- Upland plains
- Lakeshore plains
- Seasonal floodplains
- Seasonal and ephemeral rivers – tributaries
- Rock out crops/Islands in the lake

Mangochi, Lake Malawi - Lake Malombe Zone

This section has also been described according to information taken from the FAO (1989 – 1992) reports, verified by rapid assessment by a Land Use/Botany specialist (Norconsult, 2003) and reassessed by a second rapid assessment as part of the current study.

- Water Zone
- Perennial Swamp
- Seasonal swamp/marshlands
- Seasonal floodplains
- Alluvial terraces – occasionally inundated
- Seasonal and ephemeral rivers – tributaries
- Dry bush savannah

Lake Malombe to Kamuzu Barrage

This section has been written following detailed site inspections of selected vegetation communities, in addition to those taken from FAO (1989 – 1992) reports and Norconsult, 2003.

This zone covers the Liwonde National Park (LNP) on the south-eastern side of Lake Malombe, as well as the LNP section to the west of the river, as far down as Kamuzu Barrage. Arable lands and Liwonde Township abut the lower reaches of this section. There are eight typical landscapes in this zone:

- Water Zone
- Perennial swamp
- Seasonal swamp/marshlands
- Seasonal floodplains
- Alluvial terraces – occasionally inundated
- Dry bush savannah
- Seasonal and ephemeral rivers – tributaries
- Hill outcrops

Kamuzu Barrage to Kholombidzo Falls

This zone covers an extensive stretch of the river, from the Barrage down to Kholombidzo Falls, on the old Matope Road Bridge. There are eight typical landscapes in this zone.

- Water Zone
- Perennial swamp
- Seasonal swamp/marshlands
- Seasonal floodplains/Dimba
- Alluvial terraces – occasionally inundated
- Dry bush savannah
- Seasonal and ephemeral rivers – tributaries
- Hill outcrops

Middle Shire River – Rapids and Falls Areas

- Alluvial floodplains
- Adjacent escarpments

Lower Shire River (including Elephant Marsh)

- Alluvial floodplains
- Adjacent escarpments

5.2.1.1 Zone Descriptions

Lake Malawi

This section covers all of Lake Malawi, and the Shire River as far as the Kamuzu (Liwonde) Barrage. The descriptions here are taken from the FAO (1991) documents and have been updated based on the findings of field studies conducted in 2011.

Natural Vegetation

In spite of the rapid opening up of new land in recent years it is estimated that about 40-45% of the Kamuzu Barrage area of influence remains under natural or derived vegetation. The overriding influences on vegetation type are climate and soils, particularly soil drainage. The groups of woodlands and savannahs found on the rift valley floor and the low hills within it are distinct from those on the escarpments, prominent hills and plateaus.

The Rift Valley Floor and Associated Hills of Low Altitude

Generally in the Rift Valley vegetation types show marked zonation, and the distribution of communities reflects soil and drainage changes. A considerable part of the Upper Shire Valley has *Colophospermum mpoane* woodland that occurs either in almost pure stands, or associated with a number of other trees and shrubs. In areas where termitaria have a string influence, *Dalbergia melanoxylon* dominates the understory, but in other places *Albizia anthelmintica* and *Commiphora* spp. are more common. Other species associated with mopane woodland are found in the Rift Valley in general and include *Acacia nigrescens*, *Sclerocarya birrea*, *Adansonia digitata*, *Sterculia* spp. and shrubs like *Grewia* spp. Grass cover is sparse consisting mostly of *Setaria* spp. and *Aristida adscensionis*.

Woodland savannahs dominate most of the remainder of the Shire Valley and Lakeshore Plain areas, where soils have reasonable drainage. These contain and association of *Cordyla africana*, *Sclerocarya birrea*, *Sterculia africana*, *Adansonis digitata*, *Tamarindus indica*, *Lonchocarpus*, *Kigelia africana* and *Acacia* spp. There are almost pure stands of *Hyphaene petersiana* associated with sandy soils or salt affected areas, and where drainage is poor communities of *Acacia xanthophloea* occur.

Lake Malawi National Park

There are some thicket areas remaining on the Nankumba Peninsula (Lake Malawi National Park) and the Liwonde National Park where the dominant trees are *Pterocarpus lucens* and *Newtonia hildebrandttii* with trailing and climbing *Acacia*, *Grewia* spp, *Capparis* spp, etc. in the understorey.

There are also thicket-like stands of *Acacia ataxacantha*, particularly in less well-drained sites, but these are probably colonisers of disturbed areas. The woodland savannahs support a variety of grasses including *Panicum maximum*, *Urochloa mossambicensis* and species of *Hyparrhenia*, *Digitaria* and *Setaria*.

Apart from Liwonde National Park, most of the areas of semi-deciduous riverine forest have been cleared for cultivation, but where these still occur *Khaya nyasica* (*Khaya anthotheca*), *Sterculia appendiculata*, *Ficus* spp, *Kigelia africana* and *Acacia albida* are found. *A. albida* trees have been left standing when land is opened for cultivation and now form park like areas in various parts of the Project Area, where ground water is available throughout the year.

On areas of low hills where soils tend to be shallow and stony, tree savannahs occur containing some of the species of the valley floor, but dominated by *Combretum* spp. *Diplorhynchus condylocarpon*, *Pseudolachnostylis maprouneifolia*, *Terminalia sericea*, *Strychnos spinosa*, *Diospyros kirkii*, *Afzelia quanzensis*, *Sterculia quinqueloba*, and *Acacia* spp. Grasses include *Hyparrhenia* spp. and *Themeda triandra*. The higher land within the Phirilongwe Hills carries *Brachystegia boehmii – B. Manga* woodland and *B. bussei* and *B. glaucescens* dominate the hills at Cape Maclear.

A woodland savannah of Combretum, Acacia and Bauhinia originally covered the Namwera Plain, but this has been entirely cleared for cultivation.

All the woodlands in the Project Area are in a degraded state due mainly to annual burning. Ground cover is almost nonexistent, particularly in the early part of the wet season, and effects of soil erosion are very clear to see.

The open grassland areas are in the floodplains associated with the Lakes – Chilwa and Chiuta and the Shire River, and grass species are therefore mainly those found in wet habitats, and show zonation according to distance from the water. Common species are *Hyparrahenia rufa*, *Panicum repens*, *Bothriochloa* spp., *Ischaemum afrum*, *Chloris gayana*, *Echinochloa pyramidalis*, *Setaria sphacelata*, *Sporobolus pyramidalis*, *S. Consimilis* and *Cynodon dactylon*.

Areas within the Project Area classified as Marsh (M) consist of communities of *Typha domingoensis*, *Cyperus* spp. or *Phragmites mauritianus* and floating vegetation such as *Pista stratiotes* and *Nymphaea* spp.

With rocky hills and islands the water level can go up or down considerably before there is any impact on the shoreline vegetation and land systems.

The Shire River System

The Shire River is the only outlet of Lake Malawi, and runs from Samama to the border with Mozambique, before it joins the Zambezi River. From a topographical point of view, it appears logical to divide the Shire River in to three sections, Upper, Middle and Lower.

The Upper Shire River stretches from the lake outlet at Samama to Matope, and includes Lake Malombe. This part of the river has a very low gradient, 0.12 m per km.

The Middle Shire stretches from Matope, through several waterfalls, including Murchison and Livingstone Falls, to Kapichira. The section starts at the location of Kholombidzo Falls. The gradient in this part of the river is relatively high, 3.6 m per km.

The Lower Shire stretches from Kapichira to the border with Mozambique, and includes Chikhwawa lagoons, Elephant Marsh, Bangula Lagoon, and Ndinde Marsh in Nsanje District. Ndinde Marsh is shared with Mozambique. This stretch of the Shire again has a low gradient, 0.22 m per km. This gradient continues in Mozambique to the confluence with the Zambezi.

Several tributaries join the Shire, e.g. Mulunguzi, Lunzu, Mwanza, and Ruo Rivers. In the lower part of the Shire, water inflow from the tributaries may at times be more important to the flow in the main river than the supply from Lake Malawi.

In the Upper Shire, Lake Malombe is a shallow lake as an extension of the Shire about 12 km from the Lake Malawi outlet. Lake Malombe is 30 km long and 15 km wide, with a surface area given as 390 km^2 at a water level of 472 m. As the lake is positioned in a shallow depression, it varies significantly with the water discharge in Shire, and thus ultimately with water levels in Lake Malawi. The average depth is five to seven metres, and the maximum depth is 17 m. From Lake Malombe almost to Liwonde, the river runs through Liwonde National Park. A small part of the south-eastern section of Lake Malombe lies within the Liwonde National Park.

The areas around the Lower Shire are characterised by extensive wetlands. Ndinde Marsh lies to the west of the Shire River, and is sustained by the waters of the Shire. During the rainy season, the Chikhwawa lagoons are joined to the Shire River either by a rise in water level or by flooding. This is the time that the lagoons are replenished with various species of fish.

The water volume in the Bangula Lagoon swells during the rainy season, when flow in the Shire River is obstructed by the flooding Ruo River. This causes a rise in water levels in the Shire, and water flows into the Bangula Lagoon. The Ruo River joins the Shire a few kilometres south of the Bangula Lagoon.

Mangochi – Lake Malawi Outlet to Lake Malombe

The descriptions for this zone are taken from field observations and supplemented by research documented for the area, including Dudley and Blackmore (1994), and Dudley and Osborne (1988).

The descriptions cover both the land systems and the vegetation.

Water Zone

This zone consists of the main river as it flows from Lake Malawi into Lake Malombe.

The channel is about 200-300m wide at the narrowest section, and approximately three to six metres deep.

Vegetation in the channel consists of river bottom dwelling plants and floating aquatic plants. The river current pushes through most of the latter from Lake Malawi to Lake Malombe, otherwise they settle in to backwater areas in the river margins, where there are perennial and seasonal swamps and marshlands.

5.2.1.2 Biotic Communities

For the purpose of rapid assessment the biotic communities represented within 100m of the high water-line edge were included in the assessment; the rational being that this was the zone of influence of any fluctuation in water levels resulting from the Barrage upgrade. Six (6) distinct biotic communities were identified as being represented within the Project area during the field assessment, including:

- Perennial Marshes
- Seasonal Marshes – Uncultivated
- Seasonal Marshes - Under Cultivation (*dambos*)
- Seasonal Flood Plains
- Riverine Woodlands; and
- Dry Bush Savannah

A brief description of the characteristics of each biotic community type is provided below.

5.2.1.2.1 Perennial Marshes

Perennial Marshes are found along parts of the river and in certain sections of the lakeshore zone on both Lake Malawi and Lake Malombe. The largest area is Elephant Marsh (Figure 13) in the southern part of the Project area. The permanent swamp areas are in relatively shallow water, but the soils are almost permanently inundated. The vegetation consists of tall reeds and aquatic grasses, and various smaller floating and/or submerged plants, where the river current is either weak or virtually non-existent (Table 4). Full descriptions of Aquatic Macrophytes in the Upper, Middle and Lower Shire are given in Blackmore, Dudley & Osborne (1988). Some common species are given below to provide the reader with some detail for the aquatic systems that may be affected by this Project.

TABLE 4. COMMON AQUATIC MACROPHYTES FOUND IN PERRENIAL MARSHES OF THE SHIRE RIVER

Reeds, rushes, sedges and grasses	Water lilies and other floating aquatics
Cyperus papyrus	*Azolla pinnata*
Typha capensis	*Commelina benghalensis*
Vossia cuspidate	*Ipomoea aquatic*
Phragmites mauritianus, P australis	*Nymphaea caerula, Nymphaea lotus*
Thelipterys confluens (Pteridophyta)	*Pycreus mundtii*
	Salvinia hastata
Submerged plants	
Ceratophyllum demersum	
Ottelia spp. (e.g. O. exserta., O. scabra)	
Potamogeton pectinatus, P. thunbergia	
Spirodela polyrhiza	

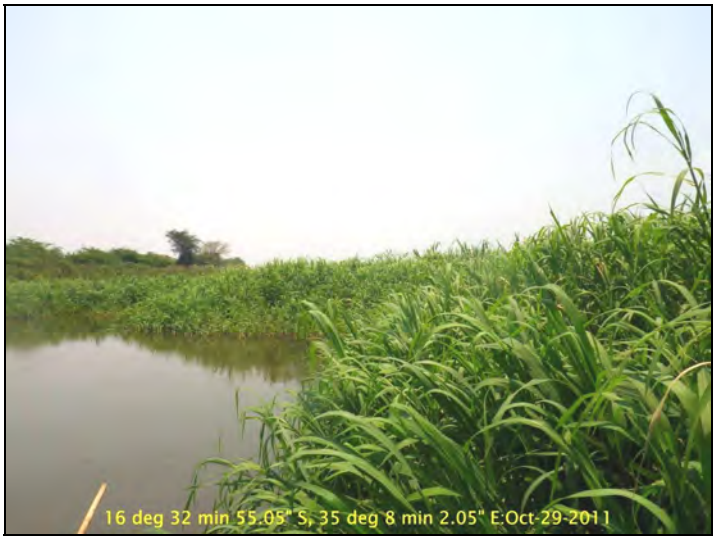


Figure 13. Example of a Perennial Marsh (Elephant Marsh)

5.2.1.2.2 Seasonal Marshes - Uncultivated

The lake and river levels rise and fall on average one metre in a single year. These fluctuations are due to annual rainfall inflow mainly to Lake Malawi. The fluctuations are also affected by the rate of water release at the Kamuzu Barrage, so they are not true seasonal fluctuations, but a combination of natural and managed cycles of water flow.

The species are similar to those found in Perennial Marshes, with die-back of aquatic plants when water levels recede, plus the addition of plants that tolerate wet and dry soils. Water tolerant woody plants occur here, as do water tolerant grasses, sedges and reeds (Table 5). The landscape is generally flat with tall reeds and grasses, with scattered, short trees and shrubs that sometimes form small thickets (Figure 14). In addition to the species listed for the permanent swamp areas, there are a few emergent woody plants (Table 5). These tend to be rooted in silt and humus accumulations formed on the tops of reed banks and papyrus suds.

TABLE 5. COMMON EMERGENT WOODY PLANTS

Woody Plants	Reeds, rushes, sedges and grasses
Hibiscus diversifolius	*Cyperus spp. (numerous)*
Mimosa pigra	*Echinochloa haploclada, E. pyramidalis*
Sesbania bispinosa	*Hemarthria altissima*
Syzygium cordatum	

Figure 14. Example of an Uncultivated Seasonal Marsh

5.2.1.2.3 Seasonal Marshes – Cultivated

Most of the seasonal marshes around Lake Malombe and in the Upper Shire were under some form of '*dambo'* cultivation at the time of the assessment. Brinkman and Blokhuis (1986) define *dambo* as:

> *"areas that have free water at or on the surface for at least the major part of the growing season. The water is sufficiently shallow to allow the growth of a wetland crop or of natural vegetation rooted in the soil".*

The most commonly planted *dambo* crop is maize (Figure 15); other common crops are beans, peas, sweet potatoes and sugar cane. Vegetables such as cabbage, rape, pumpkin leaves, champiru or mustard are grown to a lesser extent (Klarer 2008).

Figure 15. Example of Cultivated Seasonal Marsh (dambo)

5.2.1.2.4 Seasonal Floodplains

Seasonal floodplains occur where there are shallow gradients from the lake and river body sides on to dry land. The land is more commonly dry than submerged here, as opposed to seasonal marshlands and/or swamp, which is more commonly submerged, but may dry out from time to time.

Here we see scattered tall trees, predominantly palm species, and tree and scrub thickets (Table 6), most commonly associated with low lying islands and termite mounds.

The flat-lands areas are covered in tall grasses, reeds and sedges and in the lower lying locations, these merge in to seasonal marshlands (Figure 16).

TABLE 6. TYPICAL FLOODPLAIN PLANT SPECIES

Woody plants - Trees	Woody plants - Shrubs
Hyphaene petersiana	*Adina spp.*
Phoenix reclinata	*Carissa spp.*
Kigelia Africana	*Dichrostachys cinerea*
Afzelia quanzensis	*Ficus spp.*
Acacia nilotica	*Garcinia spp.*
Acacia nigrescens	*Grewia spp.*
Dalbergia melanoxylon	*Gymnosporia senegalensis*
Combretum imberbe	*Maerua triphyllum*
Lonchocarpus capassa	*Ormocarpum kirkii*
Trichilia capitata	*Rhus spp.*
Xanthoxercis zambeziaca	
Ziziphus mucronata	

Woody plants - Trees	Woody plants - Shrubs
Reeds, rushes, sedges and grasses	Non-grasses
Cyperus spp. (numerous)	*Asparagus spp.*
Kyllinga spp.	*Hibiscus spp.*
Mariscus spp.	*Leonotis spp.*
Pycreus spp.	*Ocimum canum*
Brachiaria brizantha	*Pluchea spp.*
Echinochloa haploclada, E. pyramidalis	*Sanseveria aethiopicia*
Hemarthria altissima	*Sesamum spp.*
Oryza spp.	*Sesbania spp.*
Phragmites australis, P. mauritianus	*Veronia spp.*
Sporobolus festivus, S. robustus	

Figure 16. Example of Seasonal Flood Plains

5.2.1.2.5 Riverine Woodlands

Riverine Woodlands tend to predominate in the steeper areas of the Middle Shire where the river banks are drier, these woodlands tend to be species rich (Table 7). The trees are relatively tall, varying in height from 12 to 30 m, with secondary shrub and emerging tree understory (Figure 17). The tree canopies are relatively close and vary from interlocking to slightly apart (up to about 5m).

TABLE 7. COMMON PLANTS ASSOCIATED WITH RIVERINE WOODLANDS

Woody plants	Cont.
Acacia xanthophloea	*Dichrostachys cinerea*
Albizia brevifolia	*Diospyros spp.*
Balanites aegyptica	*Faedherbia albida*
Cissus quadrangulifolia	*Strychnos spp.*
Colophospermum mopane	*Tamarindus indicus*
Combretum mossambicensis	*Terminalia sambesiaca*
Commiphora africana	*Thylachium africanum*
Dalbergia spp.	*Xeromphis obovata*

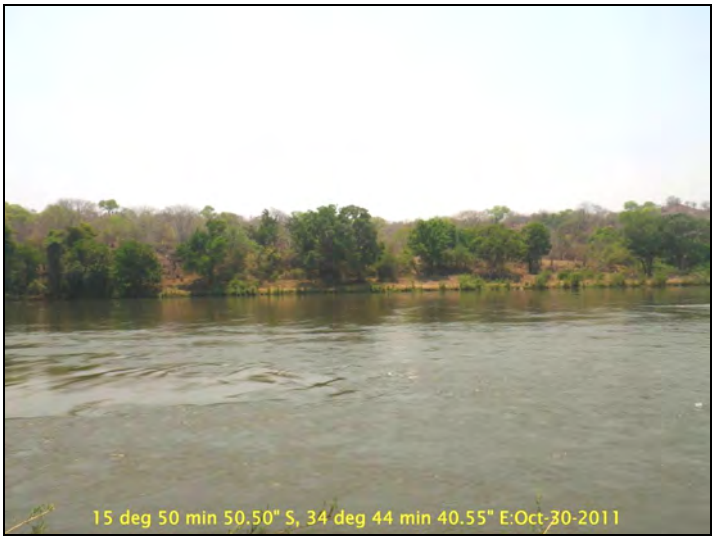


Figure 17. Example of Riverine Woodland

5.2.1.2.6 Dry Bush Savannah

This vegetation type occurs on the higher-lying areas of Southern Lake Malawi shoreline. The soils are generally quite shallow and gravelly, of various soil parent materials. Much of the soil parent material is of colluvial origin, from the upper slopes and escarpments on the sides of the Rift Valley.

The vegetation consists of mixed bush, tall grasses and scattered tall trees (Figure 18). Often the woody vegetation occurs in clumps with dense shrub thicket surrounding the base of a single tall tree, or a clump of tall trees. The baobab is a dominant tree on this part of the landscape. Much of this vegetation type has been disturbed, either by clearing for agriculture, or by felling trees for construction timbers and fuel wood. Examples of common tree species are given in Table 8.

TABLE 8. COMMON TREE SPECIES

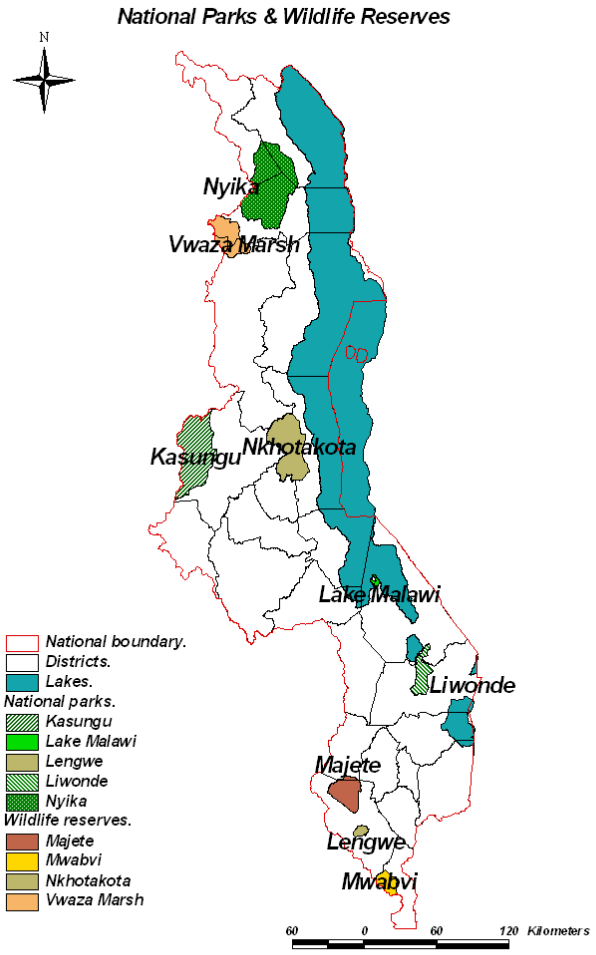
Woody plants	Cont.
Acacia nigrescens	*Combretum spp.*
Acacia spp.	*Cordyla Africana*
Adansonia digitata	*Pterocarpus spp.*
Albizia spp.	*Sterculia quinqueloba*
Borassus aethiopium	*Trichilia emetic*
	Ziziphus maurtitanus

Figure 18. Example of Dry Bush Savannah

5.2.2 Terrestrial and Aquatic Wildlife

5.2.2.1 Wildlife Habitats

The Project area spans over a variety of habitats from open water, floating meadows, lagoons and reeds, floodplain grassland woodland mixed woodlands. The habitats adjacent to the Shire River and Lake Malombe include wetlands, open grasslands and mixed woodlands. Wetlands and open short grasslands occupy most of the floodplains. The extent of coverage varies from place to place but the Project area being generally flat allows water stagnation during flooding and raining. There are also a number of protected areas within the Project area including Liwonde National Park and Majete Wildlife Reserve (Figure 19).



(Source: Department of National Parks and Wildlife)

Figure 19. National Parks and Wildlife Reserves within the Project area

5.2.2.2 Critical Habitats

In the World Bank's Natural Habitats Policy (OP/BP 4.04), critical natural habitats are defined to include most types of protected areas, as well as other areas of known high conservation value. Critical habitat can also be construed as habitat that is essential for maintaining the integrity of an ecosystem, species or assemblages of species. Evaluation of the habitats in the Project area with the associated species which utilise the habitats and taking into consideration the ecology of the species and community ecology the habitats shown in Table 9 can be considered as critical habitats responsible for the survival of a number of species in the Project area.

TABLE 9. CRITICAL HABITATS IN THE PROJECT AREA

Type	Significance
Open water	Important habitat for hippopotamus, crocodiles, terrapins, amphibians, fresh water invertebrates and other species
Sand banks (beaches) along Lakes Malawi and Malombe and along Shire River	Nesting areas for crocodiles and terrapins
River sandbars	Serve as roosting and nesting areas for African Skimmers and other birds including waterfowl.
Emergent boulders in middle Shire River channel	Habitat for highly localised bird species, the Rock Pratincole (*Glareola nuchalis*)
Reeds	Breeding areas for some birds including weavers.
Riparian short grasslands on river or lake banks	Important grazing area for many herbivores especially during the dry season when most other areas are dry and void of grass and water.
Mopane woodland	Prime habitat and breeding area for the threatened Lillian's Lovebird and also important habitat for many herbivores
Riverine vegetation including *Brachystegia* wooded grassland in Majete Wildlife Reserve	Habitat for the reintroduced black rhinoceros in the Reserve.
Marshes and wetlands	Critical habitat for migratory birds

The Shire River system which includes the Project area spanning from Lake Malawi down to the Zambezi comprises of various habit types described earlier including sand bars, sand beaches and emergent boulders. The occurrence of these habitats in the system depends on various factors such as geomorphology, nature of parent rock and soils, terrain and volume of flowing water. Sand bars, beaches and emergent boulders are important habitats for various fauna species depending on where the habitat is located, human influence and season of the year.

5.2.2.2.1 Sand Bars

A sand bar may be described as "a long mass or low ridge of submerged or partially exposed sand built up in the water along a shore or beach by the action of waves or currents". Usually these are found in mature river systems or beaches with gentle or flat gradient and water flow is not very fast. Most are formed from deposition of sand and alluvial or may be formed following water recession due to reduced water flow. Sand bars presence depends on amount of water flowing and may be covered under water or even disappear during floods.

In the Project area sand bars were observed in a number of places visited. They appear from where the Shire River leaves Lake Malawi to Lake Malombe and downstream to locations such as Mvuu Camp in Liwonde National Park (Figure 2) and Elephant marshes. No attempt was made to document all sand bars in the Project area but those encountered during the field work were noted. Nevertheless local people report of presence of sand bars in many parts of the Shire River. In some locations such as Kausi village and Liwonde National Park (Figures 20 and 21) some vegetation patches on sand bars were observed in the middle of the river which eventually may die due to water currents and erosion.

African skimmers (*Rynchops flavirostris*), waders and other water birds are some of the major users of the sand bars along the Shire River. AEWA (1998) reports that the skimmer is an intra-African or Afro-tropical migrant associated with the Zambezi river system and it appears in both the Bonn Convention and AEWA appendices of migratory species. It is usually present in the area between April and December. The species migrates up and down larger rivers, and to and from inland lakes, dispersing widely after the breeding season. Migration is driven by the need for calm weather. African skimmers require a 'predictable' river level that neither floods out of season nor drops so much that the birds are exposed to terrestrial predators.

AEWA (1998) further reports that the species has an unfavourable conservation status due to the dam activities in the Zambezi basin, and the need for unseasonal river flow for the production of hydroelectricity. This makes the sandbars no longer safe from floods, and rocks emerge too much out of the river and banks are undercut by unseasonable flow (and also by speed-boat activity) all with a potential risk to the survival of the species. The African Skimmer is "ecologically dependent on wetlands" specifically rivers. In addition, the Skimmer is very vulnerable for tourists' activities.

According to the IUCN Red List (2012) the African Skimmer is near threatened (NT) and it requires expanses of calm water for feeding. Breeding takes place during the dry season when rivers are at their lowest and sandbars most exposed. This generally occurs mainly from July to November south of the equator. Breeding takes place along broad rivers on large, dry sandbars that are largely free from vegetation (IUCN Red List 2012). In Malawi the Shire River is the main habitat and breeding area for the African Skimmer. Pairs nest in loose colonies and lay clutches of one to four eggs in a large usually unlined scrape in the sand. Scrapes occur within 30 m of water but receding water levels may increase the distance. The incubation period is about 21 days.

5.2.2.2.2 Sand Beaches

Sand beach may be described as a gently sloping zone where deposits of unconsolidated sediments are subject to wave action at the shore of an ocean, lake or river. Most of the sediment making up a beach is supplied by rivers or by the erosion of highlands adjacent to the coast. Beaches extend from a low waterline landward to a definite change in material or physiographic form, such as the presence of a cliff or dune complex marking a clear demarcation of the edge of a coast or beach. In the Project area sand beaches occur along parts of the Shire River and Lake Malombe. Beaches are only found in places where there is very gentle or almost flat gradient to the water level. Rocky banks or cliffs do not allow formation of beaches.

Sand beaches are important habitats for crocodiles and in most cases crocodile conservation is in direct competition with other forms of land use such as agriculture and fisheries. Crocodiles need sand banks as nesting sites but the same sites are required as boat yards by fishers and as recreation areas. In marshy areas crocodiles need the islands as nesting sites but these are required for "*Dimba*" cultivation (flood recession agriculture). For example in Lower Shire Valley dimba land supplies a considerable proportion of total food production and it appears that dimba production is increasing in importance (Mphande 1987). On the other hand young crocodiles tend to hide in the reeds and bask in isolated areas which are not easily accessible making these habitats also vital for the recruitment and survival of crocodile populations.

One of the threats reported previously to the crocodile population has been the closing of Kamuzu Barrage gates on the nesting crocodiles in Liwonde National Park. The Barrage is opened and closed to regulate the flow of water in the middle Shire for hydroelectric power generation. The closure of the Barrage causes a rise in the water level in the Liwonde National Park. The Barrage is normally closed after the crocodiles have laid their eggs (i.e. October) hence submerging the eggs. The Barrage in such years is a major mortality factor. Ways and means have to be found to alleviate this problem. A compromise solution between the Ministry of Forestry and Natural Resources and ESCOM was proposed to be worked out and if possible the Barrage should be closed before crocodiles start nesting i.e. August (Mphande 1987). The average incubation period for crocodiles is about 80 days and by laying their eggs in October hatching would take place at the beginning of the long rain season which starts in November and runs up to April.

Terrapins are reported to occur in the Project area occupying logs, rocks and mud banks while in the rainy season they are common in isolated pans and waterholes. Nesting takes place in October – November at the beginning of the rain season and hatchlings emerge in November to January. Nests are vulnerable to predation by water monitor and mongoose (Broadley and Boycott 2009).

5.2.2.2.3 Emergent Boulders

These are rock outcrops found along river valleys above water level. They are formed in areas where the geomorphology comprise of hard rock not easily eroded by water current or other erosion agents. Rock outcrops are common in the middle Shire River for about 80km from Matope to Chikwawa and south wards to Majete Wildlife Reserve. On this stretch the River is characterised by rock bars and outcrops. Some areas of the Shire like parts of Mvuu Camp steep rocky banks define the river valley. Series of rocky rapids were observed along the Shire at Kapichira power station located within Majete Wildlife Reserve but photos could

not be taken due to security restrictions covering the area. The rocky islands of the Shire River in Majete Wildlife Reserve provide habitat for breeding populations of the Rock Pratincole (*Glareola nuchalis*).

The Rock Pratincole is another intra-African or Afro-tropical migrant in the Zambezi River system and appearing in July and leaving sometime in December or January though it is reported to be endemic in the Majete area. It also requires a 'predictable' river level that neither floods out of season nor drops so much that the birds are exposed to terrestrial predators. This little bird nests on the emergent rocks in white water areas, often near waterfalls. Although it is classified as "Least Vulnerable" on the IUCN Red Data List, the Rock Pratincole is widely distributed in Africa.

5.2.2.3 Fauna Biodiversity

The Project area is rich in biodiversity particularly Liwonde National park (Table 10). Wildlife is found around almost all villages surrounding the Project. However the eastern banks of Shire River record more species than the western banks due to having greater wilderness areas and easy mobility of wildlife in the areas. The western parts are more populated with increased human activities that include farming, settlements and infrastructure development.

TABLE 10. SUMMARY OF WILDLIFE POPULATION TRENDS IN LIWONDE NP AND SURROUNDING AREAS FROM 2004 TO 2009.

Species	Population estimate					
	2004	2005	2006	2007	2008	2009
Savannah Elephant	604	1064	751	857	805	928
Waterbuck	1522	2524	2451	2517	2566	3539
Impala	983	3656	2356	3187	2652	4163
Sable	457	869	800	508	527	736
Warthog	1323	1246	1655	1618	1547	3156
Bushbuck	260	374	399	297	449	604
Greater Kudu	70	200	207	314	187	409
Common Duiker	71	184	111	156	146	325
Bush Pig	19	40	NR	NR	NR	NR
Reedbuck	72	86	39	76	89	72
Klipspringer	6	8	NR	NR	NR	NR
Grysbok	14	50	NR	NR	NR	NR
Suni	4	2	NR	NR	NR	NR
Buffalo	425	388	553	657	781	864
Eland	76	53	63	71	62	79
Plains Zebra	58	66	110	65	74	78
Hartebeest	54	56	100	89	70	118
Roan Antelope	38	42	45	40	43	43
Black Rhino		8	8	8	10	11
Oribi		4	NR	NR	NR	NR
Hippopotamus		926	NR	NR	1136	NR
Nile Crocodile		534	NR	NR	3105	NR

(Source: Liwonde National Park 2004, 2005, 2006, 2007, 2008, 2009a, 2009b)
NR: No records available

If wildlife populations show a stable or increasing trends in the Project area then this may suggest that the impacts of the existing Barrage to wildlife, if any, is less important than other factors.

5.2.2.4 Species of Conservation Interest

There are many species of conservation interest. Records show that a number of protected areas in the Project area now harbour reintroduced species after the previous populations became locally extinct mainly due to hunting or habitat loss. Of key interest are rhinoceros, roan antelopes, leopards, buffaloes, eland and zebra. There are also species translocated to Liwonde National Park from Kasungu National Park in the north in order save them from local extinction. However, wildlife population trends from annual census conducted by Liwonde National Park suggest that the populations of most large game species are stable. There also other species of birds, reptiles, amphibians and selected invertebrates of conservation interest. For example, the globally near-threatened African Skimmer is dependent on river sandbars (surrounded by water) for roosting and nesting, so it only occurs along the Shire River when water levels are low enough for the sandbars to be exposed. Three turtles classified as Least Concern (LC) on the IUCN Red List occur within Malawi. The Yellow-bellied Turtle (Pelusios castanoides) is the most common while the East African Black Mud Turtle (*Pelusios subniger*) and African Helmeted Turtle (*Pelomedusa subrufa*) are rarely mentioned though their range of distribution includes Malawi.

Figure 20. Crocodile in Liwonde NP.

Figure 21. Elephant in Liwonde NP.

Yellow-bellied Turtles are semi-aquatic and are found in rivers, marshes and swamps. This is the turtle which is commonly reported in Malawi and appears among the fairly common reptiles found in the marshes and swamps. It feeds mainly on large pulmonate snails and floating water lettuce. The Yellow-bellied Mud Turtles in captivity from Malawi are reported to lay about 25 eggs towards the end of September. It is also reported that during the dry season, this species may aestivate in the mud.

The East African Black Mud Turtle eats insects, worms, snails, small fish, amphibians, crabs and aquatic plants that grow in water such as water grasses. These turtles are generally nocturnal but will bask in the sun or wander about on land during the rainy season. East African Mud Turtles tend to like a watery habitat and if their river or pond dries up during the dry season they may 'aestivate' in underground burrows when the temperatures become too warm, too cold, or conditions become too dry, re-emerging again when conditions return to a suitable level when water returns. In captivity, the East African Black Mud Turtle has been recorded laying its eggs in February and March, with hatchlings emerging around 58 days later (when incubated at 28 to 30°C), although this may vary with location. Three to twelve eggs are produced per clutch by the female and buried in a flask-shaped nest cavity.

African Helmeted Turtle also known as the Marsh Terrapin or Crocodile Turtle are semi-aquatic, living in rivers, lakes, and marshes, and they also like rain pools and places that are fertilized. The species is omnivorous and will eat almost anything including insects, small crustaceans, fish, earthworms, and snails. They may also feed on carrion. The fine claws on its feet help it tear its prey apart. Groups of these turtles have been observed capturing and drowning larger prey such as doves when they come to drink, the commotion caused by these group attacks are often mistaken for crocodiles. The female will lay 2 to 10 eggs on average, normally during late spring and early summer. The eggs are placed in a flask shaped nest that is about four to seven inches deep. The eggs hatch in 75– 90 days.

5.2.3 Fish and Fisheries

5.2.3.1 Description of Fish and Important Aquatic Habitats

At the time of the fisheries survey, it was noticeable that the water level in Lake Malawi at the south east arm had receded tremendously as evidenced by wide sandy beaches which are usually inundated during periods of more water in the Lake.

During peak water levels, the vast sandy beach stretches along the lake are submerged under water creating breeding areas for cichlids. Unfortunately, in the south east arm of Lake Malawi (Mangochi) most of these fish breeding sandy beaches have been cleared for holiday resorts which have flourished in recent years. This suggests that irrespective of whether it is peak or low water level in the Lake, breeding of fish is still compromised by the fact that these sandy beaches are frequently used by tourists (for swimming and boat landings) as well as by fishers using seine nets from the beaches.

The area at the southern end of Lake Malawi is marshy and relatively shallow due to a sand bar. Common fishing gear in this area is gill nets as the muddy and marshy beaches do not favour operation of beach seines. Fishing in this area is very active especially for Chambo (tilapia) which are caught with gill nets.

Downstream of Lake Malawi the river becomes wide up to Lake Malombe and beyond to the Kamuzu Barrage at Liwonde. The Upper Shire is a very active section in fishing activities. Many types of fishing methods are employed ranging from beach seines, gill nets and the recent destructive light fishing using mosquito nets.

Lake Malombe is the most productive lake in Malawi with marshy shorelines and muddy beaches – an aquatic environment which provides excellent habitat for fish breeding. However, Lake Malombe is also the most heavily fished lake in Malawi and fish catches especially the Chambo (*tilapia*) have declined nearly to extinction (Kapute *et a*l., 2008).

The section of the Shire River after Lake Malombe to a few kilometres upstream of Kamuzu Barrage is a national park (Liwonde National Park) hence a protected area to fishing. The area thus acts as a breeding area for fish which later migrate to other parts of the River and into Lake Malombe. Liwonde National Park (about 580 km^2 in area) lies on the banks of the Upper Shire River, bordering Lake Malombe to the north and encompassing a large area east of the river. It is the best described of the nine national parks and wildlife reserves in Malawi. The vegetation of the park along the Shire River is diverse ranging from riverine swamps, lagoons and reed-beds.

During the field study, it became apparent that the National Park is by far the most environmentally important area in relation to the upgrading of the Barrage at Liwonde. The Park as mentioned earlier is home to many fish species and acts as an important breeding area for the fish. Elsewhere in the Shire River System, fish hardly have a chance to breed because of the uncontrolled heavy fishing pressure.

The shoreline of the section of the Shire River from Lake Malombe down to Nkula Falls does not have many infrastructures (buildings), or an intensive agricultural industry. This suggests that this is a favourable area for fish spawning especially riverine species which are chiefly *Cyprinids* such as *Opsaridium microlepis* (Mpasa), *Opsaridium microcephalus* (Sanjika), *Labeo cylindricus* (Ntchira) and several *Barbus* species.

The Shire River between Liwonde and Nkula is relatively narrow with many meanders. As opposed to the flat terrain between Lake Malawi and Liwonde, in this area, the topography is hilly hence the many narrow fast flowing river channel sections present. There are also a series of waterfalls in this section of the Shire River which provide a natural barrier to the upstream migration of fish and other aquatic organisms.

5.2.3.2 Shire River Fisheries

The species composition for Lake Malombe like the entire Upper Shire and the south-east arm of Lake Malawi is diverse i.e. multi-species. Most of the species in the Upper Shire are also found in the south east arm of Lake Malawi and Lake Malombe probably due to migration. In Lake Malombe and the Upper Shire River the fish stocks are exploited only by the artisanal sector which employs gillnets, chambo seines, kambuzi seines and nkacha nets. In Lake Malawi, in addition to the artisanal sector, the stocks of the south-east arm are exploited by the semi-industrial and the industrial fisheries. It is reported that total annual catches from the Upper Shire River have declined from more than 1,200 tons in the early 1980s to the recent levels of around 500 tons (FAO, 1993).

Though Lake Malombe supports a highly productive fishery because of its high primary productivity, uncontrolled fishing has overexploited the fish stock and what remains are small cichlids (Figure 22) locally known as kambuzi (Weyl *et al*., 2004a & b; Banda *et al*., 2005; Kapute *et al*., 2008). The tilapia (Chambo) fishery which used to be vibrant in the lake has almost collapsed (Weyl et al., 2004a & b). *Copadichromis chrysonotus* species (Utaka) also dominate the kambuzi (small cichlids) catch (Turner, 1995). *Oreochromis shiranus* (Shire River Tilapia) appears to be the most commercially abundant species which is usually sold around the Barrage either fresh or in smaller quantities processed (smoked) (personal observation).

Figure 22. Small cichlid (kambuzi) catch from south east arm of Lake Malawi

In the Lower Shire, the fish fauna is essentially of Zambezi River Basin origin as more than 60 species are caught in this fishery, but only three namely, Mlamba (*Clarias gariepinus*), Chikano (*Clarias ngamensis*) and Mphende (*Oreochromis mossambicus*) are of commercial importance (Willoughby and Tweddle, 1978). These three contribute 90% to the total fish catch. In general, the Shire River has a multi-species fishery especially the Upper and Lower Shire sections.

Previously, the Lower Shire Valley used to contribute between 10 and 15% of the total national landings (Malawi Department of Fisheries 1989; Bulirani *et al*., 1999). The system is highly productive and efficiently utilised by fishermen suggesting why catches have increased recently. The fishery is small scale and subsistence in nature. It is pursued almost exclusively using dugout canoes from numerous permanent and temporary traditional fishing villages. The main fishing methods in the Lower Shire include seine nets, gill nets, fish traps, scoop nets, cast nets and encircling fish fence and dug-out canoes and plank boats without engines are the main types of fishing craft employed. Gill nets are however, the commonest type of fishing gear used.

5.2.3.3 Breeding Seasonality and Migration of Fish in the Shire River

Riverine fish species are generally migratory species (Welcomme 1985) mainly for breeding purposes. In the Shire River, important and commercially valuable migratory species include *Opsaridium microlepis* (Mpasa) and several Barbus species found in the Upper and Middle Shire (www.anglingmalawi.org). Mpasa has been included under the IUCN 'Red List' of endangered species.

The riverine species usually breed during the rainy season and also when the river is flooding. The diverse ecosystems of the Shire River ranging from falls, rapids, swamps to floodplains may have resulted in the varied breeding pattern of fish in the River. This is due to the fact that spawning periodicity in fish is to a greater extent influenced by abiotic factors such as hydrological regime of the river, climatic seasonality and habitat characteristics (Welcomme, 1995). For example, most of the life cycle of the fish in the lower Shire valley is subject to the seasonal drying of the marshes while breeding occurs during high water when feeding is also at its peak (Willoughby and Tweddle, 1978).

In the Upper Shire River, fish seasonally migrate to and from the southeast arm of Lake Malawi through the Shire River to Lake Malombe (FAO 2003). Juveniles are found in the river from May to July moving towards Lake Malombe (Seisay *et al*., 1992).

In the lower Shire, the general observation is that most of these species breed most intensively during the rainy season although some species breed throughout the year.

5.2.3.4 Endangered Fish Species in the Project Footprint Area

The fish community of the Shire River including Lake Malombe is typical of that of Lake Malawi comprising key genera such as Lethrinops, Otopharynx, Copadichromis, Oreochromis, Engraulicypris, Clarias, Synodontis, Opsaridium, Barbus among many others. A comprehensive list of fish species recorded for the Shire River is provided in Appendix 6. Apart from the Chambo (*Tilapia*) fish stock where catches have significantly declined in recent years, *Opsaridium microlepis* (Mpasa or Lake Salmon), a cyprinid and a lacustrine fish species, is by far the most tasty and commercially viable riverine species in Malawi. Mpasa is at the verge of extinction in Malawian natural waters due to multiple factors such as use of bad fishing methods e.g. river/stream blocking when fish are migrating for breeding; degradation of the riverine environment due to catchment destruction e.g. by farming and use of chemicals; siltation and in extreme cases drying of rivers and streams etc. The fish was to that effect included on the IUCN Red List of threatened species in 2006 (IUCN, 2006). Interestingly, with Mpasa which has been fished out in nearly all rivers and streams in Malawi, there appears to be some remnants in Liwonde National Park where it is still found in abundant numbers.

The fish community of Lake Malawi consists of 500 - 1,000 species. Of major importance in terms of species diversity is that nearly 100% of the cichlids are endemic to Lake Malawi (i.e. they are found nowhere else in the world). Moreover, many of the cichlid species have a very restricted distribution within the lake. This is particularly the case among the rock-dwelling mbuna which utilise the rocky shores.

5.3 Socio-economic Environment

This Section relies on baseline information collected through the socio-economic household survey undertaken as part of the RAP study as well as secondary data sources. Data from the household survey has been processed and analysed with output provided in the form of tables, charts and other statistical formats. Perceptions and opinions on defined issues concerning stakeholders and their communities have also been included throughout this Section.

5.3.1 Administrative Context

The country is divided into three regions Northern, Central and Southern regions. Malawi has twenty-eight districts, six in the north, nine in the central region and thirteen in the south. For the purposes of the socio-economic survey, eight districts were sampled, namely Salima, Mangochi, Machinga and Balaka, Blantyre, Chikhwawa, Zomba and Nsanje. These districts are located adjacent to the Shire River, and Lakes Malawi and Malombe in the Project area. Balaka, Mangochi and Salima districts are located upstream of the Barrage. Machinga, Zomba, Blantyre, Chikhwawa and Nsanje districts are located downstream; with Chikhwawa and Nsanje being located furthest from the Project site.

Within each of these districts there are formal and informal institutions. Formal institutions include the District Councils, headed by District Commissioners. The informal institutions are headed by Traditional Authorities whose areas of jurisdiction are known as Area Development Committees, headed by chiefs. Each of these traditional authorities is “composed of villages which are the smallest administrative units, and the villages are presided over by village headmen” (National Statistical Office, 2011).

5.3.2 Socio-Economic Profile of Project Area

The socio economic survey undertaken for this Project covered 520 households who live along the shorelines of the Shire River and Lakes Malombe and Malawi. The households are mostly within rural areas, with only six located in the semi-urban area of Machinga. Of the total households surveyed, 156 households are located upstream of Kamuzu Barrage with the remainder located downstream. The results of the survey were used to supplement published socio-economic data to describe the socio-economic profile of the Project area.

5.3.2.1 Demography

5.3.2.1.1 Population

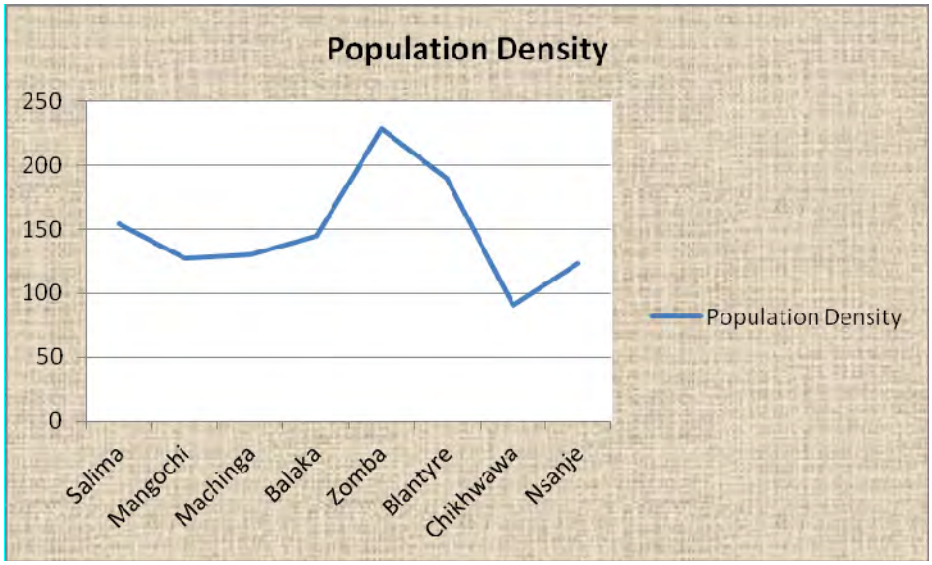
The 2008 Census recorded the population of Malawi as 13,077,160 with an annual average growth rate of 2.8% (National Statistical Office, 2009). Table 11 shows the population of the eight surveyed and potentially impacted districts. From this it can be seen that Mangochi is the largest district in terms of population with around 22 % of the total population of all eight districts.

TABLE 11. POPULATION OF PROJECT IMPACTED DISTRICTS

Districts	Population		Population Density (per km^2)
	Male	Female	
Salima	165,015	172,880	154
Mangochi	380,174	416,886	127
Machinga	233,385	257,194	130
Balaka	152,056	165,268	145
Zomba	276,650	302,989	228
Blantyre	164,766	153,200	190
Chikhwawa	215,598	219,050	91
Nsanje	115,219	122,884	123
Total	1,702,863	1,810,351	148.5

Source: *National Statistical Office, 2009: Population and Housing Census; National Statistical Office, 2010: Demographic and Health Survey.*

In terms of population density, Zomba and Blantyre have the highest density and only Chikhwawa has a population density of less than 100 persons/km^2. Figure 23 depicts the population density of Project impacted districts surveyed as part of the socio-economic survey undertaken for the Project.



Source: *National Statistical Office, 2009: Population and Housing Census; National Statistical Office, 2010: Demographic and Health Survey.*

Figure 23. Population Density

5.3.2.1.2 Age and Gender Distribution

Table 11 above indicates that in all districts the gender ratio is in favour of females for the population as a whole. In terms of age composition of households, around 90% of household members (both male and female) are 45 years old or younger with half of these being 14 years old or younger (Table 12) reflecting a relatively young household population.

TABLE 12. AGE COMPOSITION OF HOUSEHOLDS

Households	Age Composition (%)			
	0-14	15-45	46-60	61+
Male	47	44	6	3
Female	46	43	7	4

Source: Socio-economic Survey, 2011

Household size is large with over 40% of households having six to eight members and almost 50% having three to five household members (Table 13).

TABLE 13. HOUSEHOLD SIZE

Households		
Number of Members	Frequency	Percentage
<= 2	48	9.2
3 – 5	249	47.9
6 – 8	223	42.9
Total	520	100.0

Source: Socio-economic Survey, 2011

The demographic characteristics reflect that the fertility and mortality rates are still high in these districts. Blantyre and Zomba districts report relatively lower fertility rates whereas Chikhwawa is the only district having a mortality rate of less than ten per thousand liv birth. All other are above ten and Blantyre and Mangochi report much higher mortality rates (Table 14). Infant mortality rate is one of the indicators of human development. Except for Blantyre and Balaka all other districts reported a very high rate of infant mortality. The higher mortality rate can be attributed to a number of factors including a higher incidence of poverty, lack of nutrition and postnatal care and lack of medical facilities.

TABLE 14. FERTILITY AND MORTALITY RATES

District	Fertility Rate	Mortality Rate*	Infant Mortality Rate
Salima	6.5	10.3	91
Mangochi	6.1	13.9	82
Machinga	6.1	10.8	77
Balaka	6.2	14.2	66
Zomba	6.0	12.6	80
Blantyre	5.4	13.3	69
Chikhwawa	6.2	9.2	82
Nsanje	6.8	10.9	83

*Crude Death Rate in 2008

Source: *NSO, 2010, PHC, Analytical Report: Volume 1; NSO, 2010, Malawi Demographic and Health Survey*

5.3.2.1.3 Social Composition

In Malawi, there are followers of two major religious groups, namely, Christianity and Islam. At a national level, about 82 % of households follow Christianity and 13 % follow Islam (NSO, 2009). Table 15 shows the division amongst surveyed households at District level within the Project area. Mangochi (79%) and Salima (53%) Districts reflect a much greater Islamic following than the national average.

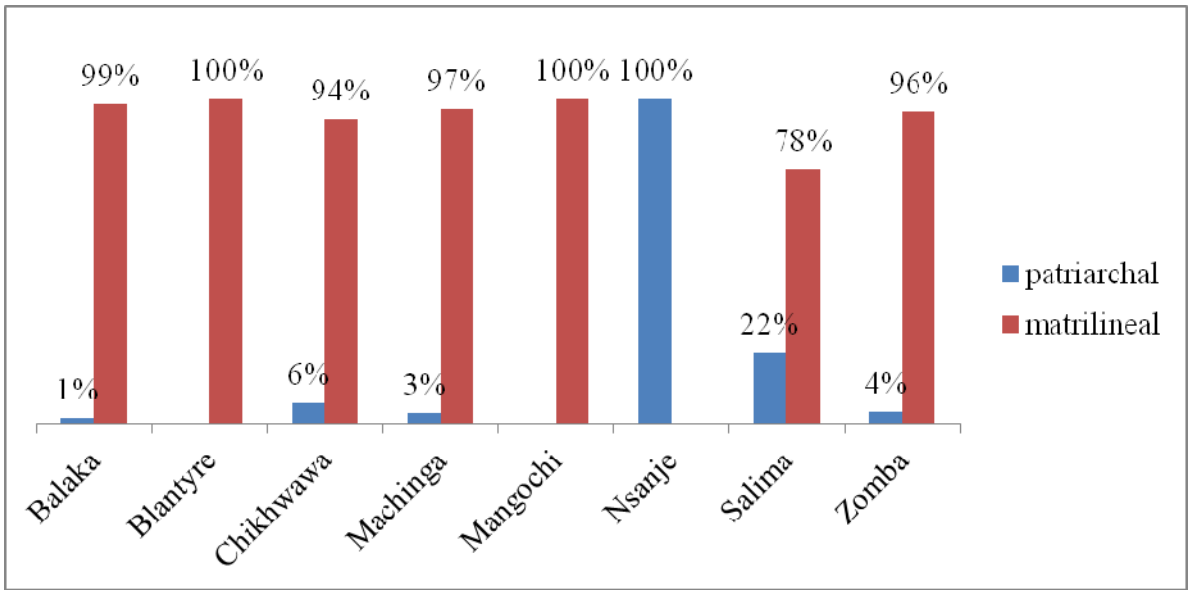
TABLE 15. SURVEYED HOUSEHOLDS BY RELIGION

District	Type of Religion	Households	
		Frequency	%
Balaka	Christianity	35	50.7
	Islam	31	44.9
	Other	3	4.3
Blantyre	Christianity	46	93.9
	Islam	3	6.1
Chikhwawa	Christianity	42	84.0
	Islam	5	10.0
	Other	3	6.0

District	Type of Religion	Households	
		Frequency	%
Machinga	Christianity	52	51.5
	Islam	49	48.5
Mangochi	Christianity	15	21.1
	Islam	56	78.9
Nsanje	Christianity	41	89.1
	Islam	2	4.3
	Other	3	6.5
Salima	Christianity	35	47.3
	Islam	39	52.7
Zomba	Christianity	34	60.7
	Islam	21	37.5
	Other	1	1.8

Source: Socio-economic Survey, 2011

In terms of type of society followed in different districts and particularly along the lake shorelines more than 85 % of households reported a matrilineal arrangement (Figure 24).



Source: Socio-economic Survey, 2011

Figure 24. Surveyed households by type of society in the study area

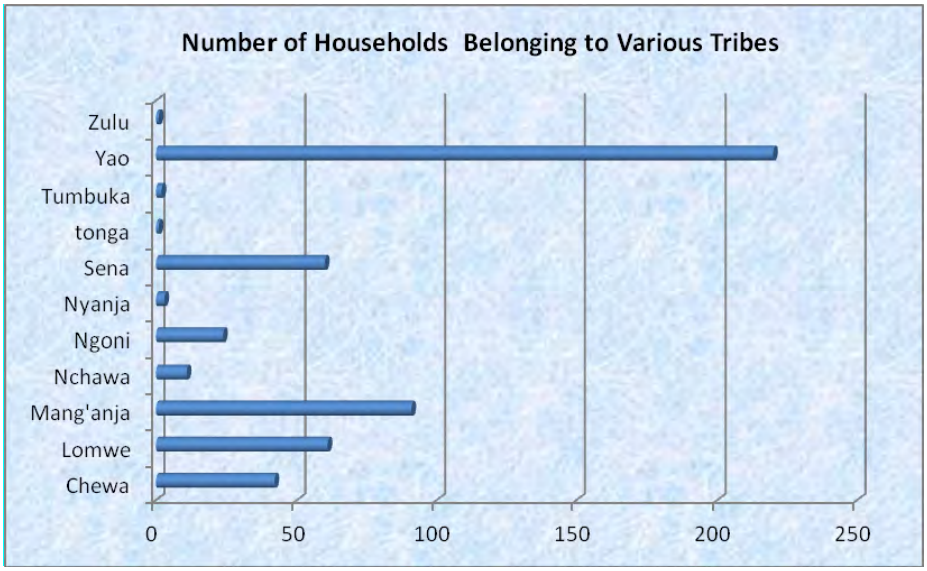
Although several tribes are found in the Project area, the Yao are by far the dominant tribe followed by Lomwe, Chewa, Sena, Manganja and Ngoni tribes (Figure 25). Other tribes include: Nyanja, Tonga and Tumbuka. The composition of tribal lineage of surveyed households for each district surveyed is shown in Figure 26.

Chiyawo and Chingoni are the main local languages. Chichewa, which is a common language in Malawi, is spoken by almost everybody.

The Yao, Lomwe, Nyanja and Ngoni ethnic groups have earlier had distinct cultural traditions and beliefs but due to religion, intercultural marriages and mixing of ethnic groups most cultural aspects and beliefs are mixed with the exception of Muslims who follow Islamic laws and beliefs (Malawi Government, 2001).

Amongst these ethnic groups the Yao, Sena and Lomwe still enforce initiation ceremonies for their children (both boys and girls) in order to develop good cultural and moral behaviour as is required by their respective cultures. For the Yao, Mang'anja, Lomwe, Chewa and Ngoni inheritance over chieftainship and property is

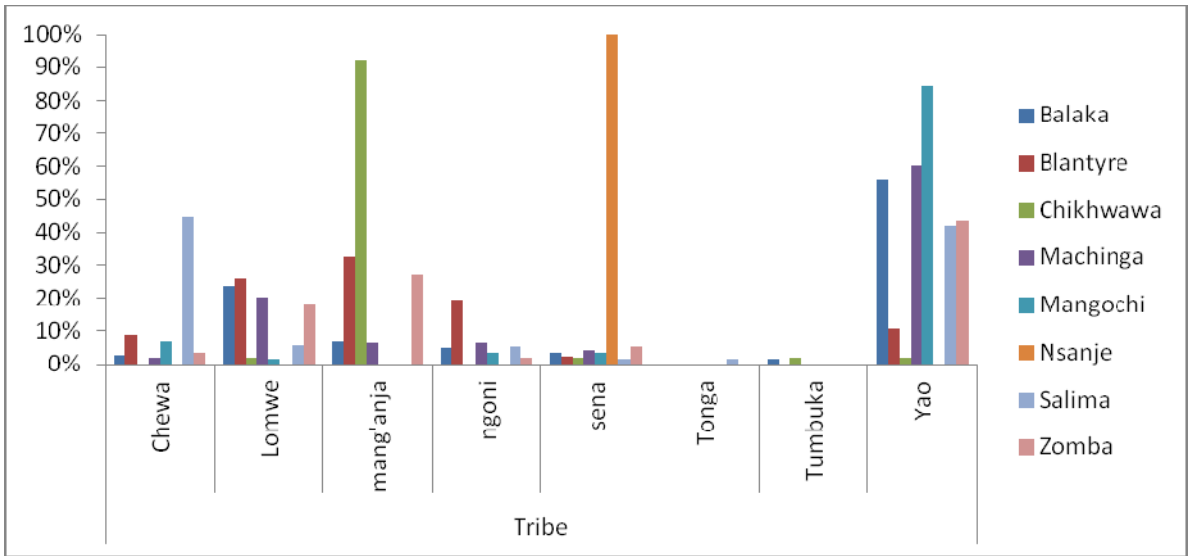
matrilineal while the Sena follow the patrilineal system whereby inheritance follows the male line and the wife moves and stays in her husband's village.



Source: Socio-economic Survey, 2011

Figure 25. Tribal Lineage of Households

Generally, the people in Machinga, Mangochi and Balaka districts follow the matrimonial marriage system whereby the men follow and live with their wives, (Malawi Government 2001). The woman's brothers exercise more control over property and the children than the husband.



* n for households = 520
Source: Socio-economic Survey, 2011

Figure 26. Tribal composition of households

5.3.2.1.4 Gender and Educational Attainment

Mangochi has 239 primary schools and 34 secondary schools. The Project area TA Chimwala and TA Chowe on the eastern side has the highest primary school dropout rates in the district between 2004 and 2007, (Malawi Government, 2010).

Machinga district has 145 primary schools and 17 secondary schools. The enrolment rates of boys and girls in primary school are 51% and 49% respectively.

Balaka District has 17 secondary schools and 154 primary schools. The district has low literacy levels (76%) and a pupil dropout rate of 3.6%. The primary school enrolment rate for boys and girls is almost equal (Malawi Government 2010).

Table 17 (overleaf) presents the household education levels disaggregated by Districts based on the socio-economic survey. In the case of female literacy, Blantyre has the highest rate of above 85 % followed by Zomba at 75 %. In terms literacy rate for males, Zomba and Blantyre again top the table with above 88 %. These two districts fall in one of the developed areas of Malawi. Among the upstream districts, Salima has the higher rate of literacy in comparison to Mangochi for both males and females. There were no clear gender differences in literacy rates.

Despite the relative high literacy rates, educational attainment significantly declined with higher education levels in all districts. Few household members (<1%) had an education level at high school or above.

5.3.2.2 Settlement

Settlement patterns include dispersed (though by no means isolated) dwelling nucleated villages and small urban centres. Houses are often constructed on both sides of the road. Buildings in the dense centres of the large villages face the road, but are set back at least ten to fifteen metres. Outside the centres, houses are oriented away from the road. Trading activities of fruits and small shops are located in village centres. Religious facilities such as churches and mosques are found almost in all village centres. Rural parts of the villages have their own morphology with many internal paths and tracks.

Most households have access to health facilities, although access is poorest in households located within Mangochi, Balaka and Zomba Districts, with distance to health units as a likely constraining factor (Table 16).

With the exception of households in Machinga and Nsanje, a high percentage (>67%) of households have access to grazing lands (Table 16).

As would be expected, access to recreation facilities is highest for households located in Salima (82%) and Mangochi (73%) which are closest to Lake Malawi and Lake Malombe (Table 16).

TABLE 16. AVAILABILITY OF SOCIAL UTILITIES IN THE STUDY AREAS

District	% of Households with Social Utilities Available				
	Grazing Land	Playground	Health Facilities	Recreation Facilities	Graveyard
Balaka	67	74	51	42	100
Blantyre	96	96	70	72	100
Chikhwawa	72	90	78	42	86
Machinga	46	79	90	54	98
Mangochi	94	96	49	73	100
Nsanje	53	90	74	25	98
Salima	87	100	87	82	100
Zomba	91	96	57	41	96

Source: Socio-economic Survey, 2011

TABLE 17. EDUCATION LEVEL OF HOUSEHOLD MEMBERS

District		Education Level of Household Members (%)						
	Sex	Illiterate	Primary	Secondary	High School	Graduate	Vocational	Other
Balaka	Male	20.00	66.04	13.29	-	0.43	-	-
	Female	17.07	68.83	13.54	-	0.56	-	-
Blantyre	Male	7.65	82.25	10.10	-	-	-	-
	Female	7.63	79.27	13.10	-	-	-	-
Chikhwawa	Male	19.11	71.95	8.13	-	-	0.61	0.20
	Female	19.56	73.13	6.29	-	-	0.51	0.51
Machinga	Male	11.00	70.24	18.28	0.29	-	0.19	-
	Female	13.14	68.80	17.05	0.67	-	0.33	-
Mangochi	Male	16.82	74.89	8.30	-	-	-	-
	Female	16.47	72.25	11.27	-	-	-	-
Nsanje	Male	19.89	68.72	11.39	-	-	-	-
	Female	20.20	70.13	9.67	-	-	-	-
Salima	Male	13.39	75.32	10.69	0.60	-	-	-
	Female	15.37	74.49	9.32	0.82	-	-	-
Zomba	Male	22.06	75.16	2.78	-	-	-	-
	Female	20.68	76.06	3.26	-	-	-	-

Source: Socio-economic Survey, 2011

5.3.2.3 Housing

Most of the houses in the households surveyed have brick and cement walls with grass thatched roofs. There were 182 brick and cement-wall houses and 234 grass thatched houses downstream of the Barrage. Upstream of the Barrage there were 85 houses with brick and cement walls and 129 grass thatched houses. In total there were 30 bamboo walled houses and 159 houses were built with unburnt brick walls. Only two of the households surveyed had tiled houses and they were located upstream (Table 18).

TABLE 18. TYPES OF HOUSES OWNED BY HOUSEHOLDS

Type of House	Material	Location			
		Upstream		Downstream	
		Frequency	%	Frequency	%
Floor	cement/concrete	53	27.3	37	11.4
	mud	141	72.7	287	88.6
Wall	burnt brick and cement mortar	85	43.8	182	62.1
	mud with bamboo poles	7	3.6	23	7.8
	compacted soil	17	8.8	14	4.8
	unburnt bricks	85	43.8	74	25.3
Roof	corrugated iron sheets	63	32.5	91	28.0
	grass thatched	129	66.5	234	72.0
	tiles	2	1.0		

Source: Socio-economic Survey, 2011

5.3.2.4 Household Assets Owned

Table 19 lists the assets owned by households surveyed excluding landholdings which are shown in Table 20. The most common asset owned was a radio (56.5%) closely followed by bicycles (50%) and chickens (49.4%). The next most common asset owned was a cell phone. Few households (less than 10%) owned furniture such as sofas, beds, televisions and fridges. Cattle ownership was also not common with less than 5% of households owning them. Car ownership was very low with only four households owning one. This was the least common asset owned. The type of assets owned reflects the poor socio-economic state of the households surveyed.

TABLE 19. ASSETS OWNED BY HOUSEHOLDS

Assets Owned	Frequency	Percent (%) of Households
Chickens	257	49.4
Goats	204	39.2
Cattle	25	4.8
Radio	294	56.5
Television	30	5.8
Cell phone	231	44.4
Sofa set	32	6.2
Beds	151	29.0
Refrigerator	11	2.1
Bicycle	260	50.0
Car	4	0.8

n= 520; Source: Socio-economic Survey, 2011

Land holdings owned by surveyed households are very small at two hectares or less with more than half being less than one hectare in size (Table 20).

TABLE 20. LAND HOLDINGS OWNED BY HOUSEHOLDS

District	Land size (ha)	Frequency	%
Balaka	<1.00	37	55.2
	1.00 - 2.00	30	44.8
	Total	67	100.0
Blantyre	<1.00	28	56.0
	1.00 - 2.00	20	40.0
	>2	2	4.0
	Total	50	100.0
Chikhwawa	<1.00	28	57.1
	1.00 - 2.00	20	40.8
	>2	1	2.0
	Total	49	100.0
Machinga	<1.00	68	68.7
	1.00 - 2.00	30	30.3
	>2	1	1.0
	Total	99	100.0
Mangochi	<1.00	44	63.8
	1.00 - 2.00	24	34.8
	>2	1	1.4
	Total	69	100.0
Nsanje	<1.00	17	36.2
	1.00 - 2.00	30	63.8
	Total	47	100.0
Salima	<1.00	54	75.0
	1.00 - 2.00	18	25.0
	Total	72	100.0
Zomba	<1.00	40	71.4
	1.00 - 2.00	15	26.8
	>2	1	1.8
	Total	56	100.0

5.3.2.5 Basic Household Facilities

Table 21 describes basic facilities used by households. Overall, few households have direct access to power, water supply and sanitation in their homes. Only 16 households had electricity although they use alternative sources including open fires, torches and candles. Less than three percent of households had direct access to drinking water and most sourced their water from communal boreholes, lake and rivers. Sanitation facilities were also low with only 4.2% of households reporting they had a toilet within the home. Toilet outside house but within yard, and use of neighbour's toilet and bush were the more commonly used facilities.

TABLE 21. AVAILABILITY OF BASIC FACILITIES

Facilities	Number of Households	Alternatives used (when facility not available)
Electricity	16 (3.1%)	Open fire, torch, candles
Drinking Water	12 (2.3%)	Communal borehole, tap, lake, river
Toilet	22 (4.2%)	Toilet outside house but within yard, use neighbour's, use bush

Source: Socio-economic Survey, 2011

Most households obtained their water from bore wells (Table 22).

TABLE 22. HOUSEHOLD WATER SOURCES

District	Source of Water	Households Accessing Water	
		Frequency	%
Balaka	bore well	61	88.4
	river or lake	3	4.3
	piped water	1	1.4
	other	4	5.8
Blantyre	bore well	35	71.4
	river or lake	9	18.4
	piped water	2	4.1
	stream	1	2.0
	other	2	4.1
Chikhwawa	bore well	41	82.0
	river or lake	1	2.0
	piped water	8	16.0
Machinga	bore well	61	61.0
	piped water	35	35.0
	stream	1	1.0
	other	3	3.0
Mangochi	bore well	50	70.4
	river or lake	5	7.0
	piped water	9	12.7
	other	7	9.9
Nsanje	bore well	43	89.6
	river or lake	2	4.2
	piped water	1	2.1
	stream	2	4.2
Salima	bore well	57	81.4
	piped water	11	15.7
	other	2	2.9
Zomba	bore well	52	92.9
	river or lake	4	7.1

In the absence of access to electricity, most households used either firewood and to a lesser extent charcoal as energy sources (Table 23).

TABLE 23. HOUSEHOLD ENERGY SOURCES

District	Source of Energy	Households Using Energy	
		Frequency	%
Balaka	charcoal	4	5.8
	firewood	65	94.2
Blantyre	firewood	50	100.0
Chikhwawa	charcoal	7	14.0
	firewood	43	86.0
Machinga	charcoal	9	9.0
	firewood	91	91.0
	Total	100	100.0
Mangochi	charcoal	5	7.0
	kerosene	1	1.4
	firewood	65	91.5
Nsanje	charcoal	1	2.1
	firewood	47	97.9
Salima	charcoal	7	10.4
	kerosene	1	1.5
	firewood	59	88.1
Zomba	charcoal	1	1.8
	firewood	55	98.2

5.3.2.6 Infrastructure, Services and Movement Patterns

Postal services are found at district headquarters. Telephone services are available throughout the Project area. Airtel and TNM mobile phone networks are the main networks available though in some places the signal is weak.

There are minibuses operating all along the road from Lilongwe and Blantyre to Mangochi, Balaka and Machinga. There are also buses operating in the Project area connecting to different town centres. Field observations indicate very little traffic turning onto or off the highway from the relatively few side roads.

Traffic mainly comprises small commercial vehicles – minibuses, small lorries used for freight and pickups although bicycles and motorcycles were also observed along local roads. The road passing over Kamuzu Barrage is a major traffic route both locally (the town of Liwonde is located on both sides of the Shire River) and regionally and is part of the SADC Regional Trunk Road Network.

The most common form of transport used by households is bicycle taxi followed by mini bus (Table 24). Households in Mangochi, Nsanje, Salima and Zomba also use boat transport.

TABLE 24. TYPE OF TRANSPORT USED BY HOUSEHOLDS

District	Type of Transport	Households Using Transport	
		Frequency	%
Balaka	mini bus	12	17.9
	Bus	4	6.0
	bicycle taxi	42	62.7
	any other	9	13.4
Blantyre	mini bus	28	58.3
	bicycle taxi	17	35.4
	any other	3	6.3

District	Type of Transport	Households Using Transport	
		Frequency	%
Chikhwawa	mini bus	12	26.1
	bicycle taxi	30	65.2
	any other	4	8.7
Machinga	mini bus	26	28.6
	Bus	4	4.4
	bicycle taxi	47	51.6
	any other	14	15.4
Mangochi	mini bus	23	34.3
	bicycle taxi	37	55.2
	boat	1	1.5
	any other	6	9.0
Nsanje	mini bus	15	32.6
	Bus	5	10.9
	bicycle taxi	20	43.5
	boat	2	4.3
	any other	4	8.7
Salima	mini bus	19	28.4
	Bus	4	6.0
	bicycle taxi	27	40.3
	boat	5	7.5
	any other	12	17.9
Zomba	mini bus	6	11.5
	bicycle taxi	32	61.5
	boat	10	19.2
	any other	4	7.7

Travelling to market is the main purpose of household travel followed by social occasions (Table 25). Other reasons for travelling include education and employment.

TABLE 25. MAIN PURPOSE OF TRAVELLING

District	Purpose of Travelling	Household Travelling	
		Frequency	%
Balaka	social	5	8.1
	market	39	62.9
	education	1	1.6
	employment	1	1.6
	other	16	25.8
Blantyre	social	3	7.0
	market	32	74.4
	employment	3	7.0
	other	5	11.6

District	Purpose of Travelling	Household Travelling	
		Frequency	%
Chikhwawa	social	6	14.0
	market	30	69.8
	employment	3	7.0
	other	4	9.3
Machinga	social	10	13.0
	market	54	70.1
	employment	2	2.6
	other	11	14.3
Mangochi	social	8	13.1
	market	37	60.7
	education	1	1.6
	employment	3	4.9
	other	12	19.7
Nsanje	social	10	26.3
	market	14	36.8
	employment	3	7.9
	other	11	28.9
Salima	social	8	12.7
	market	36	57.1
	other	19	30.2
Zomba	social	10	22.2
	market	29	64.4
	employment	2	4.4
	other	4	8.9

5.3.2.7 Land Use

The most common land uses in the Project area are agriculture, grazing, human settlement, commercial enterprises and tourist /recreational development. The Lake shore areas are used for hotel and cottage development.

The greater part of the Project area is cultivated with other areas being protected areas including forest reserves and National Parks. Commonly grown crops include maize, cassava, millet, sweet potatoes and sorghum. Tomatoes and onions are also grown closer to the river banks and are irrigated. Livestock keeping is also practiced in wooded and open grasslands. Chickens and goats are the main type of livestock kept. Human settlement is found along roadways (linear settlement in nature). Handcrafts consisting mainly of baskets and mats are often seen along roads waiting for travellers to purchase items. Deforestation and bush fires are common practices in the Project area. The main land tenure system is customary followed by government owned land and private land.

5.3.2.8 Livelihoods and Employment

Kiosks and shops sell sugar, soap, matches, textiles and other goods brought from the regional centre of Lilongwe and neighbouring countries including Tanzania, Mozambique, Zambia and South Africa. Retail commerce is undeveloped, being confined to small shops and kiosks. The district headquarters are also administration centres for the respective districts, therefore they have hospitals, police, post offices, Secondary Schools, fuel stations, guest houses, hotels, bar and restaurants etc. The tourist hotels are located adjacent to beaches along Lake Malawi and the Shire River.

TABLE 26. MAIN OCCUPATION OF HOUSEHOLDS

Occupation	District															
	Balaka		Blantyre		Chikhwawa		Machinga		Mangochi		Nsanje		Salima		Zomba	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Agriculture	106	79.7	93	75	99	78	147	68.4	101	70.1	97	89	79	56	90	79.6
Landless Labour	6	4.5	9	7.3	8	6.3	10	4.7	4	2.8	-	-	11	7.8	6	5.3
Business	14	10.5	14	-	9	7.1	28	13	16	11.1	8	7.3	35	24.8	12	10.6
Government Services	1	0.8	-	-	3	2.4	10	4.7	1	0.7	-	-	-	-	1	0.9
Private Job	5	3.8	7	7.3	6	4.7	15	7	15	10.4	3	2.8	1	0.7	2	1.8
Fishery & Livestock	1	0.8	1	11.3	1	0.8	5	2.3	6	4.2	1	0.9	9	6.4	1	0.9
Bicycle Taxi	-	-	-	-	1	0.8	-	-	1	0.7	-	-	4	2.8	1	0.9
Other	-	-	-	-	-	-	-	-	-	-	-	-	2	1.4	-	-
Total	133	100	124	100	127	100	215	100	144	100	109	100	141	100	113	100

Source: Socio-economic Survey, 2011

TABLE 27. WOMEN INVOLVEMENT IN ACTIVITIES

District	Women Involvement in Activities	Agriculture	Allied Activities	Forestry	Business	Agricultural Labour	Non Agricultural Labour	Household Work	Industry Work	Look after Children
		Frequency	Frequency	Frequency	Frequency	Frequency	Frequency	Frequency	Frequency	Frequency
Balaka	Yes	68	35	42	43	32	27	69	1	67
	No	1	34	27	26	37	42	0	68	1
Blantyre	Yes	50	32	36	28	34	18	46	1	49
	No	0	18	14	22	16	32	4	49	1
Chikhwawa	Yes	50	33	29	22	25	9	47	4	45
	No	0	17	20	28	25	39	3	46	5
Machinga	Yes	101	46	59	61	56	40	99	11	98
	No	0	54	41	40	45	59	1	89	2
Mangochi	Yes	71	41	50	45	31	31	71	3	71
	No	0	30	21	26	40	40	0	68	0
Nsanje	Yes	47	27	36	38	30	15	49	1	46
	No	2	20	12	10	16	29	0	46	3
Salima	Yes	61	32	49	55	37	34	73	3	74
	No	13	41	25	19	37	37	1	67	0
Zomba	Yes	55	38	36	23	31	12	48	3	47
	No	0	14	17	30	24	40	6	50	7

TABLE 28. WOMEN INVOLVEMENT IN DECISION MAKING

District	Women Involved	Financial Matters		Education of Children		Health Care		Purchasing of Assets		Social Functions		Day to Day Activities		Local Governance	
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Balaka	Yes	51	73.9	67	97.1	67	97.1	67	97.1	66	98.5	66	97.1	51	73.9
	No	18	26.1	2	2.9	2	2.9	2	2.9	1	1.5	2	2.9	18	26.1
Blantyre	Yes	40	80.0	45	90.0	48	96.0	48	96.0	50	100.0	49	98.0	41	82.0
	No	10	20.0	5	10.0	2	4.0	2	4.0	0	0.0	1	2.0	9	18.0
Chikhwawa	Yes	40	80.0	43	86.0	45	91.8	44	88.0	45	90.0	47	94.0	44	88.0
	No	10	20.0	7	14.0	4	8.2	6	12.0	5	10.0	3	6.0	6	12.0
Machinga	Yes	80	79.2	90	89.1	101	100.0	77	76.2	79	78.2	99	98.0	76	75.2
	No	21	20.8	11	10.9	0	0.0	24	23.8	22	21.8	2	2.0	25	24.8
Mangochi	Yes	57	81.4	67	97.1	98.6	98.6	68	97.1	69	98.6	66	94.3	55	78.6
	No	13	18.6	2	2.9	1.4	1.4	2	2.9	1	1.4	4	5.7	15	21.4
Nsanje	Yes	35	71.4	45	91.8	93.8	93.8	33	67.3	44	89.8	42	87.5	40	83.3
	No	14	28.6	4	8.2	6.3	6.3	16	32.7	5	10.2	6	12.5	8	16.7
Salima	Yes	53	71.6	73	98.6	74.0	100.0	71	95.9	74	100.0	74	100.0	59	79.7
	No	21	28.4	1	1.4	0.0	0.0	3	4.1	0	0.0	0	0.0	15	20.3
Zomba	Yes	47	83.9	52	92.9	53	94.6	56	100.0	55	98.2	55	98.2	54	96.4
	No	9	16.1	4	7.1	3	5.4	0	0.0	1	1.8	1	1.8	2	3.6

Source: Socio-economic Survey, 2011

The fishing industry is reportedly one of the major sources of employment and income in the study area with 16,000 directly employed in the industry and 40,000 benefiting indirectly through fish trading, boat building, fishing gear making. Although commercial fishery in Lake Malombe collapsed in 1998 due to over exploitation, people still continue to fish the Lake because there are very few alternatives to gain income apart from dimba (wetland or flood recession) cultivation. As such, some fish landing sites are located along the shores of Lake Malombe. The importance of the fishery industry was not reflected in the main household occupations reported from the socio-economic survey.

According to the socio-economic survey results (Table 26) the main household occupation was agriculture in all 8 districts surveyed, ranging from 56% (Salima) to 89% (Nsanje) of households. The next most common occupation was business followed by private job; landless labour; fishery and livestock; government services and bicycle taxi. The dominance of agriculture is shown in Figure 27. Eighty two percent of households were reported to be engaged in agriculture. Only one of the surveyed households was engaged in providing transport (bicycle taxi). Machinga district had the largest number of households engaged in agriculture, followed by Mangochi, Machinga, Chikhwawa, Nsanje and Blantyre respectively. The highest number of government workers in the sample was in Machinga while the highest number of private jobs was in Balaka. Business was highest in Salima (17), followed by Balaka (5 households).

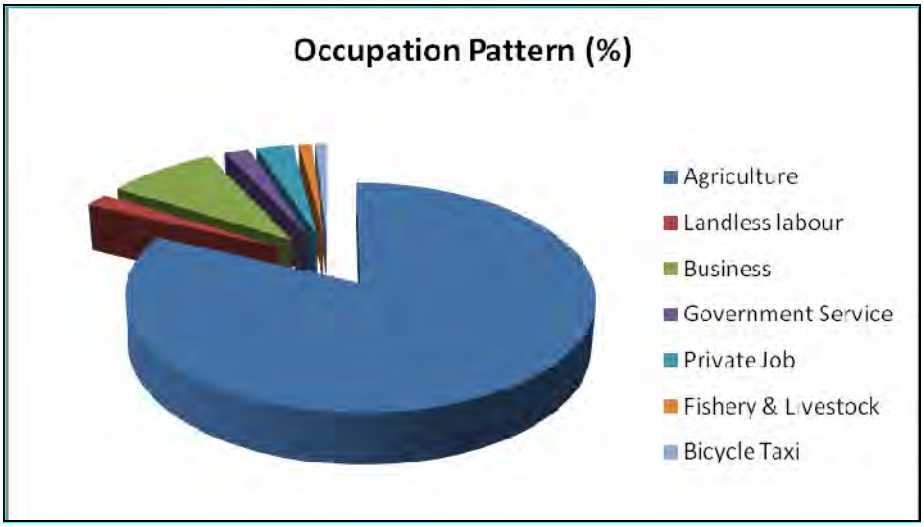


Figure 27. Occupational Pattern of Households

Other economic activities mentioned in the area include trading, craft industries (tailoring, carpentry, and basketry), transport and service. These are however on a small scale.

Women are involved in all activities undertaken by the household (Table 27). The more common activities undertaken by women are agriculture, household work and looking after children. Women are least involved in forestry and industry activities. The high rates of participation by women are also reflected in their involvement in household decision making in all areas including: financial matters; education of children; health care; purchasing of assets; social functions; day to day activities; and, local governance (Table 28).

Employment

Mangochi district has agriculture and natural resources as the main sources of employment for about 85% of the people (Malawi Government, 2009). The major source of employment is commerce and includes the tourism industry, petty traders, and handcrafts makers making cane chairs and mats. Micro and Small Enterprises (MSEs) provide a very good source of employment and include: manufacturing, trade, services, production of crops, livestock, forestry products, fishing and mining, (Malawi Government 2009). MSEs employ 65% of the rural people, with men dominating this employment sector, (Malawi Government, 2009). Salima district has agriculture as its mainstay as more than 84% of households find employment in this sector Table 29). Economic activities and livelihoods in Machinga district include: agriculture; fishing; bee keeping, mining; trading; manufacturing; tourism; businesses and employment, (Government of Malawi, 2001).

TABLE 29. ECONOMIC ACTIVITIES

District	Farming (%)	Self Employed (%)	Family Business (%)	Employed / Salaried	Landless Labour /Ganyu*	Other
Salima	84	7	1	5	2	2
Mangochi	76	10	1	7	1	5
Machinga	79	8	1	4	6	1
Balaka	81	8	1	5	0	4
Zomba	86	5	1	5	2	2
Blantyre	74	11	0	9	1	3
Chikhwawa	91	2	1	3	1	2
Nsanje	89	5	1	4	1	1

*does piece work
Source: *NSO, 2009, Welfare Monitoring Survey*

Balaka district has its employment rate at 98% with a labour force participation rate of 99.1%. Most of this employment is in the informal sector and the formal sector adds to 2,860 of which 402 are women (Malawi Government, 2010). This means that there are gender inequalities in the employment sector. Chikhwawa reported the highest followed by Nsanje and Zomba for their dependency on farming in terms of people's engagement in these activities. As seen in Table 29, the dependency on farming is stark.

Of the total households surveyed, more than 80 % reported to be unemployed and do not have a permanent source of employment throughout the year (Table 30). It was also found that less than 45 % of households earn less than MWK 10,000 per month. However, a sizeable 30 % earn more than MWK 40,000 per month.

TABLE 30. EMPLOYMENT AND MONTHLY INCOME

	Employment Status			Monthly Income			
	Year Round	Seasonal	Unemployed	Less than MWK 10,000	MWK 10,000 to 20,000	MWK 20,000 to 40,000	Above MWK 40,000
Percentage of Households	9.4	9.8	80.8	45	12	12	31

Source: Socio-economic Survey, 2011

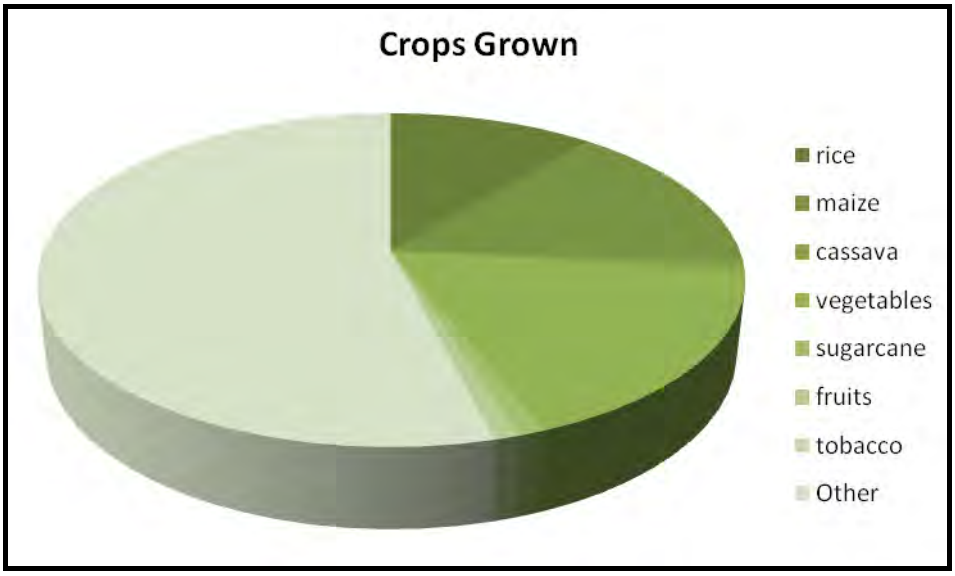
Major produce in these districts include rice, cassava, bananas, tobacco maize, groundnuts, tomatoes, sugarcane among others and these are offered for sale along main roads (Table 31). Most households divide their harvests, keeping some for home consumption and some portion for sale.

TABLE 31. CROPS GROWN BY HOUSEHOLDS

Crops Grown	Households Growing Crops	
	Frequency	%
Rice	89	9
Maize	475	47.8
Cassava	7	0.7
Vegetables	104	10.5
Sugarcane	14	1.4
Fruits	5	0.5
Tobacco	3	0.3
Other crops	297	29.9

Source: Socio-economic Survey, 2011

Households engaged in farming reported maize, rice and vegetables as major crops. Cassava, sugarcane, fruits and other crops were also reported. The share of different crops as reported is shown in Figure 28.



Source: Socio-economic Survey, 2011

Figure 28. Crops Grown

Table 32 reports the crop production area under irrigation versus rain-fed as well as income realised from production for households surveyed. The rain-fed crop area is much greater than the irrigated crop area.

TABLE 32. CROP PRODUCTION UNDER IRRIGATION AND RAIN FED AS WELL AS INCOME REALISED FROM PRODUCTION

District	Crop Area and Income	N	Mean
Balaka	Area with irrigated crops (ha)	21	0.4
	Area with rain fed crops (ha)	65	1.2
	Income earned from crops (MWK)	35	24,338
Blantyre	Area with irrigated crops (ha)	13	1.8777
	Area with rain fed crops (ha)	33	2.00
	Income earned from crops (MWK)	27	19,200
Chikhwawa	Area with irrigated crops (ha)	9	1.2
	Area with rain fed crops (ha)	30	1.6
	Income earned from crops (MWK)	31	36,129
Machinga	Area with irrigated crops (ha)	10	1.4
	Area with rain fed crops (ha)	73	1.7
	Income earned from crops (MWK)	56	34,113
Mangochi	Area with irrigated crops (ha)	29	0.5
	Area with rain fed crops (ha)	67	0.9
	Income earned from crops (MWK)	33	27,121
Nsanje	Area with irrigated crops (ha)	6	0.9
	Area with rain fed crops (ha)	20	2.1870
	Income earned from crops (MWK)	25	16,092
Salima	Area with irrigated crops (ha)	6	0.6
	Area with rain fed crops (ha)	50	0.8
	Income earned from crops (MWK)	19	54,837
Zomba	Area with irrigated crops (ha)	22	0.8
	Area with rain fed crops (ha)	55	1.4
	Income earned from crops (MWK)	43	29,147

Source: Socio-economic Survey, 2011

A high number of households (69%) reported facing food shortages during the year (Table 33). Food shortages usually occurred during the rainy season when land for flood recession agriculture is limited highlighting the dependence on this type of agriculture for their livelihood.

TABLE 33. HOUSEHOLD FOOD SECURITY

District	Number of Households Facing Food Shortage (n=520)	Number of Households Facing Food Shortage in Different Seasons		
		Summer	Rainy	Winter
Balaka	46	9	37	0
Blantyre	36	16	20	0
Chikhwawa	40	26	14	0
Machinga	59	13	57	0
Mangochi	41	3	38	0
Nsanje	44	31	10	5
Salima	45	11	33	1
Zomba	47	5	43	0
Total	358	114	252	6

Source: Socio-economic Survey, 2011

The coping strategies utilised by households during food shortages are listed in Table 34. The most common strategy employed is to use household money to buy from the market followed by sourcing additional income from casual labour or obtaining assistance from relatives and friends. Obtaining credit or selling firewood and traditional medicines are amongst the least used strategies.

TABLE 34. STRATEGIES USED BY HOUSEHOLDS DURING FOOD SHORTAGE

Food Shortage Coping Strategy	Number of Households
Use own money to buy from the market	45
Source money from casual labour	36
Get assistance from relatives and friends	19
Source money by catching and selling fish	7
Do business to source money	7
Sell crops	7
Depend on salary	6
Sell livestock	6
Dry and cooked cassava	5
Boil mangoes	4
Sell charcoal	5
Starve family	3
Cooked bush leaves	1
Go to Mozambique to fetch food	1
Get credit to buy food	1
Sell firewood	1
Sell traditional medicine	1
Dig roots	1

Source: Socio-economic Survey, 2011

Food and farm inputs accounted for most household expenditure (Table 35). The least amount of household expenditure was for health / medications. On a District basis, households in Salima tended to spend more on food, beverages, travel and health / medications.

TABLE 35. HOUSEHOLD EXPENDITURE ON VARIOUS ITEMS PER MONTH

Expenditure on Item (MWK)	Percent of Household							
	Balaka	Blantyre	Chikhwawa	Machinga	Mangochi	Nsanje	Salima	Zomba
Food								
less than 1000	10.3	14.6	15.6	13.1	4.2	23.9		14.5
1000 to 3000	39.7	25.0	42.2	35.4	9.9	43.5	12.5	32.7
3000 to 5000	30.9	14.6	20.0	18.2	32.4	19.6	22.2	34.5
above 5000	19.1	45.8	22.2	33.3	53.5	13.0	65.3	18.2
Clothes								
less than 1000	76.5	18.9	33.3	27.8	41.5	33.3	69.0	41.2
1000 to 3000	17.6	37.8	25.0	37.0	24.4	48.5	14.3	35.3
3000 to 5000	5.9	10.8	22.2	16.7	24.4	12.1	7.1	8.8
above 5000		32.4	19.4	18.5	9.8	6.1	9.5	14.7
Beverages								
less than 1000	90.9	79.5	73.0	87.0	80.3	76.9	81.0	79.1
1000 to 3000	9.1	15.9	21.6	10.1	13.6	19.2	6.9	20.9
3000 to 5000		2.3	2.7	1.4	4.5	3.8		
above 5000		2.3	2.7	1.4	1.5		12.1	
Social Functions								
less than 1000	80.0	66.7	56.7	83.0	63.8	67.7	66.7	66.7
1000 to 3000	16.0	15.4	26.7	13.2	23.4	16.1	23.8	29.6
3000 to 5000	4.0	7.7	13.3	1.9	10.6	6.5	2.4	3.7
above 5000		10.3	3.3	1.9	2.1	9.7	7.1	
Education								
less than 1000	90.6	81.0	68.8	84.4	71.9	81.6	63.8	92.5
1000 to 3000	5.7	11.9	12.5	9.4	14.1	18.4	22.4	5.0
3000 to 5000		4.8	6.3	1.6	6.3		6.9	2.5
above 5000	3.8	2.4	12.5	4.7	7.8		6.9	
Farm inputs								
less than 1000	50.0	19.0	25.0	25.4	27.1	66.7	41.0	25.0
1000 to 3000	25.0	28.6	46.9	19.4	25.0	15.2	10.3	35.0
3000 to 5000	11.4	11.9	15.6	10.4	12.5	12.1	17.9	12.5
above 5000	13.6	40.5	12.5	44.8	35.4	6.1	30.8	27.5
Health/Medication								
less than 1000	100.0	84.8	83.3	78.7	87.5	89.7	69.9	94.1
1000 to 3000		8.7	16.7	17.3	12.5	10.3	20.5	5.9
3000 to 5000		6.5		2.7			4.1	
above 5000				1.3			5.5	
Travel								
less than 1000	59.0	45.2	65.9	74.0	65.6	77.8	45.2	66.7
1000 to 3000	30.8	42.9	25.0	15.6	25.0	19.4	29.0	33.3
3000 to 5000	7.7	4.8	6.8	5.2	6.3	2.8	11.3	
above 5000	2.6	7.1	2.3	5.2	3.1		14.5	

Source: Socio-economic Survey, 2011

5.3.2.9 Impacts of Lake Malawi, Lake Malombe and Shire River on Households

Households considered that Lake Malawi and Lake Malombe and the Shire River were very important to them in terms of agriculture and fishing and to a lesser extent for transport (Table 36).

Conversely, households in all districts indicated that they were adversely impacted by flooding from Malawi and Malombe Lakes and the Shire River (Table 37). Adverse impacts from water animal attacks (crocodiles and hippopotamuses) were also considered as significant in all districts. Drought was the other adverse impact identified by households from all districts except for Mangochi, Nsanje and Salima.

TABLE 36. ADVERSE IMPACT OF RIVER SHIRE AND LAKES MOLOMBE AND MALAWI ON HOUSEHOLDS

District	Impact	Households Affected	
		Frequency	%
Balaka	Flooding	34	53.1
	Water animal attacks	22	34.4
	Drought	6	9.4
	Any other	2	3.1
Blantyre	Flooding	27	55.1
	Water animal attacks	20	40.8
	Drought	2	4.1
Chikhwawa	Flooding	45	91.8
	Water animal attacks	3	6.1
	Drought	1	2.0
Machinga	Flooding	60	60.6
	Water animal attacks	23	23.2
	Drought	12	12.1
	Any other	4	4.0
Mangochi	Flooding	41	60.3
	Water animal attacks	23	33.8
	Any other	4	5.9
Nsanje	Flooding	42	91.3
	Water animal attacks	3	6.5
	Any other	1	2.2
Salima	Flooding	40	64.5
	Water animal attacks	4	6.5
	Any other	18	29.0
Zomba	Flooding	41	73.2
	Water animal attacks	9	16.1
	Drought	1	1.8
	Any other	5	8.9

Source: Socio-economic Survey, 2011

TABLE 37. USEFULNESS OF SHIRE RIVER AND LAKES MALAWI AND MALOMBE TO HOUSEHOLDS

District	Usefulness	Fishing		Agriculture		Transport		Other Activities	
		Freq	%	Freq	%	Freq	%	Freq	%
Balaka	Yes	64	94.1	67	98.5	49	73.1	11	22.9
	No	4	5.9	1	1.5	18	26.9	37	77.1
Blantyre	Yes	40	80.0	49	98.0	26	52.0	8	16.0
	No	10	20.0	1	2.0	24	48.0	42	84.0
Chikhwawa	Yes	35	70.0	45	90.0	29	59.2	4	8.0
	No	15	30.0	5	10.0	20	40.8	46	92.0
Machinga	Yes	92	91.1	98	97.0	54	55.1	9	9.4
	No	9	8.9	3	3.0	44	44.9	87	90.6
Mangochi	Yes	69	97.2	63	88.7	42	59.2	23	32.4
	No	2	2.8	8	11.3	29	40.8	48	67.6
Nsanje	Yes	42	85.7	46	93.9	38	77.6	16	32.7
	No	7	14.3	3	6.1	11	22.4	33	67.3
Salima	Yes	73	98.6	21	28.4	54	74.0	54	91.5
	No	1	1.4	53	71.6	19	26.0	5	8.5
Zomba	Yes	54	98.2	55	100.0	52	94.5	9	75.0
	No	0	0.0	0	0.0	3	5.5	3	25.0

Source: Socio-economic Survey, 2011

5.3.2.10 Health

5.3.2.10.1 Health Facilities

The Project area is well serviced by government and private hospitals. There are also health centres in many parts of the rural communities. Mangochi district has four hospitals, 29 health centres, two health posts and 248 outreach clinics, (Malawi Government 2009). The average catchment population for a health centre is 10,000 but the lowest population that the health centres are servicing in the district is 28,112 (Malawi Government 2009). Some health centres located in the Project area such as Chimwala in the Lake Malombe area has 3 health centres servicing a population of 107,673; while Chowe area on the western side of Lake Malombe also serves a population that is outside of the 5km buffer zone, (Malawi Government, 2009). Balaka District has 23 health facilities and considering the population of the District there are capacity problems in terms of human resources and space.

5.3.2.10.2 Common Diseases

Malaria is by far the most common disease in Mangochi district followed by respiratory infections, diarrhoea, anaemia and urinary infections such as bilharzia, (Malawi Government 2009). The high incidence of Malaria is due to the general abundance of standing water, combined with often inadequate prevention efforts, (Malawi Government 2009). The Malawi Government has currently increased efforts to reduce Malaria incidence in the district by 50%.

Mangochi district has also been experiencing an increase in number of new HIV infections and AIDS. According to the National AIDS commission (2003) sentinel surveillance survey Mangochi comes third after Blantyre and Lilongwe with an estimation of 14% of the population infected, (Malawi Government 2009). The Demographic Health Survey (2005) puts the HIV/AIDS prevalence rate in Mangochi at 21%.

As of 2000, Machinga district had one referral hospital located in Liwonde Township and 12 health centres. The health services are not enough because most health centres are serving more than the 5,000 people within the five kilometre radius, (Government of Malawi, 2001).

The most common diseases in Machinga District are Malaria, Respiratory infection, Diarrhoea, skin diseases, STIs, worm infections, malnutrition, ear diseases, cholera, (Government of Malawi, 2001), with Malaria being the most common ailment.

The commonly occurring diseases in Balaka district are Malaria, waterborne diseases, eye infections, tuberculosis and acute respiratory infections. The current HIV/AIDS prevalence rate is 16.2%.

Table 38 lists the common diseases affecting households as recorded in the socio-economic survey. Malaria, diarrhoea and asthma were the most common diseases experienced by households, which is similar to the District disease statistics outlined above.

TABLE 38. COMMON DISEASES AFFECTING HOUSEHOLDS

Type of Disease	Number of Households Affected
Malaria	220
Diarrhoea	34
Asthma	20
Leg problem	17
Stomach ache	17
TB	14
Chicken pox	12
Blood pressure	11
Cough	11
Measles	10
Pneumonia	10
Rheumatism	10

Type of Disease	Number of Households Affected
Anaemia	8
Headache	8
Epilepsy	7
Tooth problem	6
Ulcers	6
Bilharzias	5
Rash	4
Cancer	2
Cholera	2
Dysentery	2
Blindness	1
Goitre	1
Tumour	1

Source: Socio-economic Survey, 2011

5.3.2.11 Cultural Heritage

There are few records of cultural heritage in the Project area. Within the construction footprint of the proposed Project, there were no cultural or heritage items reported during the socio-economic survey which would be affected by the Project.

The EIA prepared in 2003 (Norconsult 2003) for the Upgraded Kamuzu Barrage proposal mentions that a few graves were potentially impacted by the Project. These appear to be located at a higher level than is planned for the current upgrading of the Barrage. The EIA does not mention any other cultural heritage items.

5.3.2.12 Key Information from Stakeholder Consultations

The most common issues cited by communities amongst those consulted had to do with access to basic services and food insecurity. A review of the socio-economic profiles made available to the assessment team revealed that the development issues mentioned have also been recognized by the District Councils and are part of the District Development Plans. In some communities, there appeared to be some disenchantment with the many requests by 'people like you' to prioritise community needs and yet nothing comes out of these suggestions.

The following list of issues recurred from community to community, with differences observed only in the rankings in order of priority:

- Lack of Potable Water: either water is salty when it is available in bore wells (Nsanje and Chikhwawa) or there are few water points.
- Limited access to social services: either facilities are too far or cannot be easily accessed because of lack of bridges on some of the main tributaries into the Shire River. These services were mainly health, education, maize mills, markets and others;
- Food Insecurity: due to poor harvest, limited capability at household level to find money and other resources to purchase food when own production is inadequate and high food prices;
- Low Literacy levels: either classes had been discontinued where they existed before due to lack of teachers as volunteer teachers drop out, or they had not been initiated yet;
- Insecurity of property: incidences of theft were reported, especially for cattle and other valuable household items. The communities felt there was need for police stations to exert a dissuasive influence on those that are bent on committing crime.

Within the communities consulted, poor access to socio- economic services and food insecurity are key issues. Consequently, should the upgrade impact negatively on these, the situation is likely to be exacerbated and attitudes towards the Project would be poor.

6 Analysis of Alternatives

6.1 Project Alternatives

Over the last century Lake Malawi has experienced severe periodic water level fluctuations which in turn have caused social, economic, and environmental changes. Some of this natural water level fluctuation has produced significant adverse impacts, such as during the period 1915 to 1937 the water level of the Lake was so low that the outflow from the Lake more or less stopped, leaving the Shire River dry. If this scenario were repeated today, it would have disastrous consequences at a national level, since so much of Malawi's electricity generation, urban water supply, agricultural production, and fisheries depend upon adequate water levels within the Shire River.

Different ways of securing the Shire River's water flow have been suggested and studied. The most recent of these studies is the 2003 Lake Malawi Level Control Study – Phase I and II (Norconsult 2003) which analysed different types of interventions to ensure adequate dry season flows in the Shire River, including the "no-action" alternative. One option involved a pumping scheme which required construction of a new Barrage on the Shire River close to Lake Malawi and draw down of Lake Malawi water levels through pumping water from the Lake (minimum water level of 469 masl in Lake Malawi). The main environmental concern from this option is lower water levels in Lake Malawi than at present which potentially impacts on fish and fisheries (aquatic life), harbours and Lake transport.

Another option was to augment flow in the Shire River by storing more water in Lake Malawi by constructing a large dam to increase the level of Lake Malawi and create sufficient storage capacity. The main environmental concern from this option is higher Lake levels (maximum of 477 masl) than at present causing flooding of foreshore areas impacting on tourism infrastructure, flooding or private houses, cemeteries etc. and inundation of beaches and dimba land. It requires a large quantity of water, which would become dead storage.

Based on social and environmental considerations, the preferred option identified to help ensure adequate water in the Shire River was to upgrade the existing Kamuzu Barrage at Liwonde by increasing the maximum regulating capacity by no more than 40cm corresponding to a Lake Malawi water level of 475.72 masl.

6.2 Alternative Barrage Operating Levels

6.2.1 Alternative Barrage Regulated Water Levels

The existing Kamuzu Barrage is capable of regulating upstream water levels in Lake Malawi, Lake Malombe, and the upper Shire River within Liwonde National Park, within the range 474.4 masl to 475.32 masl, as measured at Lake Malawi. The Feasibility Report prepared in 2003 considered a 20 cm water level increase with the refurbished Kamuzu Barrage, which would lead to a regulation range of 474.4 masl to 475.52 masl. This increase in the level of Lake Malawi was considered sufficient at the time for meeting downstream water demands. It also minimised the impacts of higher water levels upstream of the Barrage in the Shire River, Lake Malombe and Lake Malawi. Higher water levels upstream of Kamuzu Barrage above 476 masl would have much greater social and environmental impacts by resulting in resettlement, along with greater impacts on tourist facilities and inundation of riparian vegetation and river sandbars within Liwonde National Park.

Presently, the technical design for the upgraded Kamuzu Barrage provides for a 40 cm increase in water level, based on the fact that this is the maximum level allowable for the clearance under the existing bridge over the Barrage. The actual height of the water will be dependent on the operating rules that will be developed during the end of the design phase, refined before Barrage construction, and strengthened by a real-time decision support system to guide operations from a multi-sectoral perspective. The maximum structural height increase and the maximum operational level would need to reflect the findings of this assessment. Since this ESIA and the parallel Detailed Design study for the Kamuzu Barrage are being carried out in close consultation with each other, the final Barrage design will reflect the environmental and social input concerning different design choices.

However, current downstream water demands along the Shire River have increased such that a 40 cm increase in the range of regulation for Lake Malawi's water level is now being considered for the Project so

that the increased water demands downstream can be met. The quantitative change in impacts from a change in the rise of water levels upstream to 40cm is considered acceptable in terms of social and environmental impacts.

6.2.2 Alternative Barrage Operating Rules

The water release operating rules for the upgraded Kamuzu Barrage will take into account the environmental and social considerations, both upstream and downstream of the Barrage. This ESIA will provide input to the operating rules for the upgraded Barrage by providing environmental and social boundary conditions for Barrage operation. These boundary conditions will cover (i) the maximum water level that should intentionally be stored above the Kamuzu Barrage (whether 40 cm above, 20 cm above, or some other figure with respect to the status quo); (ii) the seasonal timing and amplitude of any "simulated floods" to support downstream fisheries, maintain suitable conditions within the Elephant Marsh, enable flood-recession agriculture, and meet other important objectives; (iii) the maximum daily fluctuation (if any) in deliberate water releases from the Barrage. Such fluctuations could help to meet peaking power demands, but (above some amplitude) could harm downstream fisheries, aquatic biodiversity, flood-recession agriculture, the Elephant Marsh, etc.; and (iv) the speed at which water flows from the Kamuzu Barrage are intentionally increased or decreased (too rapid a change could cause fish stranding, river bank erosion, etc.), among others.

6.3 "Do Nothing" Option

The upgraded Kamuzu Barrage will ensure a more reliable water supply for most of Malawi's power generation (through the existing Nkula, Tedzani and Kapichira hydropower stations), drinking water supplies for Blantyre and smaller towns, and existing irrigation systems (mostly large-scale sugar cane cultivation). The upgraded Barrage also provides minimum flows in the Shire River during low flow periods to meet the needs of traditional farmers and other human water users, as well as many species of river-dependent plant and animal life (including within the Elephant Marsh). Without the planned upgrading of the Kamuzu Barrage, the local economy would also miss out on benefits resulting from construction activities. If the reconstruction and upgrading of the Kamuzu Barrage did not proceed, Malawi would forego significant economic benefits and the local communities living around the Barrage would miss out on potential improvements in their living standards.

ESCOM is struggling to control floating weeds (particularly Water Hyacinth) on the Shire River from damaging its plant and equipment. The existing weed barrier upstream of the Barrage is ineffective. The proposed refurbished Barrage includes a new weed boom upstream of the Barrage to replace the existing one which will be more effective in removing floating weeds in the Shire River. ESCOM would have to make alternative arrangements for managing floating weeds if the Project did not proceed.

The aging existing Barrage would also continue to undergo wear and tear, with its performance becoming progressively less reliable over time. There is risk that future operation of the Barrage gates will be further diminished so that optimal flow releases could not be made and in major flood situations in the Shire River, failure to operate the gates could even lead to overtopping of the Barrage and subsequent complete structural failure leading to severe flooding impacts downstream as well as immediate loss of an important vehicle transport route across the Barrage. This latter effect would have significant local and regional adverse consequences.

The current design engineering investigation of the Barrage has also indicated that there is scouring of the river bed immediately downstream of the Barrage. If left unchecked, this erosion could lead to structural failure of the Barrage.

The upgrading of the Kamuzu Barrage has strategic importance to Malawi and this would be lost if the Project did not proceed.

7 Social and Environmental Impacts

Project impacts have been assessed based on five impact criteria, namely: scale; duration; severity; certainty and direction (refer to the Legend at the end of Table 45). Table 45 provides a summary of the impacts which are described in the following Sections. Since the current Project involves refurbishing the existing Kamuzu Barrage (which has existed since 1965), with increased water level regulation capacity, the impacts from the refurbished Barrage will be incremental in nature and less significant than if a new Barrage were built. Nevertheless, the refurbished Barrage will result in potentially significant impacts on the aquatic and adjacent terrestrial environments both upstream and downstream of the Barrage.

Social impacts will also result from the increased duration of inundation of land upstream of the Barrage along the Shire River and along the foreshores of Lakes Malombe and Malawi. These areas are subject to inundation under natural flow conditions in the Shire River and the natural fluctuations in water levels in Lake Malawi. However, the effect of increasing the regulating height of the Barrage will mean these areas become inundated for longer periods of time than at present. The extent of land inundated is not anticipated to result in involuntary resettlement and effects on building structures is anticipated only within the construction footprint area near the Barrage.

These impacts need to be managed carefully and appropriate mitigation measures adopted to minimise the adverse impacts from the Project. This Section identifies the main potential impacts resulting from the Project. Suitable mitigation measures to minimise these adverse impacts and maximise Project benefits are described in Section 8.

7.1 Project Benefits

7.1.1 Improved Hydropower Generation

The upgraded Barrage will help to ensure adequate minimum flows in the Shire River, thus enabling the more reliable generation of hydropower from existing facilities especially during the dry season when River flows are low. This will have a positive effect on local, regional and national economies. Most of Malawi's power supply comes from hydropower and the whole country currently experiences severe power outages because supply cannot meet demand.

7.1.2 Removal of Floating Weeds

The existing weed structure upstream of Kamuzu Barrage is ineffective in controlling floating weeds, especially water hyacinth (locally known as "Namasupuni") which is a nuisance aquatic plant that affects operation of ESCOM's power plants along the Shire River. The upgraded Barrage includes provision of construction of a new weed boom gate upstream which will be more effective in removing floating water weeds and thus will benefit operation of the power plants. However this will create a problem of disposal of the weeds collected.

7.1.3 Urban Water Supply

The upgraded Kamuzu Barrage will help to ensure a consistently adequate minimum water level in the Shire River, so that the city of Blantyre and other towns can continue to obtain adequate water supplies through pumping from the River.

7.1.4 Irrigation Developments

According to the Water Resources Board major irrigators along the Shire River downstream of Kamuzu Barrage who are licensed are Demeter Irrigation (720,000 m^3/day); Cattle feed lot (129,600 m^3/day) and SUCOMA Sugar Plantations (2,058,740 m^3/day). SUCOMA Sugar Plantations command an irrigation area estimated at 14,000 ha. They currently have plans to expand the irrigation area however availability of water is a limiting factor.

These irrigators will benefit from increased flow regulation resulting from an upgraded Kamuzu Barrage.

7.1.5 Drought Risk Reduction

If the Shire River were to run dry again (as during 1908 - 1935), it would have disastrous implications for electricity generation, urban water supplies, irrigated and flood-recession agriculture, fisheries, and boat navigation, as well as the natural ecosystems and wildlife that exist along the River.

7.1.6 Improved Road Transport

The upgraded Kamuzu Barrage will be stronger and wider, providing both motorists and pedestrians with a useful, easy, and safer means of transit across the Shire River at Liwonde. This will provide local and regional benefits as the road is the main transport corridor between Liwonde and Zomba.

7.1.7 Employment and Income Generation during Construction

During construction the Project will bring employment opportunities to local people. It is expected that direct short-term jobs and casual work will be available. There will also be opportunities to trade and sell local food to construction workers and this will have a positive impact on household income.

Also women and youth service providers particularly food vendors will establish businesses at the Project site and this will boost their household income.

Increased demand for farm products, fish and livestock due to increased population from Project workers during Barrage construction will enhance household income and increase money circulation in Liwonde and surrounding villages.

7.1.8 Social Change

The rural areas of the Project area are dominated by a single culture (Yao) and in such situations it is difficult for people to be innovative as no new ideas and experiences easily penetrate the community. Project construction will encourage people from other parts of the country to live in the area and these immigrants will come with new ideas. Such an opportunity will create room for social transformation and allow diffusion of cultural values that will assist development.

7.2 Description of Impacts

The positive impacts described above will be accompanied by negative impacts that must be mitigated to minimize their effect on people and the environment. Such impacts are expected to occur not only during the construction of the Barrage but also during planning and operation stages. The anticipated negative impacts are described in the following Sections.

7.2.1 Physical Environment

7.2.1.1 Seismicity

The following assessment is taken from the Feasibility Design Report for the Project (NORPLAN, 2012). In terms of the consequences of a potential collapse of the Barrage in the case of an earth quake, two different situations were assessed: Barrage functionality and total structural collapse.

7.2.1.1.1 Barrage Functionality

The barrage should, after a moderate seismic event, be substantially intact and stable and able to retain water. However, deformations or damages may have occurred to such an extent that one or more gates may not be operated as planned. The worst scenario in this respect would be that a number of gates remained in a closed position causing the Barrage and the road on both sides of the Barrage being overtopped and washed away. The second severe, but not fatal, consequence would be that sufficient discharge of regulated water to downstream users could not be maintained.

7.2.1.1.2 Total Structural Collapse

With a 40 cm increase in Barrage height, Kamuzu Barrage regulates, and thereby retains water within two defined regulated water levels of Lake Malawi, i.e. between Lake Level 474.4 masl as LRWL and 475.72 masl as HRWL. For Lake Levels equal or higher than the HRWL, i.e. for a flood situation, the gates will be kept fully open.

In the event of an earthquake, strong enough to cause structural collapse of the Barrage, coinciding with a flood situation with all gates open, the collapse would not have significant immediate consequences for the area and population downstream as the water flow will already be determined by the natural flow capacity of the river system.

In the situations with the Barrage in operation and the gates partially closed, the Barrage has the function of retaining water in Lake Malawi. If a full structural collapse of the Barrage would occur in this situation, the immediate worst case consequences for the downstream area and population could be a sudden and unexpected increase of the water flow. The magnitude of the sudden flow would, however, be limited to the magnitude of the natural flood conditions with all gates open. Compared to a normal high flood situation the different scenario would be that it would not be possible to give flood warnings to the downstream population after the earth quake.

Consequently, the consequences of full structural collapse have to be regarded as serious because people downstream would not get warning that a flood might suddenly occur.

7.2.1.2 Climate

Large bodies of water are known to cause changes to the surrounding micro-climate. Experience from other large storages suggests a large body of water results in raising the ambient (air) temperature in the immediate vicinity. However the rise in water level upstream of the barrage will not result in a significant incremental change from the existing situation so the impact while long term, is likely to be minor and local.

7.2.1.3 Soils

Impacts from construction activities could lead to increased soil erosion in and around work sites including quarry sites and soil / sand / aggregate borrow areas. These impacts are expected to be short term and of medium significance. Appropriate mitigation measures would reduce the residual impact significance to low.

The refurbished Barrage would also inundate additional land upstream which is already prone to flooding caused by natural fluctuations in Lake Malawi water levels. There will be a temporary increase in soil erosion as the vegetation cover in this area is inundated (the extent of vegetation die-off is dependent on the frequency and duration of inundation), exposing the soil to the effects of fluctuating water levels from the enlarged reservoir. The resultant sediments will most likely settle in either Lake Malawi or Lake Malombe rather than be passed downstream except in flood events when sediment loads in the Shire River are “naturally” high so that the downstream impact would be low. Any incremental increase in sediment would not be significant.

7.2.1.4 Mineral Resources

There are no recorded economic deposits of mineral resources which would be inundated as a result of the refurbished Barrage.

7.2.1.5 Water Resources

7.2.1.5.1 Surface Water

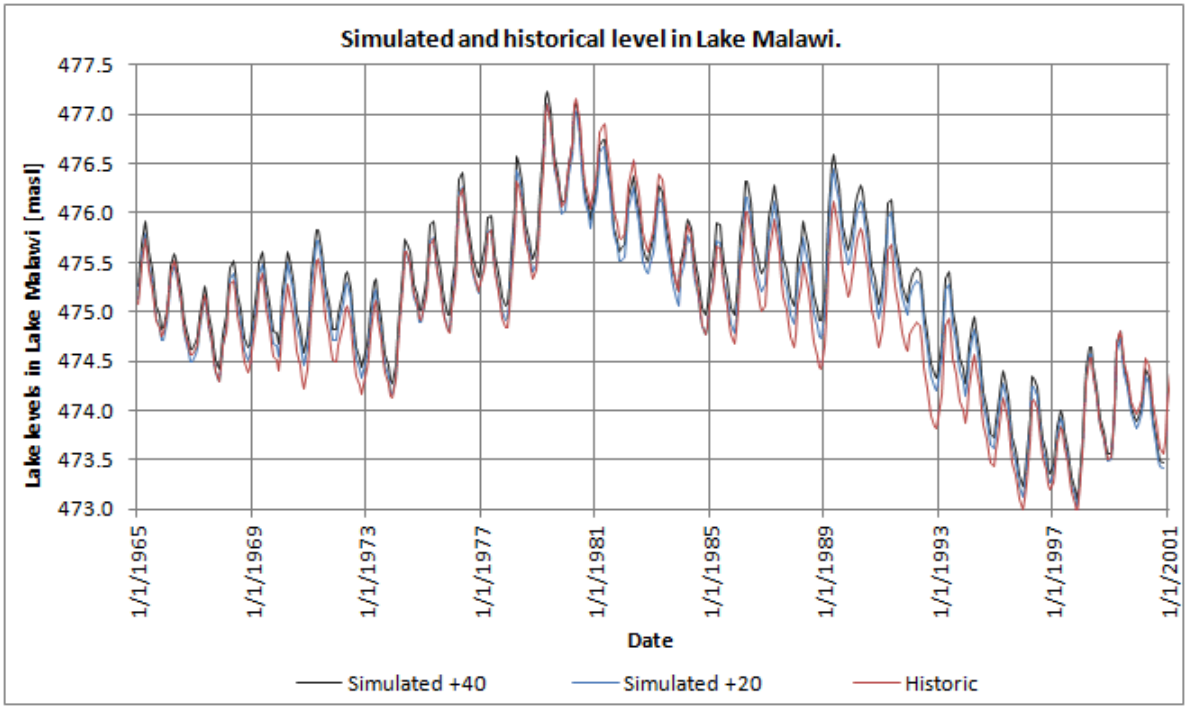
The 2003 EIA Study (NORPLAN, 2003) concluded that Lake Malawi and Shire River levels already vary within a broad range under baseline conditions and consequently changes involving permanent flooding or inundation will be of minor negative significance. The Project will not induce any permanent inundation in the sense that any flood levels will be within the same range as the baseline.

Flow and stage conditions downstream of Liwonde are purely functions of hydrology and revised release strategies, the ‘Upgraded Kamuzu Barrage’ replacing the ‘Kamuzu Barrage’ will not influence the downstream hydraulic conditions.

However, with respect to changes in Shire River flow regime downstream of the Barrage, in the operational phase, a new release strategy will be employed. This will change river flow to a more predictable pattern, including the release of an environmental flood to secure annual discharge variation amplitude. The impact on downstream water users (hydropower generation, irrigation) will be significantly beneficial. The new release strategy will reduce risk of downstream low discharges, and ensure annual floods (when Lake levels permit). The impact on the aquatic environment will depend on the timing (time of year), duration (time span) and size of flow releases from the Barrage.

At high levels, Lake Malawi is beyond the regulation range of the Barrage, the Shire River flow will revert to its "natural state" (and at very low levels also) so that the Barrage will have no influence on flows in the River.

Figure 29 gives an indication of the changes in Lake Levels with both a 20 cm and 40 cm rise in operating level of the upgraded Barrage compared to the historic (current) scenario with the existing Barrage. The degree of divergence depends on which part of the hydrology the Lake is experiencing. It can also be observed from Figure 29 that the natural year to year variation dwarfs the Barrage influence as regards to Lake Levels. For example within the last 40 years there has been a natural variation of Lake level of almost 4.5 m (between 473.0 masl and 477.3 masl) and an annual variation of a metre or so.



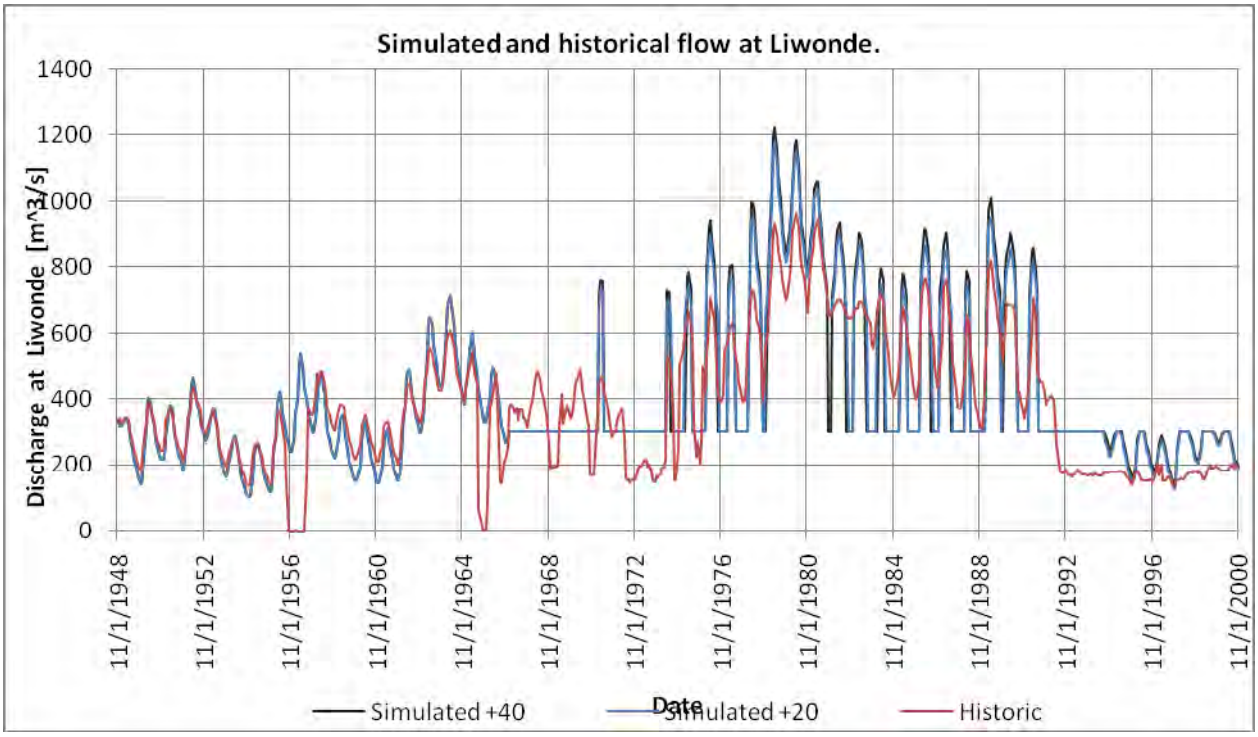
Source: NORPLAN 2011

Figure 29. Simulated and Historical Flow in Lake Malawi

Also, relevant for the downstream impacts (much more pronounced than the upstream impacts) is Figure 30 which simulates flows in the Shire River based on an operating regime that aims at maintaining a minimum flow of 300 m^3/s downstream.

7.2.1.5.2 Groundwater

An increase in water levels upstream of the Barrage will also lead to an increase in groundwater levels. The extent of the increase is dependent on the increase in water level and the duration of the increase. The longer a higher water level is maintained the more likely there will be an increase in groundwater level (NORPLAN – COWI Joint Venture, 2001 and Norconsult and Associates 2003).



Source: NORPLAN 2011

Figure 30. Simulate and Historical Flow at Liwonde

7.2.1.6 Water Quality

During the construction phase of the Project environmental impacts will centre on the changes to water quality as a result of a minor increase in sediment loadings from increases in localised rates of soil erosion. Additionally, there will be the risk of chemical and organic pollution from accidental spillages and potential failures in the environmental management system.

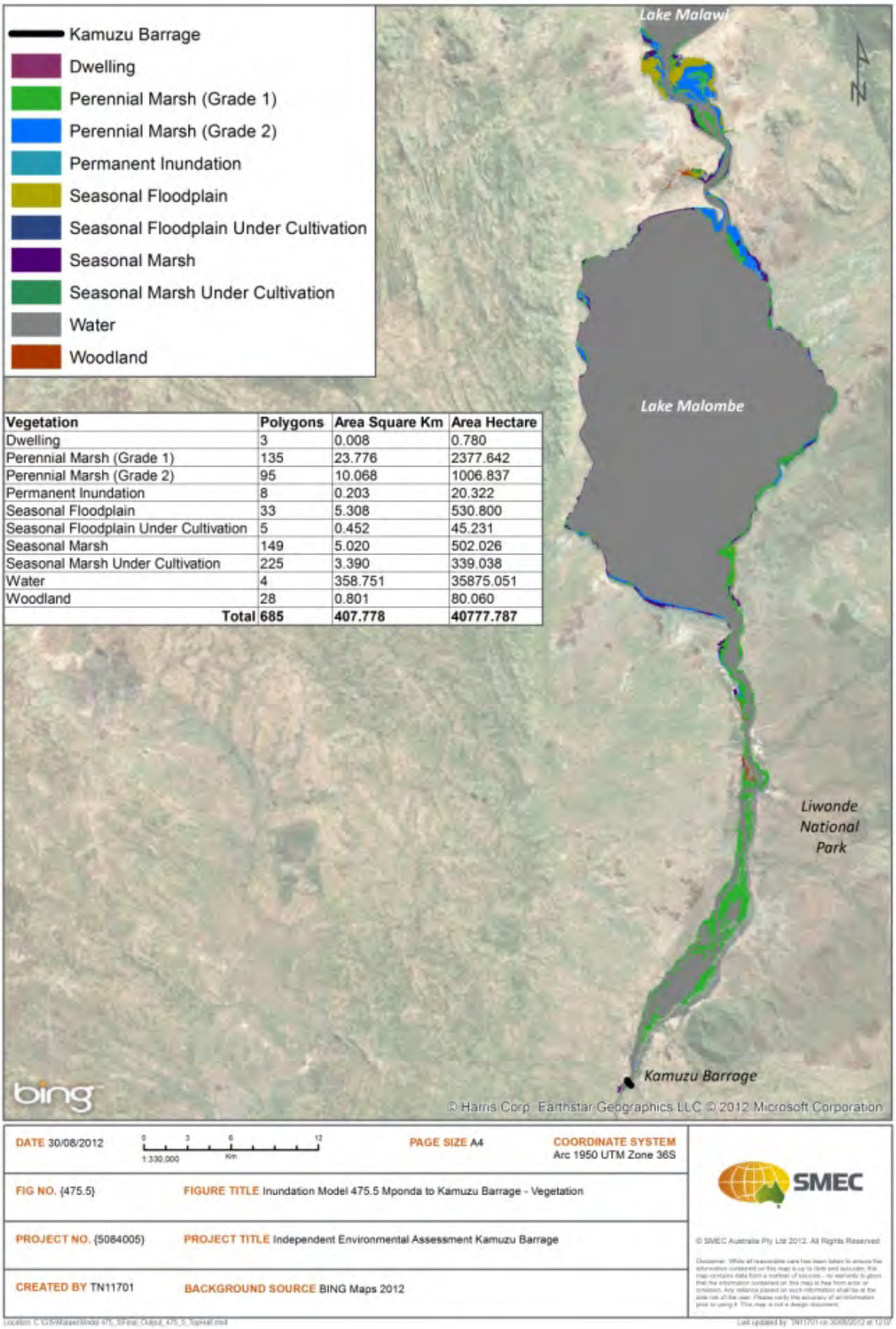
However, the significance of additional sediment loading generated specifically by construction activities will be low. Given the potential dilution properties of the Shire River, any damage occurring from accidental or illegal discharge of chemical, oils, grease etc. will likely be localised and not a threat to the River ecosystem.

No significant water quality impacts are anticipated in Lake Malawi or the Shire River System during operation. Reduced groundwater quality in areas adjacent to the Lake and Shire upstream of the Barrage is expected to be minor although monitoring of water borne disease occurrence will indicate the scale.

7.2.2 Biological Environment

7.2.2.1 Biotic (Vegetation) Communities

The outputs from the Design Consultant's hydraulic modelling for the upgraded Barrage were overlaid onto the biotic community mapping undertaken by SMEC. These outputs showed the expected upstream and downstream inundation footprints for a range of water release scenarios. By overlaying a range of inundation footprints on top of the biotic community mapping the areas of each biotic community type that will be impacted at various water levels at the Barrage, was calculated for a range of release scenarios. An example of a map produced is shown in Figure 31 which shows the inundation of each habitat / land use type upstream of the Barrage at an inundation level of 475.5.masl. The full range of maps generated is included in the Vegetation Report in Volume 2 of the ESIA.



Vegetation	Polygons	Area Square Km	Area Hectare
Dwelling	3	0.008	0.780
Perennial Marsh (Grade 1)	135	23.776	2377.642
Perennial Marsh (Grade 2)	95	10.068	1006.837
Permanent Inundation	8	0.203	20.322
Seasonal Floodplain	33	5.308	530.800
Seasonal Floodplain Under Cultivation	5	0.452	45.231
Seasonal Marsh	149	5.020	502.026
Seasonal Marsh Under Cultivation	225	3.390	339.038
Water	4	358.751	35875.051
Woodland	28	0.801	80.060
Total	**685**	**407.778**	**40777.787**

Figure 31. Inundation map 475.5 masl Lake Malawi to Kamuzu Barrage

7.2.2.1.1 Impacts Upstream of Kamuzu Barrage

7.2.2.1.1.1 Changes in Area of Inundation

It can be seen from Figure 32 that upstream of the Barrage significant inundation of fringing habitats only occurs at water levels of 475 masl and above. As the existing Barrage maintains a mean water level of 475.32 masl only changes to the structure that result in mean water levels above 475.32 masl are relevant in terms of the ecological impacts on fringing habitats.

At water levels of 475.5 masl and above the most highly impacted habitat type is Perennial Marsh, with 3,384.48 ha and 4,278.23 ha of this habitat type being inundated at 475.5 masl and 476 masl respectively. Most of the Perennial Marsh that is susceptible to inundation lies within the boundaries of Liwonde National Park.

Inundation of other habitat types is minimal at 474 masl and moderate at water levels of above 475, with the next highest maximum inundation being that of Seasonal Marsh habitat (i.e. 695 ha at 476 masl).

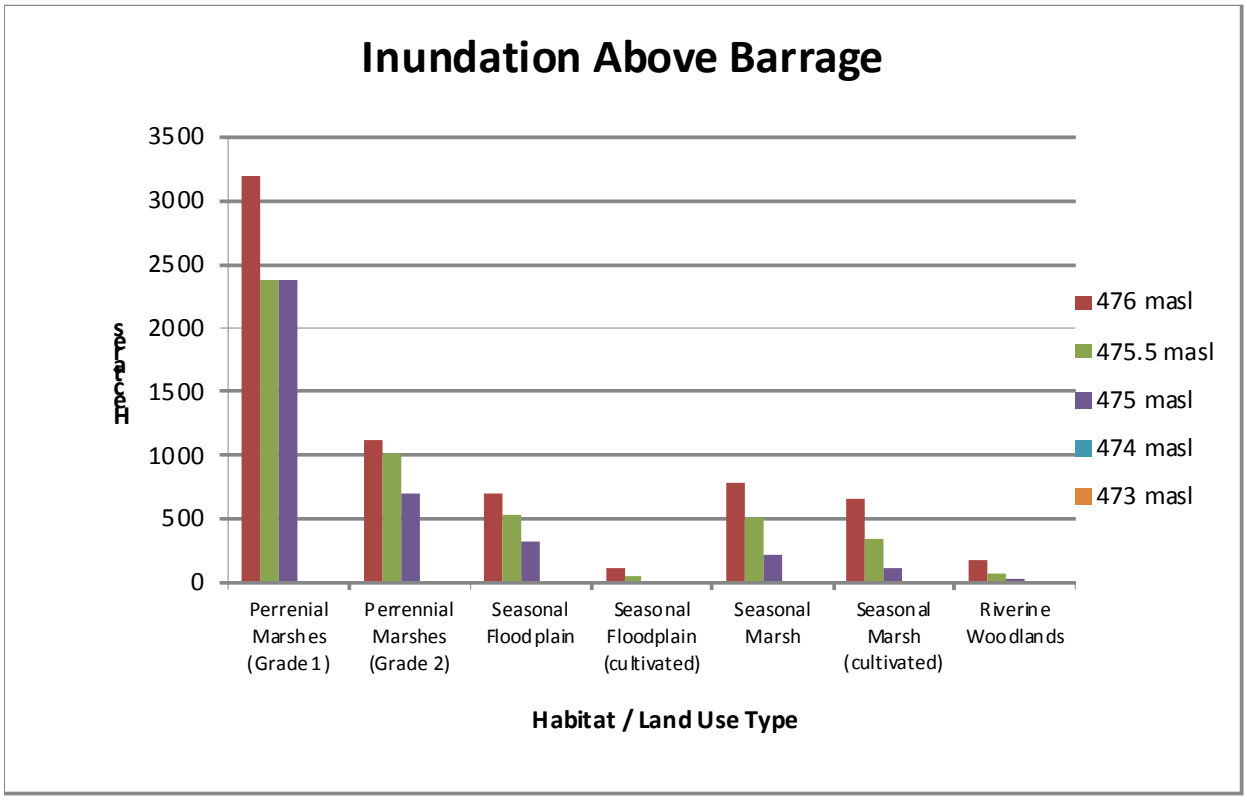


Figure 32. Habitat inundation upstream of Kamuzu Barrage over a range of water levels

7.2.2.1.1.2 Change in Inundation Period

In addition to the area of habitat inundated any changes in the inundation period must also be considered in an ecological context as this can cause a change in species composition. The data presented in Table 39 shows the predicted increases in the amount of time (expressed in both days per year and proportion of the year) that Perennial Marsh habitat will be inundated above the existing baseline level with a 20 cm and 40 cm increase in Barrage height.

The predictions in Table 39 indicate that there is no change in the inundation period of Perennial Marsh habitat for an increase in regulating height of either 20 cm or 40 cm when the level of Lake Malawi is 474 masl. However, small predicted changes in duration do occur at higher Lake levels and when the Barrage's HRWL is increased by either 20cm or 40cm. For example, at a Lake Malawi water level of 475 masl there is negligible difference in inundation period between a 20cm or 40cm increase in HRWL of the Barrage. The differences are increased slightly at Lake levels of 475.5 masl and 476 masl.

TABLE 39. INUNDATION PERIOD

Lake Malawi Water Level (masl)	Duration of Inundation			Area of Perrennial Marsh Inundated (ha)			Area of Seasonal Floodplain (uncultivated) Inundated (ha)			Area of Seasonal Marsh (uncultivated) Inundated (ha)		
	Existing Barrage Height (475.32 masl)	20 cm Increase in Barrage Height (475.52 masl)	40 cm Increase in Barrage Height (475.72 masl)	Upstream of Kamuzu Barrage to Mponda	Downstream of Kamuzu Barrage to Chigaru	Total	Upstream of Kamuzu Barrage to Mponda	Downstream of Kamuzu Barrage to Chigaru	Total	Upstream of Kamuzu Barrage to Mponda	Downstream of Kamuzu Barrage to Chigaru	Total
474	68% (248 days)	68% (248 days)	68% (248 days)	18.02	63.19	**81.21**	1.3	197.5	**198.8**	0.8	13.6	**14.4**
475	40% (146 days)	44% (161 days)	45% (164 days)	3,074.95	147.76	**3,222.71**	312.0	388.6	**700.6**	224.7	99.0	**323.7**
475.5	22% (80 days)	26% (95 days)	30% (110 days)	3,384.48	709.16	**4,093.64**	530.8	1048.5	**1,579.3**	502.0	637.3	**1,139.3**
476	8% (33 days)	12% (40 days)	15% (51 days)	4,308.22	770.7	**5,078.92**	695.0	1240.3	**1,935.3**	778.2	708.1	**1,486.3**

As Perennial Marshlands are permanent to semi-permanent wet habitats, inundation is likely to be manifested by an increase in water depth rather than an increase in the time that land is covered with water that would otherwise be dry. In addition, as the projected increases in inundation period are small, they probably lie within the natural annual variation of inundation experienced in the system (however data is not available to substantiate this supposition). Consequently the effect of this impact on available habitat quantity and quality above the Barrage is predicted to be low. Generally, regulated flow from the Barrage will be confined to the River channel and riverine environments.

7.2.2.1.2 Impacts Downstream of Kamuzu Barrage

7.2.2.1.2.1 Area of Inundation

Downstream of the Barrage the magnitude of habitat inundation is significantly less than above the structure as the Shire River narrows and becomes more incised until it reaches the low wide floodplain of the Elephant Marsh. Water flows are faster in this section and there are less Perennial Marsh areas which require relatively slow flowing water in which to become established.

In this section significant habitat inundation is only observed at water levels of 475.5 masl and above with Seasonal Floodplain and Seasonal Marsh habitats being the most severely impacted (Figure 33). Perennial Marsh habitat is poorly represented in this section of the River and inundation of this habitat type is approximately 1/5 of that above the Barrage at the highest water level of 476 masl.

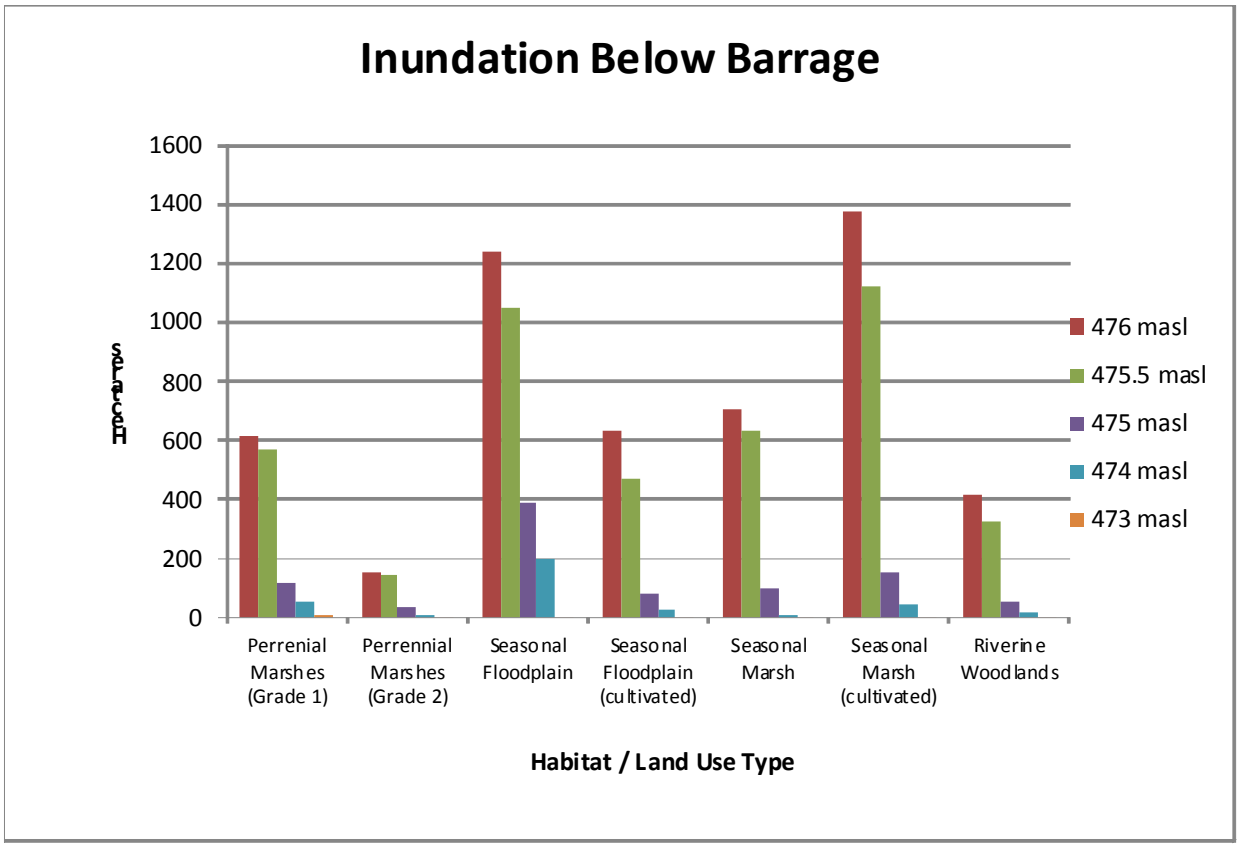


Figure 33. Habitat inundation below Kamuzu Barrage over a range of water levels

7.2.2.1.2.2 Inundation Period

The data presented in Table 39 shows that Seasonal Flood Plain and Seasonal Marsh habitats are more significantly impacted by increased inundation period downstream of the Barrage than upstream. This could potentially be an issue for egg laying reptiles, such as crocodiles and turtles that inhabit the Shire River below the Barrage if inundation occurs during the dry season when River flows are naturally low.

Female crocodiles will select a sandbank that is above flood water level, with good drainage and cover nearby to build a nest (Compass, 2000). Such conditions are only found in Seasonal Flood Plain and Seasonal

Marsh habitats in this section of the Shire River. Typically, crocodile eggs can only withstand flooding for a period of up to 12 hours (Mazzotti, 2002). If the water regulation regime at the Barrage leads to nesting sites being inundated for longer than this, decreased rates of egg viability may result.

At a water level of 475 masl at Lake Malawi (i.e. the no Barrage condition), the existing barrage height results in an increase of 0.32 masl to a baseline water level of 475.32 masl (i.e. the existing baseline condition). A 20 cm increase in the height of the Barrage will increase the water level to 475.52 masl resulting in the upstream inundation of an additional 309.58 ha (i.e. a 9.15% increase) of Perennial Marsh habitat above the baseline condition. A 20 cm increase in Barrage height will extend the inundation period of this 309.58 ha by 15 days above the baseline condition; whereas a 40 cm increase will extend the inundation period by 30 days.

At a water level of 476 masl at Lake Malawi a 20 cm increase in the height of the Barrage will result in the upstream inundation of an additional 1,233.27 ha (i.e. a 40.01% increase) of Perennial Marsh habitat above the baseline condition. A 20 cm increase in Barrage height will extend the inundation period of this 1,233.27 ha by eight days above the baseline condition; whereas a 40 cm increase will extend the inundation period by 18 days.

The majority of the additional Perennial Marsh habitat that will be inundated by any increase in the height of the Barrage lies within the floodplains of Liwonde National Park and has significant ecological value to the wildlife inhabiting the Park.

Perennial Marshes are essential to the maintenance of the aquatic system in this part of the Shire River as they provide breeding and rearing habitat for economically important species of fish, invertebrates and birds. They also contribute significantly the productivity of the aquatic system in this reach of the river. Perennial Marshes and Seasonal Floodplains are also important foraging areas for elephants and hippopotamus residing within Liwonde National Park (Government of Malawi, 2005).

As described in Section 5.2.1, the main vegetative types found in Perrenial Marshes are emergent species (e.g. *Cyperus papyrus*; *Typha capensis*; *Vossia cuspidate*; *Phragmites mauritianus*; *P australis*; and *Thelipterys confluens*), floating aquatics (e.g. *Azolla pinnata*; *Commelina benghalensis*; *Ipomoea aquatic*; *Nymphaea caerula*; *Nymphaea lotus*; *Pycreus mundtii*; and *Salvinia hastate*), and submerged plants (e.g. *Ceratophyllum demersum*; *Ottelia* spp; *Potamogeton pectinatus*; *P. thunbergia*; and *Spirodela polyrhiza*). While floating aquatics and submerged plants can tolerate extended periods of submergence, emergent species are less tolerant. Increasing the height of the Barrage by 20 cm results in minor increases in inundation periods above the existing baseline condition (i.e. 15 days and 8 days for the 475.5 and 476 masl scenarios modelled); this small increase in the period of inundation should be within the tolerance range of emergent aquatic species. However, increasing the barrage height by 40 cm results in significantly longer inundation periods (i.e. 30 days and 18 days for the 475.5 and 476 masl scenarios modelled), which may be outside the tolerance range of emergent species and result in a shift in species composition.

A 20cm rise in Barrage height results in minor increases in the area and period of inundation of Perennial Marsh habitat upstream of the Barrage and this is not likely to result in any significant change in species composition or structure of this habitat type. However, a 40 cm rise in height results in the inundation of a much larger area for extended periods of time which is more likely to result in a change in the species composition and structure of this habitat type within Liwonde National Park. Hence, a 40 cm rise in the height of the Barrage can only be recommended if accompanied by a monitoring program of the health/extent of Perennial Marshes within Liwonde National Park to track any changes in habitat extent or condition. This should be accompanied by an adaptive management program which regulates the operation of the Barrage in response to the findings of the monitoring program.

Downstream of the Barrage water levels above 475.5 masl primarily result in the inundation of an additional 659.9 ha (i.e. a 270% increase) Seasonal Flood Plains and 538.3 ha (i.e. a 643% increase) of Seasonal Marshes above the baseline condition. The primary impact from this will be social, as the majority of these seasonally flooded areas have limited ecological value as they have been modified by the local community to grow crops. Increased periods of inundation will effectively reduce the growing season on the fertile River margins resulting in social and economic impacts for the local community.

Increased inundation periods of Seasonal Flood Plains and Seasonal Marshes downstream of the Barrage could be an issue for nesting crocodiles and turtles. For example, the dry-season nesting period of the Nile crocodile results in hatching at the start of the wet season, increased periods of inundation at this time resulting from operation of the Barrage may destroy eggs if nests are flooded. In addition, the sandbanks in

which they nest are often deposited by wet-season water flows, if Barrage operations result in increased water flows during the early wet-season heavy rains the sandbanks can be severely eroded or washed away, inundating the eggs or washing them out into deep water.

7.2.2.2 Terrestrial Ecology Environmental Flow Requirements

The primary cause of impact to the terrestrial environment resulting from implementation of the Project will be associated with changes in environmental flows and flooding regimes. These impacts will be most pronounced in the low gradient areas of Lake Malawi, Lake Malombe and the Upper Shire River.

The Middle Shire River is characterised by a steep gradient, well defined incised river channel and riverine woodlands and escarpments. This reach of the river will be relatively immune to variations in volumes or patterns of water release from the Barrage as the channel has capacity to absorb relatively large fluctuations in water level without flooding the surrounding terrestrial habitats. This will hold true provided a minimal baseline environmental flow is maintained in the Middle Shire Reach.

It is important to maintain the seasonal flooding of the Marsh lands in order to preserve floodplain and seasonal marsh habitat and support the seasonal dimba agriculture that much of the local community relies upon for sustenance during the dry season when seasonal marshes provide temporary fertile land for cropping.

Downstream of the Barrage it is important that operations do not result in artificially prolonged inundation of crocodile and turtle nesting sites located on Seasonal Flood Plain and Seasonal Marshland during the critical nesting season from October to January.

7.2.2.3 Wildlife

Rapid assessment of the situation suggest that some of the immediate impacts that may arise from rising water levels include loss of habitat for some species due to inundation, loss of breeding areas for crocodiles and terrapins (freshwater turtles) and loss of habitat for migratory birds. A summary of impacts is provided in Tables 40 and 41. Second level impacts may involve increased competition for resources between species and human wildlife conflicts. Local communities have reported numerous incidences of Hippopotamuses trampling crops while foraging for food. Such incidences are likely to increase if further habitat losses occur as a result of the upgrading of Kamuzu Barrage and its operation.

One of the key species of conservation interest the Lillian's Lovebird is not greatly threatened by the higher water levels because most of its habitat is located upslope from the floodplain.

There may be some impacts to tourism depending on the effect of rising water levels on species as well as tourism infrastructure (such as the Liwonde NP boat landing facility just upstream of the Barrage).

TABLE 40. POTENTIAL IMPACTS ON KEY WILDLIFE HABITATS

Type	Significance	Potential Impacts
Open water	Important habitat for hippopotamus, crocodiles, terrapins, amphibians, fresh water invertebrates and other species	Loss of open water habitat may affect the distribution and abundance of these species.
Sand banks	Nesting areas for crocodiles and terrapins	Loss of these habitats will prevent these species from breeding affecting their recruitment and population growth
Sand bars	Essential roosting and nesting habitat of the globally Near-threatened African Skimmer.	Loss of these habitats will prevent these species from breeding affecting their recruitment and population growth
Reeds	Breeding areas for some birds including weavers	Loss or degradation of these habitats will affect recruitment of a number of avian species
Seasonal Floodplains	Important grazing area for many herbivores especially during the dry season when most other areas are dry and void of grass and water.	Increased inundation of short grasslands may negatively impact many herbivore species in the Project area depending on the extent, timing and duration of the inundation.
Mopane woodland	Prime habitat and breeding area for the threatened Lillian's Lovebird and also	Loss of Mopane woodland would affect the lovebird and other species. However, 70% of Liwonde National Park is

Type	Significance	Potential Impacts
	important habitat for many herbivores	covered by Mopane woodland and inundation is likely to affect only a very small portion of the woodland. As such flooding is not really a threat to the survival of Lillian's Lovebird
Emergent boulders in Shire River channel	Habitat for a localised bird species rare in Malawi, the Rock Pratincole	This is a riverine habitat found in Majete Wildlife Reserve and can be significantly affected by flooding in the Lower Shire River. The Rock Pratincole is confined to this type of habitat and is rare in Malawi.
Riverine vegetation in Majete Wildlife Reserve	Habitat for the reintroduced black rhinoceros in the reserve.	This is a critically endangered species which has been recently reintroduced into the reserve and is progressing well. The riverine habitat can be affected by flooding and hence threaten the survival of the rhinos.
Marshes and wetlands	Critical habitat for migratory birds	Palaearctic and intra African migratory birds utilize the marshes and wetlands in the Project area as winter refuge and breeding areas. The marshes and mud flats harbour invertebrates and other small vertebrates that are food to the birds. Some wetland vegetation cannot survive long term/permanent inundation resulting in a change to the habitat and ecology of the affected area.

7.2.2.4 Fish

7.2.2.4.1 Barrier to Fish Migration

Riverine fish species are generally migratory species (Welcomme 1985) mainly for breeding purposes. In the Shire River, important and commercially valuable migratory species include *Opsaridium microlepis* (Mpasa) and several Barbus species found in the Upper and Middle Shire (www.anglingmalawi.org). Mpasa has been included under the IUCN 'Red List' of endangered species. Physical barriers eliminate diadromous or obligate migrating fish species by preventing movement to upstream breeding sites by adults but also slowing down-stream movements of juveniles.

The fish fauna of the Upper and Lower Shire River are separated by natural barriers (waterfalls) downstream of the existing Barrage at Liwonde. As a result, fish species are very distinct and endemic to each geographical area. Most of the species in the Upper Shire are also found in the south east arm of Lake Malawi and Lake Malombe probably due to migration. In the Lower Shire, the fish fauna is essentially of Zambezi River Basin eco-region as more than 60 species are caught in this fishery. Out of the 60 species, only three species are of commercial importance namely, Mlamba (*Clarias gariepinus*), Chikano (*Clarias ngamensis*) and Mphende (*Oreochromis mossambicus*) (Willoughby and Tweddle, 1978). From the outflow of Lake Malawi near Mangochi downstream to Lake Malombe, the Shire River flows through a relatively flat area without any obstruction. The natural barrier to fish migration in the River is the water falls at Nkula downstream to Kapichira Falls. The distance between the Barrage (Liwonde) to the first natural barrier (falls) at Nkula is about 80 km. The gates at the Barrage at Liwonde when fully open are not an impediment to migration of fish. That is why fishermen catch a lot of migrating fish at the Barrage using Scoop and Cast nets when the gates are open.

The Liwonde National Park is an important refuge and breeding area for fish in the Shire River and Lake Malombe since the rest of the areas are subjected to intensive and uncontrolled fishing. Since the Kamuzu Barrage is located downstream of Liwonde National Park, it does not interfere with any fish migrations in the Shire River between the Park and Lake Malawi. Further, the upgraded Kamuzu Barrage would pose essentially the same type of physical barrier to fish movements as the existing one; hence no change from the status quo is expected with respect to fish migrations. The existing natural impediment (falls) at Nkula and Kapichira downstream will continue to block migration of fish from the Lower Shire to the Upper Shire. It is important to note nevertheless that downstream migration of the fish will still occur as the gates are often fully open under low flow and high flow conditions. Upstream migration may also be possible during these times since by their nature, fish prefer to swim against the water current.

TABLE 41. WILDLIFE IMPACT CORRELATION MATRIX FOR THE PROPOSED UPGRADING OF KAMUZU BARRAGE

Environmental parameters/impacts	Activities				
		Mobilization phase	Construction phase	Operation phase	Remarks
Species diversity	Large mammals	-1	-1	-1	Human activities often have a tendency of displacing large mammals even if the activities do not directly affect them but the associated disturbances do.
	Birds	-1	-1	-1	Human disturbances will displace some bird species
	Reptiles	0	-1	0	Construction activities may keep away some reptiles but would return when things calm down.
	Amphibians	-1	-1	0	Construction activities will chase away some amphibians.
	Invertebrates	-1	-1	-1	Many invertebrates including insects will possibly be affected at all stages of the Project construction and operation.
	All groups downstream	0	0	+2	Ensuring minimum adequate regular water flow downstream will enhance survival of a number of wildlife species.
Species recruitment	Crocodiles	0	0	-2	Inundated sand banks with nests will affect recruitment.
	Terrapins African Skimmer	0	0	-2	Inundated sand banks with nests will affect recruitment.
	Lillian's Lovebird	0	0	-1	Most of the Mopane woodland which is the breeding ground for Lillian's Lovebird is found in uplands which are not affected by Barrage operation.
	Rock Pratincole	0	0	-2	This bird breeds and roosts on emergent boulders in the Shire River in Majete Wildlife Reserve. Flooding has already been reported to reduce its habitat.
	Other birds	0	0	-1	Many birds especially weavers breed in the reeds and other vegetation in marshes/wetlands which do not tolerate long periods of inundation.
Wildlife movement	Hippos	0	0	-1	Barrage is a partial barrier for hippos to move upstream or downstream
	Crocodiles	0	0	-1	Barrage is a partial barrier for crocodiles to move

Environmental parameters/impacts	Activities				
		Mobilization phase	Construction phase	Operation phase	Remarks
					upstream or downstream
Seasonal Floodplains		0	0	-2	Critical habitat for herbivores during dry season
Riparian wooded habitats		0	0	-1	Important habitats for black rhino and elephants. The refurbished Barrage will only have a minor impact on riparian woodlands.
Water availability for wildlife		0	0	+3	Barrage has ensured water is available to wildlife both upstream and downstream during abnormally low flow conditions such as during droughts

Key: -1=Mild Adverse; -2=Adverse; -3=Highly Adverse; +1=Mild Beneficial; +2=Beneficial; +3=Highly Beneficial; 0=No impact.

7.2.2.4.2 Destruction of Fish Breeding Aquatic Habitats through Flooding and Siltation

Physical infrastructure such as barrages have been reported to cause habitat loss (Welcomme, 1985). Turbidity and siltation of the water increases after the water passes through the barrage gates (www.africanwater.org, 2011). Sedimentation could entail burying already made nests for spawning of the cichlids such as the Tilapine family found in the river course. Increase in silt load also accelerates the natural evolutionary processes of the river system resulting in choking of the substrate rendering it unsuitable for spawning by species requiring well aerated flows and clear pebble or gravel bottoms (Welcomme, 1985). *Opsaridium microlepis* (Mpasa) appears to be one of such species (www.Cbi.org, 2011). Heavy siltation could also affect the breeding of fish by destroying breeding nests for the spawning cichlids such as *Oreochromis shiranus* along the shoreline of the Shire River. Siltation is also a problem to reproductive success of fish species such as *O. microlepis* which requires silt free water to reproduce (www.Cbi.org).

However, water released from a dam or weir is usually low in sediment because sedimentation in the reservoir is dependent on residence time and flow rates within the reservoir. Therefore, the problem of destruction of fish breeding aquatic habitats through flooding and siltation due to the upgraded Barrage does not exist.

Further, riverine fishes generally migrate upstream to breed during the rainy season when water levels are already high. This is a time when the Barrage's influence at Liwonde on the water flow is least. Also, most fish species in the Shire River are riverine which do not build breeding nests but eggs that attach to substrates such as grass, rocks etc. Inundation of breeding areas as a result of the Barrage is therefore unlikely to be an issue.

The upgraded Barrage will also not release higher flows than the existing situation. In any case, the Barrage has no influence over natural flood flows in the Shire River system – they are beyond the operating level of the Barrage. Also any impact such as siltation will be short-lived and minor due to the potential dilution properties of the Shire River.

7.2.2.4.3 Changes in Water Flow Downstream

Operation of the Barrage gates at Liwonde has a direct effect on the flow of water in the Shire River downstream. In the Lower Shire, the River has numerous meanders hence reduced water flow may result in the progressive restriction of the stream to a smaller bed within the original channel leading to loss of habitats for fish.

Riverine aquatic organisms are usually adapted to particular water flow patterns (Welcomme, 1985) explaining why riverine fish species usually breed during flooding regimes which are also associated with more food availability and when most of the fish become sexually ripe. Sudden or periodic increased flow of water as a result of opening of the gates at the upgraded Barrage may trigger sexual maturity and consequently spawning of fish downstream especially the Lower Shire. This may eventually change the breeding pattern (timing) for other species of fish.

Water release patterns from the upgraded Kamuzu Barrage that would be generally favourable to downstream fish and fisheries include:

i) allowing some natural flooding to occur during the wet season, to stimulate natural fish reproduction and to maintain the vitality of the Elephant Marsh and other areas with important fish populations;

ii) avoiding significant daily fluctuations in flow rates, such as for peaking power (which can upset the natural cycles of fish and other aquatic life); and

iii) avoiding very sudden decreases in flows due to rapid gate closures at the Barrage since such sudden drops can cause large-scale fish stranding.

However, the upgraded Barrage will not result in a reduction of flow volume downstream but only a change in the flow pattern. Also, likely downstream impacts of the upgraded Kamuzu Barrage will depend on how water releases at the Barrage are managed, and whether there will be any appreciable difference from the status quo water release regime for the existing Barrage. The Barrage also acts as a facility to regulate flow in the Shire River so that there is no change in the total volume of water but a change in the timing of flows, i.e. there will be slightly less flow during the high flow season as more water is stored behind the Barrage and then slightly more flow during the low flow season as more water is released from the Barrage. There will

therefore be no change in the total volume of water released downstream by the Barrage, only a change in the timing and magnitude of the releases. Similarly, fishing activities will also to that effect not be affected in the Lower Shire River since water levels will not be significantly affected.

7.2.2.4.4 Impacts on Fish of Lake Malawi Particularly the Rock Dwelling Cichlids (Mbuna)

In Lake Malawi, Mbuna (beautifully coloured aquarium) fish species (Figure 34) are very common in Cape MaCLear near Monkey Bay, the area between the south-east and south-west arms of Lake Malawi.

(http://www.tropicalfishandaquariums.com/AfricanCichlids/index.asp)

Figure 34. Beautifully coloured rock dwelling Cichlids (Mbuna)

This area of the Lake is part of the protected Lake Malawi National Park. The Mbuna are more dominant in Cape MaClear where the Lake is deep and has a rocky bottom – which favour Mbuna's feeding on the rocky substrates. Though Mbuna have varied depth differences extending from the surface to more than 40 m (Lewis, Reinthal and Trendall, 1986), its population in the south east arm of Lake Malawi is insignificant. During the field survey, not even one was found in the south east arm of Lake Malawi, Lake Malombe and the Shire River. Therefore, as far as the south east arm of Lake Malawi (Area A) is concerned, the threat of the Mbuna species being impacted by the upgraded Barrage is minimal.

7.2.2.4.5 Impacts of Construction Activities on Fish and Fisheries Resources

Clearing of vegetation and earth moving works during the upgrading of the Barrage is likely to cause accelerated erosion in the Project area with sediments contaminating water in the Shire River and silting up spawning grounds on the river bed. Solid wastes and oils from construction plants and site may spill into the Shire River thereby contaminating its waters and likely to kill some aquatic organisms including fish. These impacts are expected to be short term and minor given the potential dilution properties of the Shire River. Thus such water pollution in the River will be localized and not affected the entire Shire River system.

7.2.3 Socio-economic Environment

7.2.3.1 Impacts Upstream of the Barrage

This area includes:

- Upper Shire River / Liwonde National Park
- Lake Malombe
- Lake Malawi shoreline within Malawi, Mozambique and Tanzania

The existing Kamuzu Barrage has a control range corresponding to water levels of Lake Malawi, defined as "Lake Level", between 474.4 masl (LRWL) and 475.32 masl (HRWL). This range is much less than the historical recorded water levels in Lake Malawi which show Lake levels varying from a low of 470.0 masl in 1915 to a high of 477.2 masl in 1980 (NORPLAN *et. al*. 2002).

Although Kamuzu Barrage only influences a small range of Lake Malawi levels in comparison to the natural variation of the Lake, the effect of the refurbished Barrage will be to raise the long term mean water level so that there is an increase in the time when the water level will be above the present maximum regulated water level by up to 40cm.

It is all the more difficult to predict the impacts upstream of the Barrage given that operation of the Barrage will depend on the natural Lake levels and flow in the Shire River which will vary from year to year. If the Lake

level is high, the impacts of the current Barrage or the upgraded Barrage (raised regulation level) will be minimal as this is beyond the regulation level of the Barrage; and if the Lake is low there will be a minor increase to an acceptable median level. The impacts of the Barrage (both the regulation level and the release strategy) will be tempered by the fact that the Shire River accounts for only 15% of the overall water balance of the Lake so that natural inflows, rainfall and evaporation on the Lake account for the large variations in Lake levels and not the Barrage. Therefore it is unlikely that any structures would have to be relocated as a result of the Barrage as this would depend on high water levels on which the Barrage has little or no influence.

Dimba gardening (flood recession agriculture) is an important economic activity around Lake Malombe. Next to fishing, it is the main preoccupation for households residing close to the Lake. During discussions with both district officials and community members, it was learned that dimba gardening was important in four ways: a) for winter cropping that is an important source of income and food for households, where produce from the *dimba* gardens is either consumed or sold. Main crops planted include maize and horticultural crops such as tomato and various cabbages. When sold the money is used to meet other household needs such as school fees for children, clothes and farm inputs for upland farming; (b) some land was said to be rented out to other households who also used it for winter cropping. Rentals per year ranged from USD 40.00-80.00 per hectare, per planting season; (c) some households depend on buying and reselling produce, mainly at the district headquarters. It was estimated that almost all the vegetables such as cabbage and tomato that are consumed at the Mangochi district centre comes from around Lake Malombe, and, (d) during times of drought, beyond that within the immediate surrounds of the Lake, the bulk of the population depends on dimba gardening for food and money as it becomes the only source of food.

The rates per hectare for *dimba* land vary from place to place, but range from USD120.00 to USD200.00 per hectare. For instance, the recently concluded World Bank funded Community Based Rural Land Development Project or locally known as '*kudzigulira malo*' implemented in Mangochi district was purchasing land at USD121.00 per hectare. This land was subsequently used to settle landless people.

Operation of the refurbished Kamuzu Barrage might result in spatial shifts during certain years of the land available for *dimba* (flood recession agriculture). However, the variation (amplitude) between high and low water levels along the Shire River and Lakes Malawi and Malombe will not be significantly affected by the Barrage, such that overall *dimba* cultivation will be possible more or less to the same extent as at present.

Table 42 shows the predicted change in duration of inundation of *dimba* land for different Barrage refurbishment options based on detailed flow modelling and inundation maps undertaken by the Project Design Consultant as well as vegetation mapping undertaken by SMEC. *Dimba* land was identified as two distinct vegetation units ("seasonal floodplain under cultivation" and "seasonal marsh under cultivation" as shown in Figure 31) which were mapped through field assessment and GIS application. Details of the methodology and further explanation/interpretation of results can be found in the specialist vegetation assessment report in Volume 2 of the ESIA. Figure 31 provides an example of predicted inundation areas from Lake Malawi to Kamuzu Barrage corresponding to Lake Malawi water level of 475.5 masl.

TABLE 42. PREDICTED CHANGES IN DURATION OF INUNDATION OF *DIMBA* LAND FOR DIFFERENT BARRAGE REFURBISHMENT OPTIONS

Lake Malawi Water Level (masl)[1]	Duration of Inundation[2]			"Dimba" Area Inundated (ha)		
	Existing Barrage 475.32 masl (HRWL)	Barrage 475.52 masl (20cm increase HRWL)	Barrage 475.72 masl (40cm increase HRWL)	Mponda Upstream to Kamuzu Barrage	Kamuzu Barrage Downstream to Chigaru	Total
474	68% (248 days)	68% (248 days)	68% (248 days)	0.890	71.751	72.641
475	40% (146 days)	44% (161 days)	45% (164 days)	118.249	236.534	354.783
475.5	22% (80 days)	26% (95 days)	30% (110 days)	118.249	1,586.350	1,704.599
476	8% (33 days)	12% (40 days)	15% (51 days)	785.056	2008.187	2,793.243

1 Corresponding to high flow release of 300m^3/s from the Barrage; 2 In any given year

The predictions in Table 42 indicate that there is no change in the duration of inundation of *dimba* land for the existing Barrage compared to an increase in regulating height of either 20 cm or 40 cm when the level of Lake Malawi is 474 masl. The predicted changes in duration of inundation increase at higher Lake levels and when the Barrage's HRWL is increased by either 20 cm or 40 cm although the increases do not correspond to a significant loss of opportunity in utilising *dimba* land. At a Lake Malawi water level of 475 masl there is negligible difference between a 20 cm or 40 cm increase in HRWL of the Barrage. The differences are increased slightly at Lake levels of 475.5 masl and 476 masl.

7.2.3.2 Impacts Downstream of the Barrage

Impacts in the Lower Shire River and at the confluence with the Zambezi River are likely to be minimal since the Shire River's contribution to flows is low in comparison to the other tributaries along the system. However in the River section between the Barrage and Matope, operation of the refurbished Barrage may incrementally increase flooding in some years depending on operation of the Barrage and the "natural" flow conditions in the Shire River at the time (Table 42). During the community consultation undertaken as part of the RAP study, some residents have attributed increased flooding to current Barrage operations resulting mainly in losses of crops rather than buildings/structures.

It is important to note that the current release of 300 m^3/s downstream of the Barrage is unlikely to change with the upgraded Barrage, only the time period that a certain minimum flow is guaranteed through the Barrage is increased.

An analysis of flow duration curves for differing release strategies indicates that extreme flows are rare and will be modestly impacted by the Barrage while extreme low flows are also outside the regulation capacity of the Barrage. Consequently, Barrage influence is mainly on the selected flow regime, rather than the elevation of the Barrage. Barrage operation is the main determining factor of impacts downstream.

7.2.3.3 Land Acquisition and Resettlement Impacts

Due to the fact that the high and low water levels (which signify the boundary areas for *dimba* agriculture vary each year and most such variation is natural and not attributable to the Barrage it is not feasible to identify specific PAPs upstream or downstream of the Barrage. The water-related issues faced by people upstream and downstream of the Barrage are addressed through environmental safeguards implemented through the Project's ESMP. The ESMP specifies:

- environmental and social boundary conditions for water releases from the Barrage, to help ensure that the future operating rules for the Barrage avoid scenarios that would exacerbate destructive flooding or other undesirable outcomes (to the extent the extremes of the possible release strategies would be able to cause this negative impact);
- an early warning system for short-term waves downstream of the Barrage due to (faulty) gate operation, as well as natural floods that are beyond the ability of the Barrage to control or regulate;
- a strong social communications and information-sharing program (involving university/engineering bodies/CBOs/Ministries) on natural and Barrage-induced changes in water levels. The program includes training/capacity building training sessions to ensure effectiveness and consistency;
- a monitoring program for water-related issues faced by people upstream and downstream of the Barrage to feed into a revision of operating rules for the Barrage to minimise any adverse impacts.

A land requisition and involuntary resettlement census was undertaken, following discussions with the design consultant and site visits to the area, for those within the footprint of the construction area. A total of nine affected households were surveyed in 2012. A follow-up survey in June 2013 identified another 5 small businesses as being temporarily affected. In summary it was found that:

- Shiri Lodge, located on the southern end of the Existing Barrage, will be impacted by a coffer dam and the new road bridge;
- The new weed boom will permanently affect boat access for Shire Camp.
- A small shelter, owned by the Liwonde Town Assembly, located on the western approach to the Barrage will also have to be removed prior to commencement of construction activities. This shelter

is currently being used by eight small business operators as a place to sell meat. This shed will be rebuilt following completion of the Barrage works;

- Three other small sheds in the vicinity of the shelter will also be temporarily impacted.
- A building owned by Mr Mwawa and rented to small business owners will be affected during construction.
- Land required for the weeds control facilities on both banks of the Shire River is Government owned.
- The permanent administration complex is located on land belonging to the Marine Police Unit. Also adjacent to this area is a designated tourist pick-up point used by Liwonde National Park. The Park Service has no objection to use of the site provided that an alternative site is made available as part of the Project;
- The temporary construction camp and equipment storage/staging area is located on land owned by two private developers and ESCOM. Part of the land is currently being used for maize cropping by a resident in the Marine Police Unit building;
- Minor structures such as fencing, drainage structures will also be impacted by construction activities and will need to be repaired/replaced;
- Except for a parcel of land used by Shiri Lodge, all land required for the new elevated roadway approaches to the Barrage is within the existing road reserve.

From the census survey it was found that no families will have to physically resettle as a result of construction activities for the Project, however, several small businesses will need to be relocated and/or compensated. Figure 35 shows the location of the assets and buildings to be impacted.

7.2.3.4 Land and Property Impacts due to Construction

The land required for the Project is a combination of government owned land and privately owned. Table 43 describes in summary the size, ownership and impact of the land required during the construction period. As can be seen the only private structures likely to be permanently affected are Shiri Lodge and Shire Camp. The market shelter on the approach to the Barrage is owned by the Liwonde Town Council and is currently used by eight small business operators, whilst it will be required during construction, thereby temporarily displacing those who are using it, it will be rebuilt upon the completion of the Project. From the discussions with the design consultant, another privately owned property (belonging to Mr Mwawa), currently used for a number of businesses including a grocery business and barber shop, will be affected by the Project. Three other sheds used by small businesses will also be temporarily affected and therefore have been included in the asset survey.

In terms of government owned land required for the construction of the Project, this includes the land for the temporary work camp, the weed anchorage points, the administrative building and the road reserve.

The temporary work camp is currently an undeveloped site owned by ESCOM and two private developers. Recent site visits have found that the plot of land is being cultivated with maize, this cropping is opportunistic use of the site. The current crop will not be impacted by the Project, however measures need to be taken to ensure that those who are currently using the site are not cultivating maize when the Project commences.

The area for weed anchorage points will need to acquired, with the majority of land only needing to be required temporarily. These are owned by Ministry of Transport and Public Works on west bank and Liwonde National Park on the east bank. The east bank site has been used as pick up point for tourists; current plans are considering moving the tourist point further upstream but within the same plot of land. Details of land requirements are presented in Table 43.

Although the Project will not physically impact on Shire River Camp buildings and site owned Mr. Billy Mphande, the construction of the weed boom will permanently affect the boat safari business by blocking boat access. Mr Mphande conducts boat tours upstream of the Shire Camp along the Shire River to Liwonde National Park.

The site of the Marine Police Unit building will be affected by the permanent administration block for the Barrage. However, it is planned that the new office building will have provision to house the Marine Police Unit premises.

TABLE 43. SUMMARY TABLE OF CONSTRUCTION AFFECTED STRUCTURES, LAND AND PROJECT AFFECTED PEOPLE

Site	Land Requirement (m^2)		Ownership	Affected Structures (number and type)		Affected People		Comment
	Total	Temporary/ Permanent		Temporary	Permanent	Temporary	Permanent	
Barrage Approaches East Bank	3,500	3,500 required for construction 1,600 permanently	This land is officially road reserve owned by the Ministry of Lands. However, 3,168 m^2 has been encroached upon by the Shiri Lodge	-	Reception building, bar, house, gate house and old restaurant	-	Owner of Lodge	Part of the structure will have to be demolished on road reserve side and also on the river side to provide for the construction of coffer dams and manoeuvrability of construction equipment. The part of the lodge that has to be demolished has been illegally built on government owned road and river reserve.
Barrage Approaches West Bank	2,500	2,500	Road Reserve Liwonde Town Council Mussa Mabuka Innocent Sanudi Adine Daudi	Building owned by Mr Mwawa Market shelter (40m^2) Bicycle shed Chip shed Meat roasting shed		Mr Mwawa' building and tenants Liwonde Town Council and tenants- this shelter is currently being used by 8 community members to operate their private business.		Construction activities will temporarily affect access to Mr Mwawa' building. The shelter will be demolished during construction and then rebuilt. The Liwonde Town authorities have identified a piece of land opposite the National Bank Building where a new shelter will be constructed. The three sheds will be rebuilt after construction is complete.
Permanent Administration Centre	3,500	154	Marine Police Unit, Liwonde	Marine Police Unit Building	-	-		Proposed design makes provision for the Marine Police Unit to be accommodated within the new administration complex.
Weeds Control West Anchor	6,000	6,000 Temporary	Ministry of Transport and Public Works	Fencing around the site.	Boat landing jetty, campsite owned by Shire Camp	-	Owner of Shire Camp	The anchor will be underground and the surface will be restored to original state after construction. Impacts are temporary. The weed boom will permanently affect boat access for Shire Camp owned by Mr Mphande.

Site	Land Requirement (m^2)		Ownership	Affected Structures (number and type)		Affected People		Comment
	Total	Temporary/ Permanent		Temporary	Permanent	Temporary	Permanent	
Weeds Control East Anchor	7,200	3,400 Permanent 3,800 temporary	Liwonde National Park	-	Tourist boat landing	-	-	National Parks requires provision of alternate site for tourist boat landing. This will be provided under Project mitigation funding.
Temporary Contractor Site	24,460	24,460 temporary	ESCOM (3,500m^2) Mr. Lucius Banda (10,098m^2) Daniel Chipeta (2,500m^2)	None	None	ESCOM Mr. Lucius Banda Daniel Chipeta	-	ESCOM only owns one out of 4 or 5 plots, which have not yet been formally allocated to prospective developers. The town council can delay the allocation of these plots until after the completion of the Project. ESCOM can also be requested to delay the commencement of their development. Mr Lucius Banda owns undeveloped land which would be temporarily affected. Officers from the Marine Police Unit are cultivating the land because it was still undeveloped. The officers said to be using the land during the rainy season.

Source of map: Design Report (NORPLAN and Associate, 2012a) and SMEC.

Figure 35. Barrage construction and work sites and location of businesses impacted by the Project.

7.2.3.5 Livelihood Impacts

Within the construction footprint there are 14 households/ businesses that are affected by the Project construction (See Table 44). These are all within the Barrage approach areas except for Shire Camp which is located on the western bank of the Shire River between the Barrage and the western anchor point for the weed boom (Figure 35). These include the eight households currently using the market shelter owned by the Liwonde Town Council as a site for their business as butchers, three sheds used for small businesses, the owner of the Shiri Lodge as well Mr Mwawa who operates a grocery and barber shop and the owner of Shire Camp Mr Billy Mphande. With the exception of the Shiri Lodge and Shire Camp, the impacts on the other households/ businesses will be temporary. Those businesses located within the road reserve, those using the market shelter and those using Mr Mwawa's building will be relocated for the duration of the Project.

Those using the market shed for business have been using the site for anywhere between 3-6 years, Mr Mwawa has been using his building for 8 years and Shiri Lodge did not respond. Each of these businesses has between 2-7 employees.

The income sources of the affected households are shown in Table 44. Three businesses have an income range from 30,000-40,000 MWK per month and four businesses have a monthly income of above 50,000 MWK per month, one business has a monthly income of 1,500,000 MWK per month, and one did not respond. There are eight households who are operating as shop owners selling meat, one as a barbershop and grocery store and one operating a hotel/ restaurant. All of the households interviewed are headed by men.

There are also a few small businesses located on the Barrage approach, who were not surveyed and are unlikely to be affected directly but access to their businesses during the construction period will need to be ensured.

7.2.3.6 Impact on Crops

The construction of the Project will not impact on any permanent cropping areas. Within the households surveyed, none had any grazing land.

Within the sites to be affected, the land allocated for the temporary work camp, owned by ESCOM is currently cultivated with maize. The current crop will not be impacted by the Project, however measures need to be taken to ensure that those who are currently using the site are not cultivating maize when the Project commences.

7.2.3.7 Impacts on Access to Services

In the PAP census it was found that all households that responded to this section of the survey had access to services, such as health units, schools government and private hospitals. Within those who responded all used piped water as their water sources and charcoal and firewood for cooking. The resettlement process for this Project will not impact upon the surveyed households' access to these services.

7.2.3.8 Impacts on Poor and Vulnerable Groups

To ensure fairness within the resettlement process, poor and vulnerable groups were considered and assessed within the PAP census. The categories assessed were:

- Unmarried women or Female headed households
- The elderly
- HIV and AIDS- infected and Affected and Chronically ill persons
- Orphans and Child Headed Households
- Small Scale Farmers
- People with Disabilities

Within those assessed there were no household heads identified as falling within this category.

TABLE 44. SOCIOECONOMIC CHARACTERISTICS OF BUSINESSES AFFECTED BY CONSTRUCTION

No	Name of business owner	Type of activity	No. of employees	Description property affected	Tenure status (titled owner, owner without documents, tenant, sharecropper, etc.)	Monthly income average	Place of selling	Duration (years) of business in affected location	Comments
1	Damiyano Makina	Butcher	3	Concrete/ brick wall and floor, corrugated iron roof	Tenant (building owner Liwonde Town Council)	30000-40000	Liwonde, Balaka	6	Temporarily affected. Site can be rebuilt following construction
2	Joseph Master	Butcher	3	Concrete/ brick wall and floor, corrugated iron roof	Tenant (building owner Liwonde Town Council)	Above 50000	Liwonde, Balaka	6	Temporarily affected. Site can be rebuilt following construction
3	Inusa Matola	Butcher	7	Concrete/ brick wall and floor, corrugated iron roof	Tenant (building owner Liwonde Town Council)	Above 50000	Liwonde, Balaka	6	Temporarily affected. Site can be rebuilt following construction
4	Symon Laison	Butcher	2	Concrete/ brick wall and floor, corrugated iron roof	Tenant (building owner Liwonde Town Council)	30000-40000	Liwonde, Balaka	3	Temporarily affected. Site can be rebuilt following construction
5	Moote Jackson	Butcher	2	Concrete/ brick wall and floor, corrugated iron roof	Tenant (building owner Liwonde Town Council)	30000-40000	Liwonde, Balaka	3	Temporarily affected. Site can be rebuilt following construction
6	Francis Phiri	Butcher	2	Concrete/ brick wall and floor, corrugated iron roof	Tenant (building owner Liwonde Town Council)	Above 50000	Liwonde, Balaka	3	Temporarily affected. Site can be rebuilt following construction
7	Shaibu Matemba	Butcher	Not provided	Concrete/ brick wall and floor, corrugated iron roof	Tenant (building owner Liwonde Town Council)	Not provided	Liwonde, Balaka	Not provided	Temporarily affected. Site can be rebuilt following construction
8	Aufi Daudi	Butcher	Not provided	Concrete/ brick wall and floor, corrugated iron roof	Tenant (building owner Liwonde Town Council)	Not provided	Liwonde, Balaka	Not provided	Temporarily affected. Site can be rebuilt following construction
9	Mussa Mabuka	Bicycle shed	Not provided	Concrete/ brick wall and floor, corrugated iron roof	Owner	Not provided	Liwonde, Balaka	Not provided	Temporarily affected. Site can be rebuilt following construction
10	Innocent Sanudi	Chips shed	Not provided	Concrete/ brick wall and floor, corrugated iron roof	Owner	Not provided	Liwonde, Balaka	Not provided	Temporarily affected. Site can be rebuilt following construction

No	Name of business owner	Type of activity	No. of employees	Description property affected	Tenure status (titled owner, owner without documents, tenant, sharecropper, etc.)	Monthly income average	Place of selling	Duration (years) of business in affected location	Comments
11	Adine Mponde	Meat roasting	Not provided	Concrete/ brick wall and floor, corrugated iron roof	Owner	Not provided	Liwonde, Balaka	Not provided	Temporarily affected. Site can be rebuilt following construction
12	Felix Mwawa	Shops and house	2	Concrete/ brick wall and floor, corrugated iron roof	Owner	Above 50000	Liwonde, Balaka	8	Temporarily affected. Access to site may be impacted during construction
13	Steve Njovuyalema Moyo	Hotel/ Restaurant	Not provided	Concrete/ brick wall and floor, corrugated iron roof	Owner Shiri Lodge	Not provided	Liwonde, Machinga	Not provided	Part of the structure will be permanently affected.
14	Billy Mphande	Accommodation / Boat Tours	15	Boat access affected by weed boom	Owner Shire Camp	1,500,000	Liwonde	9	Weed boom will permanently affect boat access for the Camp

Source: PAP census, February 2012.

7.2.3.9 Impacts on Tourism

In the Liwonde National Park average higher dry season water levels are expected to increase the back flooding up tributary channels. Modelling of impacts on riverine vegetation has shown that this increase will only be minimal. However, the main constraints to tourism occur during the wet season, when the Shire River level is well above the regulating capabilities of Kamuzu Barrage. Within Lake Malawi, higher water levels may temporarily disrupt sewage soakaways and result in a slightly higher number of occasions when infrastructure and beaches are susceptible to flooding as a result of high rainfall events which raise the Lake's water level. The overall impact is expected to be minor.

The existing National Parks boat landing immediately upstream of the Barrage on the east bank of the Shire River will be removed so the permanent operation centre can be constructed. It will need to be relocated elsewhere in the vicinity.

7.2.3.10 Loss of Heritage Items

The loss of heritage items such as gravesites, religious and cultural sites was considered and assessed during the census of the area impacted by the construction of the Barrage. It was found that the construction of the Project will not impact any site falling under this category.

7.2.3.11 Construction Impacts

Construction activities are likely to generate a range of temporary impacts that will be adverse to the living and health conditions of affected communities. These impacts include:

- an increase in dust levels and air pollution due to blasting and excavation, preparation of construction materials, increased vehicular traffic and stockpiling of material;
- an increase in noise levels due to drilling and blasting, quarrying, general earthworks and vehicular traffic;
- safety risks to communities close to the Barrage due to increased vehicular traffic, blasting and excavations;
- Communities living close to the Kamuzu Barrage have developed a habit of using the bridge as a business point as well as a recreation site. This creates a very conducive environment for traffic accidents. To make the situation even worse, pedestrians, bicyclists and drivers generally do not follow the traffic laws and regulations. Although the Barrage provides a major access road which is important locally and regionally, the road is narrow and traffic separation between road users is very poor. During construction, an increase in traffic will further increase the incidences of accidents if traffic precautions are not enforced.
- Construction traffic is also likely to cause increased likelihood (both of frequency and severity) of collisions between vehicles and livestock and will need to be managed through traffic management plans.
- damage to private property due to construction activities; for example, blasting operations and impact rollers; and
- impacts on livestock farming practices during the construction period (e.g. use of grazing areas for borrow areas).

Experience from large-scale infrastructure projects also shows that the presence of a construction workforce drawn from outside the area may have a number of effects on the local social environment including:

- greater demand for, and pressure on, social services and facilities (e.g. health, education and water supply facilities and systems);
- increases in the incidence of diseases (e.g. sexually transmitted diseases and tuberculosis) from influx of workers;
- clashes between the workforce and local communities over construction jobs; civil disturbances; and

- disturbances to the social practices and fabric of local communities (e.g. influx of job seekers; development of informal settlements; changes to the position of women and vulnerable groups; pressure on local authorities to maintain autonomy).

The occurrence and significance of these impacts are a function of workforce size and composition: the larger and more foreign the workforce, the higher the anticipated social disturbances. The "development status" of local communities, similarly, determines the extent to which social disturbances may occur: the more isolated and underdeveloped the area, the higher the anticipated disturbances. The workforce at the Barrage site will not be large in terms of the local population and is therefore unlikely to have significant effects on local communities. A strategy will be implemented to enhance the employment of local community members on the construction works. Nonetheless, some of the impacts referred to above will still occur and for individuals and households affected by them, the disturbances could be significant.

7.2.3.12 Construction Impacts on Health

Local communities and Project workers will be exposed to a number of biophysical health risk factors (e.g. noise, dust, chemicals, construction material, solid waste, waste water etc.). While the majority of these mentioned in this Section relate to the construction phase, some of them will continue into the operation phase of the Project (when the number of employees will be considerably reduced).

It is essential that the official regulations regarding occupational health be applied and monitored in order to ensure the safety and well-being of the local population and Project workers.

Other health issues relate to the increased risk to local residents of social disruption and road accidents during the construction phase and a temporary increased demand on health services during the construction period and subsequently if the local population increases. Influx of workers will also potentially bring health risks.

7.2.3.12.1 Emissions to Air

Dust

Dust and sand can be expected to be the main emission to air during the construction phase of the Project, caused by heavy traffic, excavation, blasting and crushing activities.

Combustion Gases

The construction machinery, trucks, vehicles etc. will produce substantial amounts of combustible gases.

Emissions to Soil / Waste Management

Emissions to soil are caused mostly by disposal of oils, chemicals, solid waste and waste water. During the construction phase machinery and vehicles will use large amounts of gasoline, diesel oil, oils and other petroleum products and chemicals which need to be disposed safely, preventing abuse and emissions into the soil, possibly also contaminating the ground water and surface water resources.

Biological wastes

The presence of construction workers on site will generate biological waste (solid waste and waste water) particularly at the workers' camp site. Adequate sanitary facilities have to be established, and the solid waste and waste water removed without contamination of the environment.

WHO recommends the following measures to ensure basic hygiene and sanitary workplace conditions[1]:

- Sufficient toilets for both men and women with complete sanitary fixtures;
- Safe and clean potable water for drinking and hand washing, with sanitary detergents;
- Adequate amount of water for washing facilities and sanitation;

[1] Regional guidelines for the development of healthy workplaces. World Health Organizations, Regional Office for the Western Pacific, 1999.

- Workplaces regularly cleaned, with proper management of garbage disposal (liquid, solid and recyclable waste) according to health standards.

7.2.3.12.2 Emissions to Water

Emissions to water during the construction phase will mostly involve the potential pollution of groundwater and Shire River waters through emissions to soils. The factors more likely to be affecting water quality are animal and human wastes and sediment inputs. Potentially phosphorus might be elevated by the use of detergents for washing clothes but the overall quantities will be small.

7.2.3.12.3 Noise

This category includes primarily the noise generated at quarries, borrow areas, spoil disposal areas, crusher site, construction sites and on access roads during the construction phase.

There are three main sources for high levels of noise, the crusher site, Barrage site and traffic. The crushers might generate up to around 120 dB(A). The measurement most often used is the average equivalent sound pressure level (Leq) per unit time (e.g. 24 hours) using a logarithmic decibel scale (the noise intensity doubles with any increase of 3 decibels (dB))[2]. For the public, excessive exposure to noise can lead to sleep interference, communication difficulties, effects on the performance and behaviour of students and a feeling of annoyance that undermines quality of life.

WHO recommends an outdoor noise limit of 55 dBA Leq during the day and 45 dBA Leq during the night. In industrial areas or work environments, a level of 75 dBA Leq (8 hours) is considered acceptable.

7.2.3.12.4 Road Safety

Construction will require heavy traffic both with trucks and vehicles. The subsequent increase of traffic could cause accidents for the following reasons:

- Higher traffic flows;
- The population is not used to the construction related traffic and will have to adjust to new conditions;
- Machinery and trucks may attract children out of curiosity.

7.2.3.12.5 Indirect Effect of Construction and Presence of Workers

Any (temporary) migrating large group of people is, compared to the “local” population, bound to cause some indirect effects which might impair income/purchasing power of the population. Market prices on accommodation and food are likely to inflate and may drive “near poor” families” into poverty with subsequent consequences for their health status and ability to access health services.

The main part of the migrating workers will be men. Usually this attracts the business of sex workers in spite of cultural or religious barriers. These barriers will probably not inhibit sex work entirely, but might lessen its negative health impact.

7.2.3.12.6 Water Borne / Vector Diseases

When the upgraded Kamuzu Barrage becomes operational, the main potential source of concern to health is in relation to the chemical and biological quality of the water distributed for consumption, as well as changes in the water impounded upstream in Lake Malombe, Shire River and Lake Malawi and released downstream of the Barrage. These may result in changes in the risk of water-borne, water-washed and vector-borne

[2] For example, the noise level produced by construction work: breaking concrete pavement with a pneumatic drill in excess of 100 decibels (dB) - levels which, unprotected, should not exceed more than a few minutes (or less) per day. Prolonged engine noise of high amplitude (>80 dBA) and/or low frequency can result in early (severe headache) or delayed (e.g., hearing loss) detrimental effects (truck drivers).

diseases. For biological and climatic reasons, the most often raised vector-borne diseases in relation to barrage construction are malaria and bilharzias.

In the Kamuzu Barrage area, the greatest risks to human health are from temporary ponds and pools created during the seasonal shrinkage of Lake Malombe, which become mosquito (vector for malaria) breeding habitat and can also be polluted by unsanitary disposal of human waste. The habitat of intermediate host species like the snails which host schistosomiasis may also expand from increased plant growth. The refurbishment and operation of Kamuzu Barrage may increase the incidence of these diseases amongst people living close to the Shire River and Lakes Malawi and Malombe, by expanding the habitat of the animal vectors of these diseases. Also, as a side effect of collection sites of construction material (from borrow areas, quarries) the possible water points could be new and additional sites for breeding of disease vectors.

Another potential impact on human health from domestic use and primary contact is an increased risk of gastro-intestinal diseases from faecal contamination of surface water, if sewage and sanitation of new construction worker accommodation is inadequate.

Malaria

The Kamuzu Barrage area is recognised for the high incidence of malaria compared to other parts of Malawi. It is possible that mosquitoes will find more breeding sites upstream of the refurbished Barrage particularly along the shores of Lake Malombe which is characterised by its shallow sandy shorelines which provide suitable mosquito breeding areas.

Schistosomiasis

It is possible that the infestation of the waters with schistosomiasis will increase due to the larger surface area and subsequent extended length of shoreline.

7.2.3.13 Food Security

People generally depend on agriculture for their livelihood, although those close to Lakes Malawi and Malombe and the Shire River also fish. Livestock keeping is also practiced with the most common livestock kept being chickens followed by goats. Cattle are not widely kept. Crops such as maize, groundnuts, rice millet, sorghum, bananas and other fruits were observed grown on small farms. Other non-cereal crops such as cassava are also grown. Cotton is grown as a cash crop.

It should be noted that direct impacts on agricultural activities are likely to be minor because the Barrage is already in place, it will only be upgraded and modernised. The refurbishment of the Barrage (as opposed to construction of a new one) is unlikely to have a significant negative impact on agriculture although access to some riparian land used for farming during the dry season (*dimba* agricultural land) may be lost. Also during construction there will be an increase in the population due to the increased number of Project workers who will require food resulting in a higher demand for agricultural products. The increase in agricultural products could be taken as a positive impact because this will increase prices of agriculture outputs and widen the market for farm produce and fish.

On the other hand more production of food is required to meet the demand and people will be required to keep adequate stock for food security for household consumption. Increased consumption will also place greater pressure on local food resources and Lake Malombe is already heavily overfished.

7.2.3.14 Waste Management

A considerable amount of solid waste will be generated from the old Barrage gates and these will need to be removed from site and disposed either by recycling as scrap or disposed in an approved manner. Similarly, removal of the old weed “boom” will also result in solid waste which will need to be disposed in an environmentally acceptable manner. Any material should be disposed well away from any watercourses in case it includes weed material.

7.2.3.15 Interaction with other Development Plans

A number of programs and initiatives are taking place within the Project area. These include the District Development Plans (which contain irrigation development programs) and the Green Belt Initiative. The

upgrading of Kamuzu Barrage is also a sub-project of the SRBMP which contains catchment management and forest conservation activities (refer to Section 1.1).

7.2.3.16 Displacement of Fishing away from the Barrage

The team observed that there are fishers who fish directly from the Barrage. During Project construction these people will not be able to fish directly from the Barrage, although they will still have access to fishing opportunities very close by and thus do not qualify as being displaced. Fishing from the upgraded Barrage should not be permitted since it is a hazardous practice that can interfere with normal Barrage operation.

7.2.4 Induced and Cumulative Impacts

The planned upgrading of the Kamuzu Barrage is fully justified, based on existing developments and infrastructure downstream. These existing investments include multiple hydropower stations in the middle Shire River, the Walkers Ferry pump station that provides drinking water to the city of Blantyre, and the large SUCOMA Sugar Estates as well as other irrigation developments. The question arises, nonetheless, whether the increased water regulation made possible by the upgraded Barrage would stimulate major new downstream investments. As part of the Government's "Green Belt" irrigation initiative, a large-scale irrigation project is in the early planning stages; at full development, it could encompass up to about 40,000 ha of cultivation in the lower Shire Valley. However, there are questions about the trade-offs between irrigation and hydropower in particular. Operating rules to be developed under the SRBMP would determine whether the relatively modest increment in potential Shire River regulation from the upgraded Kamuzu Barrage would be sufficient to make new large-scale irrigation in the Shire Valley more viable from a water balance standpoint. In any case, any proposed new large-scale development would need to be evaluated on its own merits, with a separate environmental and social impact assessment.

7.2.4.1 Reduced Economic Activity after Project Construction

Owners of businesses providing goods and services to the Project and Project workers will lose income after the Project is completed.

Table 45 provides a summary of the above predicted impacts from the Project including the relative significance of each impact based on scale, duration, severity, certainty and direction.

TABLE 45. SUMMARY OF PREDICTED IMPACTS

Environmental Impact / Issue	Project Phase	Impact Criteria					Significance	Mitigation / Enhancement
		Scale	Duration	Severity	Certainty	Direction		
Physical Environment								
Changes to micro-climate upstream	O	L	LT	L	L	P	N	N
Soils (floodplain, erosion; soil removal from construction activities)	C, O	L	LT	L	HL	N	L	Y
Inundation of commercial mineral resources	C, O	L	LT	L	P	N	N	N
Water resources								
Modified flows in Shire River	O	R	LT	L	HL	N	L/M	Y
Erosion of downstream river banks	O	L/R	LT	M	D	N	M	Y
Raising groundwater levels	C, O	L	LT	L	L	N	L	N
Water quality changes								
Lake Malawi	O	L	LT	L	P	N	N	N
Lake Malombe	O	L	LT	M	L	N	M	Y

Environmental Impact / Issue	Project Phase	Impact Criteria					Significance	Mitigation / Enhancement
		Scale	Duration	Severity	Certainty	Direction		
Shire River upstream of Barrage	O	L	LT	L	P	N	N	Y
Shire River downstream of Barrage	O	R	LT	L	L	N	L	Y
Biological Environment								
Loss of riparian vegetation (inundate floodplain areas of Liwonde NP)	C, O	R	LT	M	D	N	M	Y
Removal of floating aquatic weeds	O	R/N	LT	M	D	P	H	Y
Disposal of aquatic weeds	O	L	LT	M	D	N	M	Y
Wildlife (loss of habitat)	C, O	R	LT	M	D	N	M	Y
Inundate emergent boulders in Shire River (Rock Pratincole)	O	N	LT	L	P	N	M	Y
Inundate sand banks along Shire River and Lake foreshores (crocodiles, turtles)	O	R	LT	L	P	N	M	Y
Inundate sand bars within Shire River channel (African Skimmer)	O	I	LT	L	P	N	M	Y
Fish	O	R	LT	L/M	L	N	L/M	Y
Habitat loss in Lake Malawi (Cichlids)	O	I	LT	L	P	N	L	N
Loss of habitat in Lake Malombe	O	L	LT	L	P	N	M	Y
Barrier to fish movement upstream	O	R	LT	L	D	N	L	N
Socio-Economic Environment								
Increased regulated flows for more reliable hydropower generation	O	N	LT	M	D	P	H	N
National economy – more reliable power	O	N	LT	M	D	P	H	N
Local economic benefits (Project employment, increased trading)	C,O	L	LT	M	L	P	M	Y
Land Resources								
Temporary loss of access/use of Temporary Contractor Site (affects ESCOM+2 private landowners)	C	M	S	M	D	N	M	Y
Permanent loss through inundation (cultivation/grazing land)	O	L	LT	L	D	N	L	Y
Livelihoods (small businesses near Barrage)	C, O	L	S	H	D	N	H	Y
Livestock farming (loss of pasture land)	C, O	L	LT	M	L	N	M	Y
Lake Malawi transport – flooding of jetties	O	L	LT	L	P	P	L	N
Pedestrian / vehicle access across Barrage	C, O	R	LT	H	D	P	H	Y
Vulnerable groups – impact on livelihood	O	L	LT	L	P	N	L	Y
Downstream irrigators along Shire River	C	R	LT	M	HL	P	M	Y
More reliable town water supplies	O	R	LT	M	P	P	M	Y
Tourist facilities								
Inundation of infrastructure upstream	O	N	LT	L	P	N	L	N

Environmental Impact / Issue	Project Phase	Impact Criteria					Significance	Mitigation / Enhancement
		Scale	Duration	Severity	Certainty	Direction		
Construction site (Barrage) – affects Shiri Lodge, Shire Camp and NP boat landing	C, O	L	LT	H	D	N	H	Y
Health								
Air pollution at construction sites	C	L	S	L	L	N	L	Y
Improved potable water supply	O	R	LT	M	P	P	M	Y
Pollution from waste disposal work sites	C, O	L	LT	L	L	N	L	Y
Noise pollution (close to work sites, 2.5 year construction period)	C, O	L	S	L	D	N	L	Y
Increased communicable diseases (HIV/Aids, etc.) from influx of workers)	C	L	LT	M	P	N	L/M	Y
Community safety – increased traffic	C	L	S	L	P	N	L	Y
Increase in water born / vector diseases	C, O	R	LT	M	HL	N	M	Y
Technical disaster scenarios								
Barrage failure	O	R	S	H	P	N	M	Y
Downstream flooding	C, O	R	S	M	P	N	M	Y
Fire, explosion, chemical spill	C,	L	S	M	P	N	N	Y
Waste management from existing Barrage gates and existing weed boom	C	L	S	M	D	N	L	Y
Inundation of cultural resources	C, O	L	LT	L	P	N	N	Y

Legend:

Project Phase: Pre-construction, Construction or Operation

Scale: Physical scale / area over which the impact will be felt: Local, Regional, National or International

Duration: The length of time the impact is likely to occur: Short, Medium or Long Term

Severity: The intensity of the impact: Low, Medium or High

Certainty: The probability of the impact occurring: Possible, Likely, Highly Likely or Definite

Direction: Whether the impact is Positive (beneficial) or Negative (adverse)

Specialist Study Whether a specialist study is required (Y) or not (N)

Significance: Based on the above criteria, an overall rating of significance of the impact: Nil or Negligible, Low, Medium, High or Very High

The significance of the impacts on the issues mentioned range from low to very high according to level of operations. However, most of the construction impacts are localized and of temporary nature. For these issues, precautionary measures and quick response are necessary to contain negative impacts.

8 Environmental and Social Monitoring and Management

This Section is a summary of the stand-alone ESMP. It includes the following:

- Proposed environmental management measures during pre-construction, construction and post-construction (operation) stages of the Project. For each environmental impact, the corresponding mitigation measure is identified along with the location, timing and responsibility for its implementation and monitoring.
- Institutional arrangements for implementation of the ESMP.
- An outline of an environmental training program for Project proponent and contractor staff.
- Monitoring details, including monitoring indicators and a monitoring plan together with an estimate of costs.
- Reporting procedures including reporting timeframes.

8.1 Environmental Management Measures

This Section summarises the mitigation measures, monitoring and institutional arrangements for the environmental management of the Project. 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 Malawi. To ensure the effective implementation of the ESMP it is essential that an effective monitoring program be designed and carried out. The environmental monitoring program provides such information upon 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. The ESMP incorporates this Report's recommended measures for managing the environmental and social impacts expected from the Kamuzu Barrage upgrading.

8.2 Mitigation Measures

Mitigation is "the elimination, reduction, or control of a project's adverse environmental effects, including restitution for any damage to the environment caused by such effects through replacement, restoration, compensation, or any other means". Project mitigation measures are outlined in Table 47. The Table includes details on timing, location and responsibility for each mitigation measure.

8.2.1 Physical Environment

River stabilisation works immediately downstream of the Barrage are part of the construction works contract to prevent further erosion of the River bed and banks during high flow releases from the Barrage and during natural flood flows in the Shire River. Monitoring of Shire River banks and lake foreshores is also recommended to ensure Barrage operation is not causing erosion. River bank erosion is a problem in some parts of Liwonde National Park.

Water quality protection measures will be adopted by the construction Contractor to ensure temporary water quality impacts are suitably managed during the construction phase especially as large quantities of excavation and fill materials are involved in the temporary use of coffer dams within the Shire River at the Barrage site. The Project Construction Bidding Documents specify erosion control and drainage structure requirements to be implemented by the Contractor at construction sites.

Government enforcement of protective buffer zones along waterways would help to improve water quality. Existing buffer zones are not uniformly enforced and there is confusion over the width of buffer zones.

The Design Consultant has recommended a seismic study be undertaken and this needs to be completed prior to construction to allow for any design modifications to ensure the refurbished Barrage is not at risk of structural failure.

8.2.2 Biological Environment

8.2.2.1 Environmental Flow Requirements

The primary cause of impact to the fringing terrestrial habitats resulting from implementation of the Project will be associated with changes in environmental flows and flooding regimes. These impacts will be most pronounced in the low gradient areas of Southern Lake Malawi, Lake Malombe and the Upper Shire River.

The Middle Shire River is characterised by a steep gradient, well defined incised river channel and riverine woodlands and escarpments. This reach of the river will be relatively immune to variations in volumes or patterns of water release from the Barrage as the channel has capacity to absorb relatively large fluctuations in water level without flooding the surrounding terrestrial habitats. This will hold true provided a minimal baseline environmental flow is maintained in the Mid Shire Reach.

It is important to maintain the seasonal flooding of the marshlands in order to preserve floodplain and seasonal marsh habitat and support the seasonal *dimba* agriculture that much of the local community relies upon for sustenance during the dry season when seasonal marshes provide temporal fertile land for cropping.

Downstream of the Barrage it is important that operations do not result in artificially prolonged inundation of crocodile and turtle nesting sites located on Seasonal Flood Plain and Seasonal Marshland during the critical nesting season from October to January.

In order to minimise the impacts of the Project to fringing habitats, the Barrage should be operated to mimic the natural seasonal flooding regime of the Shire River, Lake Malombe and the lower part of Lake Malawi, as closely as possible. This is particularly critical when the Barrage is operating at levels resulting in water levels of 475 masl and above at Lake Malawi.

Annual simulation of natural flood events down the Shire River will help maintain terrestrial and aquatic processes within the Elephant Marsh. The simulation of a natural flood will significantly improve the situation over the baseline (there were no adequate flood releases from Liwonde during the period 1993 – 2002, apart from 1997).

A typical annual hydrograph for the Shire River is shown in Figure 36; peak flows typically occur in February and March while minimum flows are experienced during the dry season in September and October.

The proposed Project to raise the height of the Barrage will increase the existing HRWL of 475.32 masl in Lake Malawi by 20-40 cm i.e. 475.52 – 475.72 masl (which is within the historical range of Lake levels, with a high of 477.25 recorded in 1980). Modelling shows that there will be a minimal change in the area of habitat inundated and the period of inundation associated with a 20 cm increase in barrage height. However, a potentially significant increase in the area of inundation and the inundation period is possible upstream of the barrage if the height is raised by 40 cm. This may significantly impact important Perennial Marsh habitat located on the floodplain within Liwonde National Park adjacent the Shire River. It is recommended that if the Barrage is raised by 40 cm, a Perennial Marsh habitat monitoring program is implemented within the boundaries of the Park and an adaptive management program is adopted whereby the operation of the Barrage is regulated in response to the findings of the monitoring program.

It is also recommended that if levels need to be increased above 474.5 masl then the Barrage should be operated to mimic the seasonal flooding patterns of the system i.e. levels of 475.5 masl permitted during the wet season only (December – April); maintain levels below 475.5 masl during the dry season (May – October).

This operational regime will also minimise the incidences of prolonged (i.e. greater than existing levels) inundation of Seasonal Floodplain and Marshland habitats downstream of the Barrage. This habitat type may support crocodile (and turtle) nesting, during the critical incubation period lasting from October to December (Compass, 2000).

Lake Malombe

The Feasibility Study for the Shire River Flow Augmentation Project (NORPLAN *et. Al*., 2002) recommended that water levels in Lake Malombe should not fall below 473 masl to protect fisheries within the Lake. In the absence of further ecological studies of the Lake, it is reasonable to apply this figure in relation to operation of the refurbished Kamuzu Barrage.

8.2.2.2 Mitigation of Impacts on Liwonde National Park

It is critical that management of the upgraded Barrage takes into account how their actions affect the National Park. Rapid opening and closure of the barrage gates, high flood levels and dampening of the natural rise and fall of seasonal water levels all have short and long-term implications for the Park. Park management should be integrated into the institutional structures responsible for management and monitoring of the Barrage.

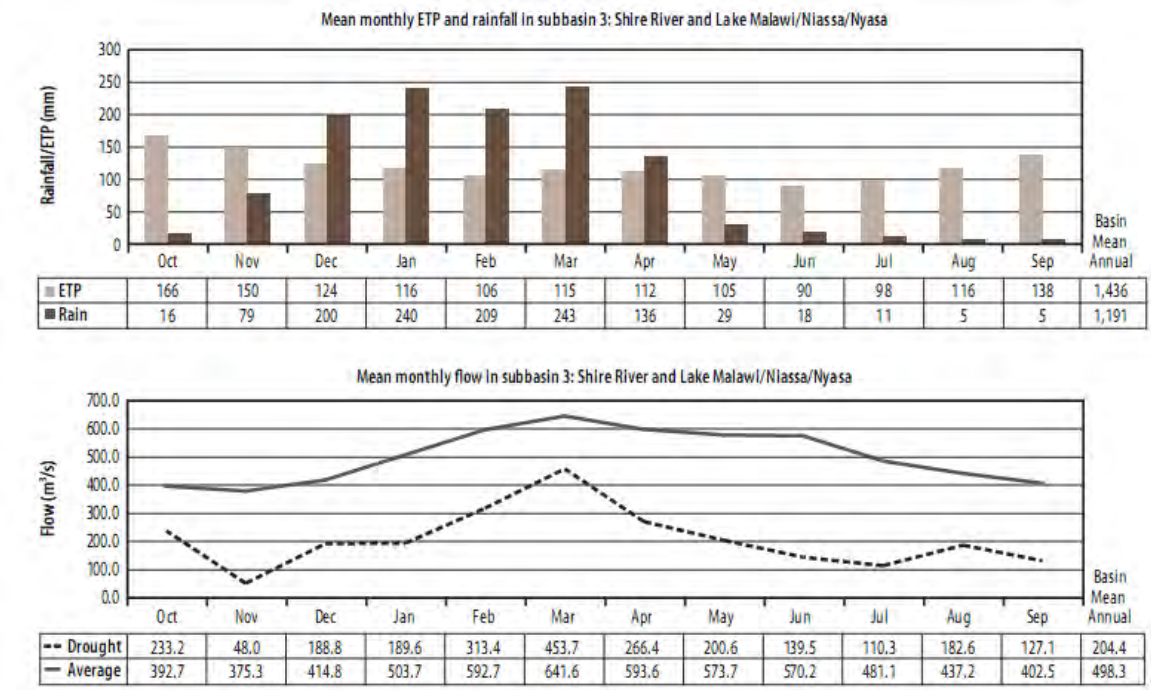


Figure 36. Shire River Hydrograph (World Bank 2010)

From a fisheries perspective, water release patterns from the upgraded Kamuzu Barrage should be managed so they are generally favourable to downstream fish and fisheries such as:

i) allowing some natural flooding to occur during the wet season, to stimulate natural fish reproduction and to maintain the vitality of the Elephant Marsh and other areas with important fish populations;

ii) avoiding significant daily fluctuations in flow rates which can upset the natural cycles of fish and other aquatic life; and

iii) avoiding very sudden decreases in flows due to rapid gate closures at the Barrage. Such sudden drops can cause large-scale fish stranding.

iv) maintaining a minimum water level of 473 masl within Lake Malombe to protect fisheries within the Lake.

8.2.3 Construction Mitigation Measures

The following measures will be implemented during the construction phase:

- Progressive rehabilitation will be under taken as earth works progress for all cut and fill areas.
- All alien vegetation in new temporary / permanent work sites, borrow and quarry areas will be removed and disposed of properly before construction takes place.
- Contractors will take appropriate measures to ensure invasive species of plants are not introduced into the area through vehicle movements.
- For all work areas, after the topsoil has been replaced and worked, appropriate grass mixtures will be planted to initially stabilise the areas before they are landscaped with native plants common to the area.

- Clearing of vegetation will be restricted to only those areas necessary for construction/access activities.
- Workers will not be allowed to harvest natural resources unless approved by local communities and the Project's environmental inspectors.
- Laws and regulations on the protection of plants and animals will be applied.
- Disposal of all waste in an environmentally acceptable manner including re-use or re-cycling where possible. This will apply to waste from removing the existing Barrage gates and the existing weed boom.

8.2.4 Summary of Water Release Boundary Conditions

Table 46 provides a summary of the water release boundary conditions based on the foregoing discussions.

TABLE 46. WATER RELEASE BOUNDARY CONDITIONS

Boundary Condition	Environmental Issue
Avoid releasing more than 400 m^3/s during the months of October to December	To protect crocodile and turtle nesting sites located on Seasonal Flood Plain and Seasonal Marshland during the critical nesting season; to minimise dry season flooding of emergent boulders used by Rock Pratincoles; to minimise dry season flooding of sand bars used by African Skimmers.
Annual simulation of natural flood events down the Shire River during January to April (wet season)	To preserve floodplain and seasonal marsh habitat (including the Elephant Marsh) and support the seasonal *dambo* agriculture
Avoid very sudden decreases in flows due to rapid gate closures at the Barrage. Large flow changes should be made gradually over a number of days to simulate natural flood recession.	To prevent large scale fish stranding downstream of the Barrage
Maintain water levels in Lake Malombe at or above 473 masl	Protect fisheries in Lake Malombe
Maintain Lake Malawi water level below 475.5masl during the dry season (May-Oct)	Protect Perennial Marsh habitat upstream of the Barrage, particularly within Liwonde National Park.

8.2.5 Aquatic Weed Disposal

A major component of the refurbished Barrage is replacement of the existing ineffective weed collection barrier with a new floating steel boom and weed collector to improve removal of floating weeds (mainly Water Hyacinth) which create problems for downstream power plant operations.

The weed disposal method for the existing barrier involves trucking the weeds to land disposal sites away from the Barrage. A similar method of disposal is proposed for the new weed boom. If land disposal is used it is important that weeds are not disposed by dumping on land surfaces in the vicinity of water courses since the seeds can remain viable for up to 15 years.

Despite the ecological problems it can cause, Water Hyacinth has some biological benefits:

- Water hyacinth can provide feed for animals i.e. the weed can be used as an ingredient in livestock feeds and research has shown that animals fed on the weed do very well;
- Some human beings have taken the weed as a vegetable;
- Water hyacinth is used as a substrate for mushrooms. Research has indicated that the weed greatly improves the productivity of mushrooms.
- Water hyacinth can be used as a mulch in crop production;
- The weed has a high nutrient level; a favourable C:N ratio and hence forms good compost manure;

- Water hyacinth can form a good soil bio-pesticide for crops through the reduction of some soil pests that affect crops;
- Fish and livestock diets made from the weed have proved very successful;
- Water hyacinth can be used in biogas production i.e. methane production at a larger scale is achieved with use of the weed;

The above uses could be further investigated by the operator of the weed boom as alternatives to dumping weeds on vacant land.

8.2.6 Socio-economic Environment

The Project's Resettlement action Plan outlines:

- the entitlement framework/matrix for affected persons; defines the eligibility criteria, including the determining criteria, a description of the eligible, and the unit of entitlement;
- procedures for the final verification and valuation of affected assets, and determination of compensation.
- organisational responsibility for the RAP, and recommends institutional and organisational arrangements for the implementation of the RAP.

Although resettlement as a result of the Project is not predicted, compensation for affected persons and assets is required and the RAP includes the following mitigation measures as part of the RAP process.

8.2.6.1 Preferential Employment Policy

A significant positive impact of the Project will be the generation of employment from Project activities, through:

- employment for the direct construction workforce; and
- contractual and work-related opportunities in the provision of direct support services to the construction works (procurement of goods and services).

In order for project-affected people to benefit from these opportunities, a preferential employment policy will be implemented by the consulting engineer through the contractor. This policy will be in line with national legislation around labour-related matters, and best employment practices.

In order to achieve the objective of optimising employment for project-affected people through project-related activities, the following measures are required:

- The MoWDI will develop an overall Project Employment Policy, including a Preferential Employment Strategy showing their commitment to the employment of project-affected people. Contained in the Strategy will be relevant procedures and mechanisms recommending: (a) selection criteria; (b) selection and recruitment procedures; and (c) preferential employment guidelines.
- Consideration will be given for the establishment of a committee; an independent body constituted and driven by relevant stakeholders, including the MoWDI, consulting engineer, project-affected households, and contractor. This committee will give input into the Strategy, monitor the recruitment, working conditions and training of local labour for the duration of the project, and provide a channel for mediation. The relationship with this committee will be included in the Project Employment Policy.
- The MoWDI can only encourage a contractor to maximise opportunities for the employment of project-affected people. To this end they will include the Project Employment Policy in tender documents, citing the Preferential Employment Strategy and calling for contractors to draw a certain percentage of the workforce from those affected. They can also request that all contracts indicate proposed steps to implement a preferential employment policy, including on-the-job training.
- An open and well-publicised process will be conducted by the MoWDI to inform the public about job opportunities. For example, the Ministry will take responsibility for the production and distribution of an Information Sheet to project-affected people well in advance of the commencement of construction, setting out: (a) the number of jobs available, the type of work/skills required, and the

proposed length of contract for each job; (b) the job advertising, selection and recruitment procedures that will be followed; and (c) the time frame for the recruitment of job seekers. This will allow sufficient time for people to respond and apply for all jobs. Although the actual advertising of job opportunities and recruitment of a workforce is the responsibility of a contractor, a contractor should endeavour to ensure that recruitment procedures are in keeping with proposals contained by the employment committee.

- A full assessment of skills and training requirements and preferences of project-affected households are required prior to the construction phase of the Project. Although training will be offered by contractors and other training agents, the MoWDI will be responsible to ensure that it is provided through:
    - on-the-job training and skills transfer to project-affected people that are employed as the Project's workforce; and
    - training to participate in the contractual work offering direct support services to the construction works.
- The policy of preferential employment will be assessed regularly by the MoWDI in conjunction with the employment committee; for example, compliance of project-related contracts will be monitored, as will related training programs.

8.2.6.2 Delivery of Entitlements

The principles outlined in the PAP Entitlement Matrix (Appendix 7) will apply to the notification of acquisition of land and associated assets, and the delivery of entitlements. The principles are consistent with the RPF for the NWDP II. Entitlements for compensation shall be based on the eligibility criteria and the various categories of losses identified through the PAP survey undertaken for the Project and which are included in the Entitlement Matrix.

8.2.6.3 Establishment of an Early Warning System

From consultation with stakeholders it was found that the operation of the Barrage and flooding in the past had caused damage to crops and gardens, which negatively impacts food security and livelihoods. This complaint was consistent amongst communities located downstream of the barrage. There was a sense that their needs were not important and it was requested that to mitigate these affects an early warning system be implemented which can serve to inform communities of the barrage release times and potentially the amount predicted to be released, thereby enabling communities to effectively prepare for the change in water levels.

8.2.6.4 Health and Safety

Due to the range of positive and negative elements the mitigations measures will have a major influence on the balance between an improved or worsened quality of life for the affected population.

8.2.6.4.1 During the Construction Period

Dust

- Frequent watering of access roads
- Respiratory protective equipment for workers

Combustion gases from construction machinery and vehicles

- Time limitation of work / exposure
- CO: combustion control
- CO_2: reduction of use of fossil fuels
- NO_x: antipollution systems (catalytic reduction)
- VOCs: increase in combustion performance
- Safeguarding combustion performance of machinery and vehicles.

Emissions to soil / Waste management

- Recovery of waste materials, restoration of site
- Removal of the informal solid waste dump alongside the Barrage approach on the right bank (west side) of the Shire River prior to commencement of main civil works.
- Workplaces regularly cleaned, with proper management of garbage disposal (liquid, solid and recyclable waste) according to health standards.

Biological wastes

- Adequate sanitary facilities and have to be established, and removal of solid waste and waste water with no contamination of water and the environment
- Sufficient toilets for both men and women with complete sanitary fixtures
- Safe and clean potable water for drinking and hand washing, with sanitary detergents
- Adequate amount of water for washing facilities and sanitation

Biological contaminants of drinking-water (viruses, bacteria, protozoa, toxins)

- Physical maintenance of water distribution (prevent leakages and recontamination of treated water)
- Ongoing monitoring of physical characteristics of drinking-water, water concentration of chemicals and biological contaminants
- Ongoing monitoring of potential biological contaminants
- Ongoing monitoring of concentration of chemicals using recommended standards:*
- Epidemiological surveillance

Noise

- Distance from crushing sites to households at least 1000m
- Hearing protection equipment for workers
- Limitation of working hours and the circulation of trucks between 7:00am and 7:00pm and no work during weekends
- Ongoing monitoring (standards or recommendations: L_{aeq} 45 dBA (night) and 55 dBA (day).

High volume, heavy traffic

- Speed limits depending on location and distance to village
- Strict control of adherence to speed limits
- Road signs in place
- Heavy traffic restricted to day period
- Schooling for communities and children on upcoming traffic risks
- Driving with lights on
- Bright colours of tracks and vehicles
- Increased presence of the police

Indirect effect of construction and presence of construction workers

- HIV/AIDS and STI education campaign among the local population, targeting not only youth but adults as well, before the start of the construction phase and be complemented by increased access to condoms, as well as to voluntary counselling and testing.
- Ongoing HIV/AIDS and STI education campaign targeting all workers hired, both national and international, complemented by easy access to condoms at the workplace as well as to voluntary counselling and testing.

- HIV/AIDS and STI education campaign among sex workers, initiated before the arrival of the workers, pursued throughout the construction phase and complemented by increased access to condoms specifically targeted for this group as well as voluntary counselling and testing, together with improved access to medical services.
- Inclusion specifically also of the diagnosis and treatment of STI and HIV/AIDS in upgrading of the health facilities, as well as the uninterrupted availability of rapid HIV testing and of AIDS counsellors, complementary laboratory tests provided by central laboratories, as well as periodical consultations by qualified physicians. These measures should encompass both the public and private health sector.

Fire, explosion and chemical spill

- Installation of automatic fire control devices in chemical storage areas, preparation of emergency plan, containment and collection measures.

Health and Safety

The safety of communities in the Barrage area may be compromised by construction activities (e.g. increased vehicular traffic, blasting and excavations) and Project operation (e.g. risk of drowning). Construction and operation plans will include procedures for the management of these security risks, as well as for flooding and operational releases from the Barrage. These will entail:

- regular liaison with local authorities and community representatives to discuss security and safety risks and management plans;
- fencing of high risk construction sites to prevent accidents;
- an early warning system at blasting areas; and
- preparation of an emergency preparedness plan for Barrage releases under normal operating and flood conditions.

Construction Workforce Impacts

The following measures will be introduced to minimise adverse workforce-induced impacts, and enhance potential benefits:

- The MoWDI will ensure that acceptable facilities are provided at construction camps (e.g. health services, water and sanitation facilities, recreational facilities and fair-price shops).
- A structured consultation program will be implemented to ensure that there is regular liaison and interaction with community representatives, local authorities and NGOs. The consultation structure will be used to discuss workforce issues and community concerns, to agree on any corrective measures and to discuss ways to enhance the provision of basic services by local entrepreneurs.

Proposed environmental and social mitigation measures for the Project are outlined in Table 47.

TABLE 47. ENVIRONMENTAL MITIGATION MEASURES

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Pre-construction Stage						
Impacts on people, assets and businesses from construction activities	Implement public consultation plan as per the guidelines in the RAP. Inform all communities affected by the Project of schedule of implementation of Project and their rights to compensation. Introduce to Lake foreshore communities a program dealing with latrine, wastewater, refuse pit, water supply and health and hygiene education matters.	All PAPs upstream and downstream of Barrage	Before the commencement of construction	MoWDI	EAD	RAP
Maintain aquatic/riparian habitats and water supply for downstream water users	Develop operating rules and decision support system for environmental flow releases. Include interim flow release strategy for construction phase.	For downstream water users	Before the commencement of construction	MoWDI	EAD	NWDP II
Community and environment safety	Prepare a disaster preparedness and response plan dealing with flood management, and Barrage failure.	Upstream and downstream areas	Before the commencement of construction	MoWDI	PoE	NWDP II
Compensation of PAPs in accordance with RAP	Complete all necessary land and building acquisition in accordance with RAP and Entitlement Framework prior to the commencement of construction works. Provide copies of land acquisition details to the SE and Contractor. Provide a list of affected property owners to the SE and Contractor.	Areas of impact Area of impact Area of impact	Before the commencement of construction Before handover of work sites Before handover of work sites	MoWDI MoWDI MoWDI	MoWDI MoWDI MoWDI	RAP RAP RAP

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
PAP and worker Health and Safety	Preparation of a Health and Safety Plan for workers and impacted communities addressing issues including: • Measures to prevent the spread of HIV/Aids including an awareness campaign • Education of workers and impacted communities • Provision of safety equipment for workers • Use of child labour to be prohibited	All work sites and affected surrounding areas	Before commencement of construction	Contractor	MoWDI	Civil Works Contract
Air pollution	Trial run of Contractor's plants, machinery and vehicles for ascertaining that their emission and noise levels conform to the standards stipulated by EAD.	Construction Camp / Vehicle depot	Before use of equipment	Contractor	SE	Civil Works Contract
Minimise environmental disturbance	Survey the proposed work sites with a level and peg the area.	All work sites	Before commencement of construction	Contractor	SE	Civil Works Contract
	Jointly inspect the surveyed areas.	All work sites	Before commencement of construction	Contractor / Engineer	SE	
	Locate, peg out and seek approval from the Engineer for each ancillary site prior to the commencement of related activities.	All work sites	Before commencement of construction	Contractor	SE	Civil Works Contract
	Inspect and approve, if correct, all pegged ancillary sites.	All work sites	Before commencement of construction	Engineer	SE	

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Protect water quality in Shire River downstream of Barrage	Remove all waste from the informal dump on the downstream bank of the western approach to the Barrage	Western approach to Barrage	Prior to commencement of main civil works	Contractor	SE	Civil Works Contract
Construction Stage						
Maintenance of river flows for the downstream environment and water users.	Maintain downstream flows in the Shire River to meet existing water demands.	Barrage	Throughout the Barrage re-construction process	SE	MoWDI	Environmental Monitoring Plan
Minimise vegetation clearance	Clearly mark out the extent of clearing within the approved worksite areas with pegs at 50m intervals or less. Identify and mark individual trees for retention within the marked extent of clearing. Seek approval for clearing from the Engineer at least 1 week prior to any proposed clearing.	All work sites	Before clearing the vegetation	Contractor	SE	Civil Works Contract
	Inspect and approve all correctly located and pegged clearing sites. Vegetation clearance shall only be undertaken once consent to clear plantation / individual trees at work sites has been obtained from each owner. Instruct all construction workers to restrict clearing to the marked areas and not to harvest any forest products for personal consumption.	All work sites	Before clearing the vegetation	SE	MoWDI	Environ-mental Monitoring Plan
	Ensure that all clearing is undertaken with minimal disturbance to the surrounding environment, within the extent of approved sites only.	All work sites	Before clearing the vegetation	Contractor	SE	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Minimise vegetation clearance	Stockpile cleared shrub foliage where possible for later use as a brush layer.	All work sites	Throughout construction period	Contractor	SE	Civil Works Contract
Construction traffic causing damage to local roads due to overloading, increase in congestion, and increased road safety hazards	Contractor and subcontractors, to use appropriate vehicles, and to comply with legal gross vehicle and axle load limits. Contractor to repair damage at own expense.	Construction areas, quarry and borrow areas	Throughout Construction period	Contractor	SE	Civil Works Contract
Road safety hazards associated with temporary traffic diversions	Contractors to minimise road safety hazards and inconvenience to other road users by taking all appropriate measures, use of flag men.	All traffic diversion stretches	Throughout Construction period	Contractor	SE	Civil Works Contract
Soil erosion	Clearly mark the areas to be cleared of vegetation before clearing commences. No clearing of vegetation shall occur outside of these areas.	All work sites	Prior to commencement of vegetation clearing	Contractor	SE	Civil Works Contract
	Wherever possible avoid locating construction areas, access tracks and construction camps in areas with intact natural vegetation.	Throughout Project area	Prior to commencement of construction	Contractor	SE	Civil Works Contract
	Identify vehicle access tracks and parking areas prior to commencement of construction. Ensure construction workers are aware of the locations of these areas and that vehicles are restricted to these areas.	Construction areas, quarry and borrow areas	Prior to commencement of construction	Contractor	SE	Civil Works Contract
	Prior to commencement of works construct necessary temporary/ permanent erosion and sedimentation control structures.	Construction areas, work camps	Prior to commencement of works	Contractor	SE	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
	Ensure topsoil is left in a non-compacted condition following completion of works. Ensure re-vegetation at the earliest time.	At all work sites	Immediately following construction work	Contractor	SE	Civil Works Contract
Soil erosion	Following completion of works prepare areas for rehabilitation by revegetation or engage local community to plant vegetation.	At all work sites	Immediately following completion of works	Contractor	SE	Civil Works Contract
	Where culverts or pipes have been installed, line waterflow exit points with stone or cement rip-rap for a length of at least two metres.	At cross-drainage structure with erosion potential	During construction	Contractor	SE	Civil Works Contract
Sedimentation of water bodies and water courses	Identify and map all areas where soil disturbance will occur. For each of these areas, identify appropriate sediment control structures and install structures prior to commencement of work.	At all work sites	Prior to commencement of construction work	Contractor	SE	Civil Works Contract
	Carefully manage removal of existing weed boom to avoid soil and weeds polluting the Shire River. Dispose of material away from any surface water courses.	Existing weed boom	Once new weed boom is operational	Contractor	SE	Civil Works Contract
	If possible, schedule works requiring large areas of soil disturbance or newly formed embankments to avoid the rainy season / high river flows.	At all work sites	Prior to commencement of construction	Contractor	SE	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
	Where possible, a bund or trench shall be constructed on the down slope of the construction areas to divert run-off to sediment control structures. The bund or trench shall be removed upon completion of construction works.	At proposed cross-drainage structure locations	Prior to commencement of work Immediately following completion of construction	Contractor	SE	Civil Works Contract
Water pollution	• Ensure that potential sources of petro-chemical (including bituminous materials) pollution are handled in such a way to reduce chances of spills and leaks. • Train work crews in safe handling of petro-chemicals. • Minimise soil sedimentation as outlined under sediment control. • Contractor to make suitable arrangements for water requirements and to provide alternative supply to any users affected by contractor's abstraction of local water source.	All work sites	Prior to commencement of construction	Contractor	SE	Civil Works Contract
Management of stockpiles, spoil heaps and batters	• Consult with nearby landholders and community about suitable locations for stockpiles and spoil heaps. • Site plans shall include all drainage provisions for construction sites. • Locate stockpiles or spoil heaps so there is no blocking of drainage lines. If stockpile locations are not level, the base shall be levelled and contained. • If a spoil heap or stockpile containing fine sediments is to remain bare during rainfall periods, it shall be covered to prevent erosion and sediment run-off.	At potential locations for stockpiling	Prior to commencement of work Prior to commencement of work Prior to stockpiling Immediately following stockpiling	Contractor	SE	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Management of stockpiles, spoil heaps and batters	• Where spoil heaps and stockpiles are large, they must be subject to stability calculations for provision of toe wall to safeguard against slips occurring. • If local landowners or community groups plan to use spoil locally, a suitable site must be prepared to which the spoil can be dumped. • In the event of spoil being available, it shall be used to backfill waste disposal pits. These areas should then be revegetated using labour from local communities.		Prior to stockpiling Prior to dumping of spoil Throughout construction period and upon completion of construction works	Contractor	SE	Civil Works Contract
Noise pollution	• Use well maintained equipment (with mufflers where appropriate). • Use noise screens or mounds near residences, schools and health centres. • Carry out noisy construction activities during daylight. • Advise local people when there will be unusually high levels of noise.	All work sites	Throughout construction period	Contractor	SE	Civil Works Contract
Water and soil pollution	• Contain all solid wastes at designated location within construction sites. • During site clean-up, re-cycle, re-use or dispose by burying away from watercourses / groundwater all spilled fuel oils and bituminous waste materials. • Crush, burn and bury all inorganic solid waste in an approved disposal area. • Remove disabled equipment, including machinery, existing Barrage gates from the area. • Use above-water table pit latrines at major construction sites. • Compost all green or biodegradable waste.	All work sites	Throughout construction During site clean-up During site clean up Throughout construction Throughout construction Throughout construction	Contractor	SE	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Protection of environmentally sensitive areas	• Identify natural habitat areas (including Liwonde NP) and cultural heritage sites, and other environmentally sensitive areas in site plans. • Locate construction sites/activities away from sensitive areas. • Ensure those involved in construction are aware of these areas and the usage limits of such areas. • Provide training to construction teams to ensure an understanding of the requirements regarding environmental protection of sites.	All work sites	Prior to commencement of works Throughout construction	Contractor	SE	Civil Works Contract
Protection of vegetation	• Identify vegetation that will need to be protected; demarcate on the ground any areas where vegetation needs to be removed. • Remove identified trees in such a way as to minimise damage to surrounding vegetation. • Ensure the construction crew is aware remaining vegetation must not be touched or damaged.	All work sites	During site preparation Prior to construction Prior to commencement of construction	Contractor	SE	Civil Works Contract
Pollution from Worker's Camp	Contractors to prepare for approval detailed site environmental plans for the base camp and other work sites, which make adequate provision for safe disposal of all wastes, and prevention of spillages, leakage of polluting materials etc. Contractor to be required to pay all costs associated with cleaning up any pollution caused by his activities and to pay full compensation to those affected.	All works sites and temporary camp Post-use of the site	Prior to and throughout construction	Contractor	SE	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Pollution from Workers camp	If necessary, solid waste from the camp shall be disposed of in a 'sanitary' landfill area. The process will involve three stages: • burning non-recyclable wastes in a pit • crushing all un-burned residues; and • burial of the crushed residues in a pit dug to avoid contamination of the water table. The pit will be covered regularly with a layer of soil or sediment.	Camp sites	Throughout construction	Contractor	SE	Civil Works Contract
Socio-environmental issues	• Advise the local community of Project plans in advance of construction, and involve them in the site / construction planning process.	For all Project activities	Prior to commencement of works	Contractor	SE	Civil Works Contract
	• Avoid disturbances near residential areas where possible.		Throughout construction	Contractor	SE	Civil Works Contract
	• Control run-off and manage sediment near residential areas.		Throughout construction			
	• Arrange for local people to be employed and trained.		Prior to commencement of, and throughout construction			
	• Include women, poor & vulnerable groups in the implementation of the Project activities.	Work sites	Prior to commencement of, and throughout construction			

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
	• Negotiate and agree on with community about soil disposal areas and stockpile sites. • Make available any waste wood to local people as building material or fuel wood.		Prior to commencement of, and throughout construction			Civil Works Contract
Drainage	• Survey and peg all designed drainage works prior to construction. Outlet drains into existing stable drainage lines, or where this is not possible, consult with adjoining down-slope landowners on mutually acceptable locations for drain outlets. • Jointly inspect the pegged drainage works. • Construct all designed drainage works prior to, during or immediately following excavation work in order to minimise the erosion hazard. • Inspect all works and ancillary sites for drainage and erosion problems after each storm event during the period of construction. Repair all failed drains and take other appropriate action as directed by the Engineer.	All work sites	Beginning with and continuing throughout construction	Contractor SE / Contractor Contractor Contractor	SE MoWDI SE SE	Civil Works Contract
Topsoil saving and re-use	• Save all available topsoil from work sites and other borrow pit areas and re-use it for site rehabilitation approved by the Engineer. • Strip and stockpile topsoil from all ancillary sites that are to be disturbed. • If topsoil is to be stockpiled, keep it separate from sub-soil material. • Sow a cover crop on each top-soiled batter within 2 days of top-soiling.	All work sites	Throughout construction	Contractor	SE	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Disposal of spoil material	• Identify, peg and seek approval from the Engineer for permissible disposal locations. • Inspect and approve all correctly located disposal locations. • Instruct the construction workforce on the approved fill/material disposal locations and strictly supervise the correct placement of fill at these sites.	All work sites	Throughout construction	Contractor SE Contractor	SE MoWDI SE	Civil Works Contract
Reinstatement of Services	• Inventory all services (e.g. power supply) to be reinstated. • Liaise and reach agreement with affected landowners, local authorities, public undertakings and local people regarding services to be maintained, temporarily cut and reinstated, including the timing and location of cuts and reinstatements. Obtain written permission from affected landowners / local people regarding the temporary cessation of services. • Maintain or provide temporary services during construction, including temporary water supplies. • Progressively reinstate or repair all interrupted services to their previous capacity. • Inspect and certify the adequate reinstatement of services.	All work sites	Prior to interruption of any services Following construction	Contractor Contractor Contractor Contractor SE	SE SE SE SE MoWDI	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Loss of productive land for borrow pits and adverse financial effects associated with exploitation of landowners by Contractors	• Equitable agreements for borrow pit development to be reached between contractors and landowners, with post-use restoration. Temporary lease arrangements to include an element which fully reflects post-use rehabilitation actions and costs. • Remove top soil and retain in a protected heap for post-use rehabilitation of the borrow area. • Avoid penetration of aquifers. • Fill excavation site with appropriate fill or incinerate construction waste in it, top and finally cover with stored topsoil. • With respect to borrow pits, estimate the quantity of material required and the period of extraction and seek approval from the Engineer. Before opening additional pits, operating pits shall be closed as per relevant Specifications. No borrow area shall be located in sensitive areas such as prime agricultural land. • Inspect and approve all correctly located borrow pits. • Ensure that each quarry or borrow pit drains into a sediment trap before runoff is discharged off the site. • Seek approval from EAD for borrow pits	All temporary access roads, quarry site and borrow areas	Whenever encountered during construction	Contractor Contractor Contractor Contractor Contractor SE Contractor	SE SE SE SE SE MoWDI SE	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Soil erosion, surface water pollution from material stockpiles	• Locate, peg and seek approval from the SE for the use of stockpile sites. • Obtain written permission from landowners for stockpiling on their temporarily acquired land. • Inspect and approve all correctly located stockpile sites. • Seed topsoil stockpiles with a cover crop where they are to be retained for more than one month. • Site plans shall include all drainage provisions for construction sites. • Locate stockpiles or spoil heaps so there is no blocking of drainage lines. If stockpile locations are not level, the base shall be levelled and contained. • If a spoil heap or stockpile containing fine sediments is to remain bare during rainfall periods, it shall be covered to prevent erosion and sediment run-off.	All work sites	Whenever encountered during construction	Contractor Contractor SE Contractor Contractor Contractor Contractor	SE SE MoWDI SE SE SE SE	Civil Works Contract
Sanitation and waste disposal from temporary Contractor site on eastern side of Shire River upstream of the Barrage (Figure 3)	• Provide and maintain worker's health check-up. • Recycle or dispose of solid waste as directed by the SE. • Sufficient measures will be taken in the construction camp, i.e. provision of garbage tanks and sanitation facilities including septic tank and soak pits. Waste in septic tanks will be cleared periodically. • Drinking water will meet National Standards. • Garbage will be collected in bins and disposed of daily. • Special attention shall be paid to the sanitary condition of camp. • Make certain that there is good drainage to avoid creation of stagnant water bodies including water in old tyres which could harbour disease vectors such as mosquitoes.	Temporary Contractor site	Throughout construction	Contractor	SE	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Workforce management	• Liaise with affected communities regarding proposed construction activities. • Ensure workers act in a responsible manner to local people and do not harvest or take personal resources, native plants, fish or wildlife. • Ensure that no wood is burnt by any construction workers on or off site. • Provide kerosene or gas for all workforce cooking needs. • Restrict working hours near habitations to between 06.00-18.00 hrs.	Near Construction camp site	Before and during building of construction camps	Contractor Contractor Contractor Contractor Contractor	SE / MoWDI	Civil Works Contract
Dust air pollution	• Vehicles delivering materials shall be covered to reduce spills and dust blowing off the load. • Use of water tankers to control dust along access roads and at construction sites adjacent villages/houses, crushing plants etc.	All work sites	Beginning with and continuing throughout construction	Contractor	SE	Civil Works Contract
Gaseous air pollution	• Vehicles and machinery will be regularly maintained so that emissions conform to National Standards.	All work sites	Beginning with and continuing throughout construction	Contractor	SE	Civil Works Contract
Noise pollution	• Workers in vicinity of strong noise will wear earplugs and their working time should be limited. • Construction would be stopped from 21:00 to 06:00 hrs at construction sites located within 150 m of residential areas. • Machinery and vehicles will be maintained to keep noise at a minimum.	All work sites	Beginning with and continuing throughout construction	Contractor	SE	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Siltation of water bodies and water courses	• Construction materials containing fine particles e.g. aggregates, limestone etc. will be stored in an enclosure away from water bodies to ensure that sediment laden water does not drain into nearby water courses.	Near cross-drainage structures and water bodies	Throughout construction	Contractor	SE	Civil Works Contract
	• Trees and grass will be planted on slopes and other suitable places to stabilise works areas.	Whenever encountered during construction	Upon completion of construction activities at these sites	Contractor	SE	
	• In sections along water courses, earth and construction waste will be properly disposed of so as to not block natural channels, resulting in adverse impact on water quality.	Near cross drainage structures	Whenever encountered during construction	Contractor	SE	
Alteration of Drainage	• All necessary measures will be taken to prevent earthworks from impeding cross drainage at streams, canal/existing irrigation and drainage systems.	Near cross drainage structures	Whenever encountered during construction	Contractor	SE	Civil Works Contract
Water resources contamination from wastes	• All justifiable measures will be taken to prevent the wastewater produced at construction camp from entering directly into natural water courses and irrigation systems. A minimum distance of any sewage source or toilet facility should be 100 m from water sources.	Near camps drainage structures and water courses	Throughout construction	Contractor	SE	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Water resources contamination from fuel and lubricants	• Vehicle maintenance and refuelling will be confined to areas in construction camp designed to contain spilled lubricants and fuels. Waste petroleum products must be collected, stored and taken to approved disposal sites. Absolutely no washing of vehicles or changing of lubricants in any water courses, including but not limited to the Shire River.	Construction camp lease area	Throughout construction	Contractor	SE	Civil Works Contract
Cultural resources	• If archaeological relics or remains are discovered, the Department of Antiquities should be notified immediately. The construction should be stopped until the Department of Antiquities assesses the remains and approves continuation of work after appropriate measures are implemented. • An Archaeologist will supervise any necessary excavation to avoid any damage to the relics.	Wherever such archaeological/cultural remains are discovered	Throughout construction	Contractor with Department of Tourism	SE / MoWDI	Supervision Consultancy
Hazards and hazardous materials handling	• Safely handle and store hazardous materials. • Seek directions from the Engineer for the disposal of hazardous materials. • Provide disposal directions to the Contractor when requested. • Clean up spills of hazardous materials immediately. • Suppress fires on or adjacent to construction or ancillary sites. • In case of spill of hazardous materials, relevant departments will be informed at once and will deal with it in accordance with the spill contingency plan.	All work sites	Throughout construction as and when required	Contractor Contractor SE Contractor Contractor	SE SE MoWDI SE SE SE / MoWDI	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Soil Erosion	• On slopes and other suitable places along the alignment, trees and grass shall be planted • On sections with high filling and deep cutting, slopes shall be covered by mulch walls and planted with grass.	Primarily at cross drainage structures	Upon completion of construction activities at these sites	Contractor Contractor	SE SE	Civil Works Contract
Compaction of soil	• Construction vehicles should operate within designated work sites to avoid damaging soil, and vegetation.	All work sites	During Construction	Contractor	SE	Civil Works Contract
Loss of trees	• Tree clearing outside designated work sites should be avoided beyond what is required for construction activities. • All vegetated areas cleared for temporary work sites will be revegetated according to a Re-vegetation Action Plan.	All work sites Areas of proposed tree plantings	During clearing / grubbing activities After completion of construction activities	Contractor Contractor	SE SE	Civil Works Contract

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Work site decommissioning	• Establish a site revegetation plan. Where possible involve local community to provide materials and implement revegetation. The revegetation plan shall include: • Name(s) of contact landowner/community group • Summarised outcome of discussions, and decisions on what will be planted; and list of seedlings/stock to be provided and by whom.	All work sites, quarry and borrow areas	Immediately following completion of construction work	Contractor	SE	Civil Works Contract
Ancillary Site Rehabilitation	• Rehabilitate ancillary sites such as borrow areas, camp sites, material storage sites etc. within 1 month of their final use, including the removal of structures, refuse, stockpiles and other temporary features. Revegetate the sites with a cover crop and permanent vegetation as appropriate.	At all ancillary sites	Within 1 month of final use of the ancillary site	Contractor	SE / MoWDI	Civil Works Contract
POST-CONSTRUCTION (OPERATION) STAGE						
Hazardous Waste Management	• Prepare a Hazardous Waste Management Plan to dispose of oil and other lubricants resulting from routine maintenance of pumps and other operating equipment.	Barrage	Prior to operation	Plant Operator	MoWDI	
Aquatic Weed Disposal	• Dispose of aquatic weeds collected via the weed boom upstream of the Barrage as per guidelines in Section 4.3.3 of ESMP.	Weed collector	During operation of new weed collector	MoWDI	EAD	

Environmental Impact / Issue	Mitigation Measures	Location	Timing	Responsible Organisation		Funding Source
				Implementation	Supervision / Monitoring	
Protection of Lake, River and wetland habitats upstream and downstream of Barrage	• Implement social and environmental water releases as per boundary conditions of ESMP as part of the operating rules for Kamuzu Barrage	In vicinity of Barrage and work sites Liwonde NP and Majete Wildlife Reserve Downstream of Barrage to Elephant Marsh	Parallel with commencement of operations	MoWDI	EAD	RAP Environmental Monitoring Plan

Note: Reference to SE refers to the Supervising Engineer of the Contractor (under the Consultancy Services for the Implementation of the Upgraded Kamuzu Barrage).

Table 48 outlines the management measures and task descriptions required to implement Project mitigation.

TABLE 48. MITIGATION MANAGEMENT

Management Issue	Task Description	Timing	Responsibility
Environmental Legal Compliance	Obtain all necessary permits / approvals from landowners, local government and EAD as necessary	Prior to commencement of work	Contractor
Health, Safety and Environment Training	Conduct environmental management and safety training for all Contract workers and site visitors	Prior to commencement of work	Contractor
Health, Safety and Environment Training	Conduct training for Contractor supervising staff, field inspectors and MoWDI Project staff	Prior to commencement of work	Supervision Consultant
Environmental Management	Preparation of Contractor Environmental Management Plan	Prior to commencement of work	Contractor
Panel of Experts (POE)	Establish POE to oversee social and environmental management	Prior to commencement of work	MoWDI
Environmental Management Programs	• Implement a resettlement and compensation monitoring program as per the RAP. • Implement a health monitoring program, based on baseline data collected before and during Barrage construction. • Implement a wildlife monitoring program as described in the ESIA. • Implement a vegetation monitoring program for Liwonde NP as per the ESIA • Implement monitoring Program for operational releases from the Barrage	Prior to commencement of operation	MoWDI
Resettlement Action Plan	Implement	Prior to commencement of construction	MoWDI
Environmental Monitoring	Implement	During construction and operation	MoWDI

8.3 Environmental Monitoring

This Section addresses the proposed social and environmental monitoring program for the Project outlined in Table 49. Monitoring has been divided into compliance monitoring (during construction) and outcome monitoring (operation). 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 Malawi. To ensure the effective implementation of the ESMP 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 may need to be taken to achieve the desired Project outcomes. Monitoring also provides information for periodic review and possible modification of the ESMP to optimise environmental protection at all stages of Project cycle.

The most important objective of the Outcome Monitoring is to provide input to the revision of the water release Operating Rules for the upgraded Kamuzu Barrage. Other objectives of the environmental and social monitoring are:

- Evaluation of the efficiency of mitigation and enhancement measures;
- Updating of the actions and impacts of baseline data;

- Adoption of additional mitigation measures if the present measures are insufficient;
- Generating the data, which may be incorporated in an environmental management plan in future projects.

Environmental monitoring is an essential component of Project implementation. It facilitates and ensures the follow-up of the implementation of the proposed mitigation measure, as they are required. It helps to anticipate possible environmental hazards and/or detect unpredicted impacts over time. Monitoring includes:

- Visual observations;
- Selection of environmental parameters at specific locations;
- Sampling and regular testing of these parameters.

Monitoring should be undertaken at a number of levels. First, compliance monitoring should be undertaken by the Supervising Engineer (SE) at work sites during construction, under the direction and guidance of the Supervision Consultant who is responsible for reporting the monitoring to the implementing agency, MoWDI. It is not the Contractor's responsibility to monitor land acquisition and compensation issues. It is recommended that the SE employ a local full time qualified environmental inspector for the duration of the Contract capable of undertaking the required monitoring. The Supervision Consultant should include the services of a highly qualified environmental and monitoring specialist as part of their team.

The MoWDI should in turn undertake independent monitoring of selected parameters to verify the results of the Contractor and to audit direct implementation of environmental mitigation measures contained in the ESMP and construction contract clauses for the Project. MoWDI also has the direct responsibility to implement and monitor land acquisition and compensation issues as outlined in the RAP. The Project team should include an environmental monitoring and management specialist as well as a sociologist experienced in land acquisition and compensation issues. A total of 4 person months per year should be allocated to the Project during the pre-construction and construction stages for social and environmental management issues. Periodic ongoing monitoring will be required during the life of the Project and the level can be determined once the Project is operational.

Environmental monitoring of the following parameters is recommended as a minimum for the Project. Monitoring methodology covers the following key aspects:

- Components to be monitored;
- Parameters for monitoring of the above components;
- Monitoring frequency;
- Monitoring standards;
- Responsibilities for monitoring;
- Direct responsibility;
- Overall responsibility;
- Monitoring costs.

8.3.1 Compliance Monitoring

Compliance monitoring involves assessing whether the Project is being implemented in accordance with the Project's Environmental and Social Management Plan. It is undertaken during the Project construction phase and involves monitoring contractor performance with respect to social and environmental management issues. A key requirement to effective monitoring is that the construction Contractor's environmental obligations are included in all tender documents so they are enforceable.

8.3.1.1 Physical Environment

8.3.1.1.1 Soils

The excavation of earth for the establishment of temporary borrow areas, temporary and permanent access roads, work camp and storage facilities will exacerbate soil erosion. It will, therefore, be the responsibility of

the Contractor's environmental inspectors to ensure the implementation and effectiveness of erosion control measures. Focus should be given to work sites where soil is disturbed and its immediate environ.

8.3.1.1.2 Water Quality Monitoring

Construction camps are often a source of significant surface and groundwater pollution if not managed and sited properly. It is recommended therefore that the Contractor undertake monitoring of any effluent, waste water, or rainfall runoff discharged from campsites. This would encourage the Contractor to implement proper wastewater treatment facilities on site through the use of settling and treatment ponds.

The parameters to be analysed should include the following:

- pH
- Electrical Conductivity (EC)
- Suspended Solids (SS)
- Turbidity
- Ammonia (NH4+)
- Nitrates (NO3-)
- Total Nitrogen
- Total Phosphorus
- Filterable Iron (Fe)
- Dissolved Oxygen (DO)
- Biochemical Oxygen Demand (BOD)
- Grease and oil
- E-coli

If the discharged effluent does not meet the WHO standards then the Contractor must take further treatment measures or refrain from discharging effluent directly into nearby watercourses.

8.3.1.2 Socio-economic Environment

8.3.1.2.1 Monitoring of Resettlement / Compensation

Monitoring will be undertaken in accordance with the RAP and monitoring and evaluation will form an integral part of the resettlement plan. The monitoring program will have three broad components:

- Performance monitoring, coordinated by the MoWDI, to measure progress with involuntary resettlement against scheduled actions and milestones, using input and output indicators.
- Impact monitoring, focusing on the effectiveness of relocation and livelihood restoration measures, the identification of constraints, and the recommendation of any corrective measures that may be necessary. While the internal monitoring reports will be a source of information, impact monitoring will require the generation of new data to compare against baseline conditions, at (1) household level, through the use of quantitative socio-economic survey instruments; and (2) group/community level, through the use of qualitative (participatory) monitoring and evaluation techniques.
- A Completion Audit, undertaken by an independent agency, such as an NGO. The overall aim will be to verify that compensation and livelihood restoration activities have been undertaken in compliance with the objectives and principles of the RP, and describe any outstanding issues that require attention prior to the closing of the Project's compensation and relocation program.

8.3.1.2.2 Monitoring of Accidents / Health

The Contractor's environmental inspectors should make sure that periodic health surveys are carried out around the Barrage site. MoWDI will have overall responsibility to oversee that all environmental measures

are put in place and that regulations are enforced. The construction supervision consultant will assist MoWDI in this process in order to make sure that contractors fulfil the environmental requirements.

The parameters listed below are proposed as indicators to assist with the follow-up of the health related impact of the construction and operation of the Project. Monitoring should commence with construction and continue for two years after construction completion.

- Number of cases of malaria by sex and age groups
- Proportion of households with mosquito nets in use
- Number of cases of bilharzia by sex and age groups
- Number of cases of STI seen at the facilities, by sex, age groups and types
- Current knowledge on key HIV/AIDS issues among the young and adult population
- Number of individuals counselled for HIV/AIDS
- Number of cases of road accidents by sex and age groups and types - records on actual accidents associated with the Barrage refurbishment could be compiled with the help of local community officials, teachers/students of local schools
- Number of cases and types of work related injuries seen in the health facilities and the facility specifically assigned to the construction workers - records on actual accidents associated with the Barrage refurbishment could be compiled with the help of local community officials, teachers/students of local schools
- Drinking water quality (surface and / or groundwater) in relation to concentration of chemicals and biological contaminants beyond standard (WHO) values
- Presence of posted visible signs at work sites, etc.
- Presence of sanitary facilities at campsites
- Level of awareness of communities pertaining to dangers/risks associated with Project construction activities

8.3.1.2.3 Noise Level Monitoring

Periodic sampling of Contractor equipment and at work sites should be undertaken to confirm that noise levels are within recommended standards (WHO as mentioned below). Noise level monitoring could be supplemented by consulting with Project Affected People in the first instance to identify the level of monitoring required. During construction, quarry sites, Barrage site and concrete batching / aggregate crushing sites will be the main sources of noise pollution. Noise is not expected to be a problem during operation of the refurbished Barrage.

The measurement most often used for measuring sound is the average equivalent sound pressure level (L_{aeq}) per unit time (e.g. 24 hours) using a logarithmic decibel scale (the noise intensity doubles with any increase of 3 decibels (dB). WHO recommends an outdoor noise limit of 55 dBA L_{aeq} during the day and 45 dBA L_{aeq} during the night. In industrial areas or work environments, such as during Barrage refurbishment, a level of 75 dBA L_{aeq} (8 hours) is considered acceptable.

8.3.1.3 Monitoring ESMP Implementation

Implementation of the overall EMP will be monitored by MoWDI on a monthly basis and an annual progress report provided to EAD. Monthly reports will be based on progress reports provided by the Contractor and Supervision Consultant as well as periodic field inspections by MoWDI staff.

An annual report will be prepared which reviews the overall ESMP and make changes to the following year's monitoring program based on progress and experience to date.

8.3.2 Outcome Monitoring

The purpose of outcome monitoring is to provide feedback usable for adaptive project management such as adjustment of Kamuzu Barrage operating rules to reflect new findings. Outcome monitoring extends beyond the construction period into the operation period.

8.3.2.1 Physical Environment

8.3.2.1.1 Water Resources

The Project will further alter the flow regime in the Shire River resulting in fluctuations in water levels downstream and these will impact on downstream water users and the river channel. Monitoring will consist of recording downstream river levels in relation to flow releases from the heightened Barrage to assess the effects on downstream water users and downstream channel stability (river banks) and riparian habitats. Based on this monitoring, an assessment will then be made to determine the need to develop and implement additional mitigation measures including any changes to Barrage operating rules.

8.3.2.2 Biological Environment

8.3.2.2.1 Vegetation

Temporary work/storage sites will be located to cause the least disturbance to areas of native vegetation and this will be monitored by the Contractor's environmental staff and by the SE inspectors.

The Contractor's environmental inspector will ensure that areas used as temporary campsites for workers are progressively rehabilitated as they are no longer required. Once a site is rehabilitated it will be "signed off" by MoWDI environmental staff.

During the operation phase, a monitoring program will specifically target the impacts of high water levels on the Liwonde National Park, as a priority. High resolution (0.25m contour level) colour aerial photography covering the NP and downstream riparian areas was flown in October 2011 and this will be used as a starting point for monitoring vegetation changes in the NP.

For monitoring purposes, the analyses of the proportional vegetation composition will be reassessed at regular intervals (approximately every two years). The reassessment will be conducted by sampling map boundaries and noting the change in vegetation structure due to different water levels in the Park.

The aerial photos will be used to construct maps showing vegetation zone boundaries. These zone boundaries will then be verified using a GPS, and establishing fixed GPS monitoring points.

At the GPS monitoring points, a fixed photo site will be set up. The photos will be taken during the same season at each monitoring event (dry season and wet season, and approximately the same dates each monitoring year). In addition to photographs, the general species composition, plant height, plant distribution (clumped, regular, dispersed) and species composition will be recorded – for each monitoring site.

The expected results from the monitoring will be a general shift in the boundaries of the vegetation types normally occurring at the perennial swamps, marshes, and seasonal floodplain interfaces. This is to be expected, if the water levels under the management regime of the refurbished Barrage are higher than the water levels under the current management regime.

It must be clearly understood, however, that shifts in the boundaries of the vegetation types will be land gradient dependent. Steep ground will only show very small shifts, while flat ground will show much larger boundary changes.

8.3.2.2.2 Terrestrial Wildlife

With respect to terrestrial wildlife, the monitoring priorities are the Rock Pratincole (dependent upon emergent boulders downstream of the Barrage), African Skimmer (dependent upon sandbars upstream of the Barrage), crocodiles and turtles (dependent on sand banks/bars for nesting), and some indicator species that are highly dependent upon the Permanent Marsh ecosystem upstream of the Barrage (such as hippopotamus and waterbuck). Monitoring of species that are sensitive to disturbance will need to be conducted carefully by trained professionals, to avoid causing nest abandonment and other undesired effects.

Since large grazing mammals (dependent upon the Floodplain Grasslands ecosystem) are already being monitored annually by Liwonde National Park personnel, monitoring would not need to be duplicated by the Kamuzu Project, although a financial contribution towards the Park's monitoring would ensure its continuation. It would also ensure National Parks personnel would be integral to the wildlife monitoring program.

It is recommended that the following key species are monitored periodically (at least every two years) to assess any changes in population in relation to operation of the Barrage.

- Status of African Skimmer, crocodile, turtles, Lillian's Lovebird, hippopotamus and waterbuck populations upstream and downstream of the Barrage and Rock Pratincole in Majete National Park.
- Parameters that could be measured include the population size, and reproductive success of these species.

8.3.2.3 Monitoring the Operational Release Strategy

The release strategy is an integral part of the Project and it must be regularly monitored. Key issues will be:

- Appointment of a competent Government Agency or independent organisation to review gauging information and conduct their own spot checks to compare actual and recorded discharge;
- Clear lines of communication between the discharge monitoring agency and the body overseeing the operation of the Barrage;
- Feedback mechanisms for ecological monitoring; cross-referencing against Lake level and River discharge patterns;
- Institutional flexibility to micro-manage release in exceptional circumstances with defined information dissemination procedures towards the discharge monitoring agency;
- Establishment of routines and funding arrangements that ensure the sustainability of the discharge monitoring program.

TABLE 49. MONITORING PLAN

Environment Component	Project Stage	Parameter	Standard	Location	Frequency	Duration	Implementation	Monitoring
Compliance (Construction) Monitoring								
Land Acquisition and Compensation	Pre-construction / operation	Compensation payments	RAP	All work sites	Monthly until complete	As per RAP	MoWDI	EAD
Water Quality	Construction	pH, EC, SS, turbidity, colour, NH4+, NO3-, total P, Fe, DO, BOD, grease & oil, E-coli	WHO guidelines	Construction Camps	Monthly during operation of camps		Contractor	EAD
Noise Levels	Construction	Noise levels on dB (A) scale	WHO guidelines	All work sites	Monthly as required by Supervision Consultant		Contractor	EAD
		Noise levels on dB (A) scale	WHO guidelines	Noise level readings taken at nearest residential house to work site	As directed by the Supervision Consultant	Readings to be taken at 15 second interval for 15 min every hr and then averaged	Contractor	EAD
Soil Erosion	Construction	Turbidity in storm water	ESIA guidelines	As identified by MoWDI	As required		Contractor	EAD
Vegetation Clearing	Construction	Area cleared (ha)	ESMP	All work sites	As required		Contractor	EAD
Rehabilitation of Work Sites	Construction	Monitoring to ensure all work sites are progressively rehabilitated	ESMP	Work camps, material storage sites, borrow areas, quarry	As required		Contractor	EAD
Health	Construction	Signs, posters displayed, health awareness lectures, health checks for workers	ESMP	All work sites, work camps and surrounding areas	Monthly		Contractor	EAD
Accidents	Construction	Number workers trained, accident reports, community consultation	ESMP	All work sites	Monthly		Contractor	EAD
Implementation of EMP	All stages	All	ESIA	Project impact area	Monthly	Life of Project	MoWDI	EAD
Outcome (Operation) Monitoring								
Downstream hydrology	Construction / operation	River levels, bank erosion	ESMP	Shire River channel	Daily River levels; monthly bank erosion	Ongoing with annual review	MoWDI	EAD
Operation release strategy	Operation	Operational discharge	ESIA	Downstream of Barrage	Daily	Project life	MoWDI	EAD
Vegetation	Operation	Vegetation communities	ESIA	Liwonde NP	Every 2 years	Review after 10 years	MoWDI	EAD
Wildlife	Operation	Key species	ESIA	Upstream / downstream	Every 2 years	Review after 10 years	MoWDI	EAD

8.3.3 Monitoring Budget

Table 50 provides a budget estimate for the monitoring outlined previously.

TABLE 50. MONITORING BUDGET

Component	Item	Unit Cost (USD)	Quantity	Total Cost (USD)
Resettlement Plan	Monitoring and evaluation (RP)	45,000	1	45,000
Water Quality (construction)	At locations specified in monitoring plan \ ESIA	5,000/year	During 2.5 year construction period	12,500
Operation release strategy	Monitoring operational discharge	600/month	Initially 5 years then review	36,000
Vegetation Monitoring	Establish baseline, monitor change in Liwonde NP	3,000/year	Life of SRBMP then review	30,000
Wildlife monitoring	Establish population numbers of key species	3,000/year	Life of SRBMP then review	30,000
Noise Levels	At equipment yards, work sites	200	30 months	6,000
Health monitoring (local people and workers)	At local health clinics / work camp	5,000/year	Initially 5 years then review	25,000
Contractor Staff	Environmental Inspectors	6,000 / person / month	1 full time equivalent staff for duration of Construction (30 months)	180,000
MoWDI Staff	Environmental monitoring staff	7,000 / month	1 full time equivalent staff for duration of Project construction (30 months)	210,000
Training	As per training program in Section 8.4	35,000	During 2.5 year construction period	40,000
TOTAL				614,500

8.4 Summary of Environmental Mitigation and Monitoring Costs

Table 51 provides a summary of the estimated compensation and monitoring costs required to address the social and environmental impacts associated with the Project.

TABLE 51. ENVIRONMENTAL MITIGATION AND MONITORING COSTS

Item	Cost (USD)
Resettlement (RAP)	777,482
Environmental Monitoring/Training (Section 8)	614,500
Total	1,391,982

8.5 Institutional Arrangements

This Section identifies the institutional needs to ensure the effective implementation of the social and environmental management and monitoring program as outlined in the ESIA, ESMP and RAP so that the Project's benefits are maximised and that the Project is implemented on a sustainable basis. It is important that the institutional arrangement provides the capacity to implement social management plans, including compensation programs relating to social impacts. Recommendations are also included for operation and maintenance training of MoWDI and contractor staff on environmental monitoring and management aspects.

The ESMP is based on MoWDI having the overall responsibility for the coordination, planning and implementation of the Project as well as the actual implementation of the environmental monitoring and management and land acquisition and resettlement components. It is also based on the appointment of a construction Supervision (Management) Consultant with responsibilities under the direction of MoWDI of directly supervising the Contractor implementing the works (as outlined in Figure 37).

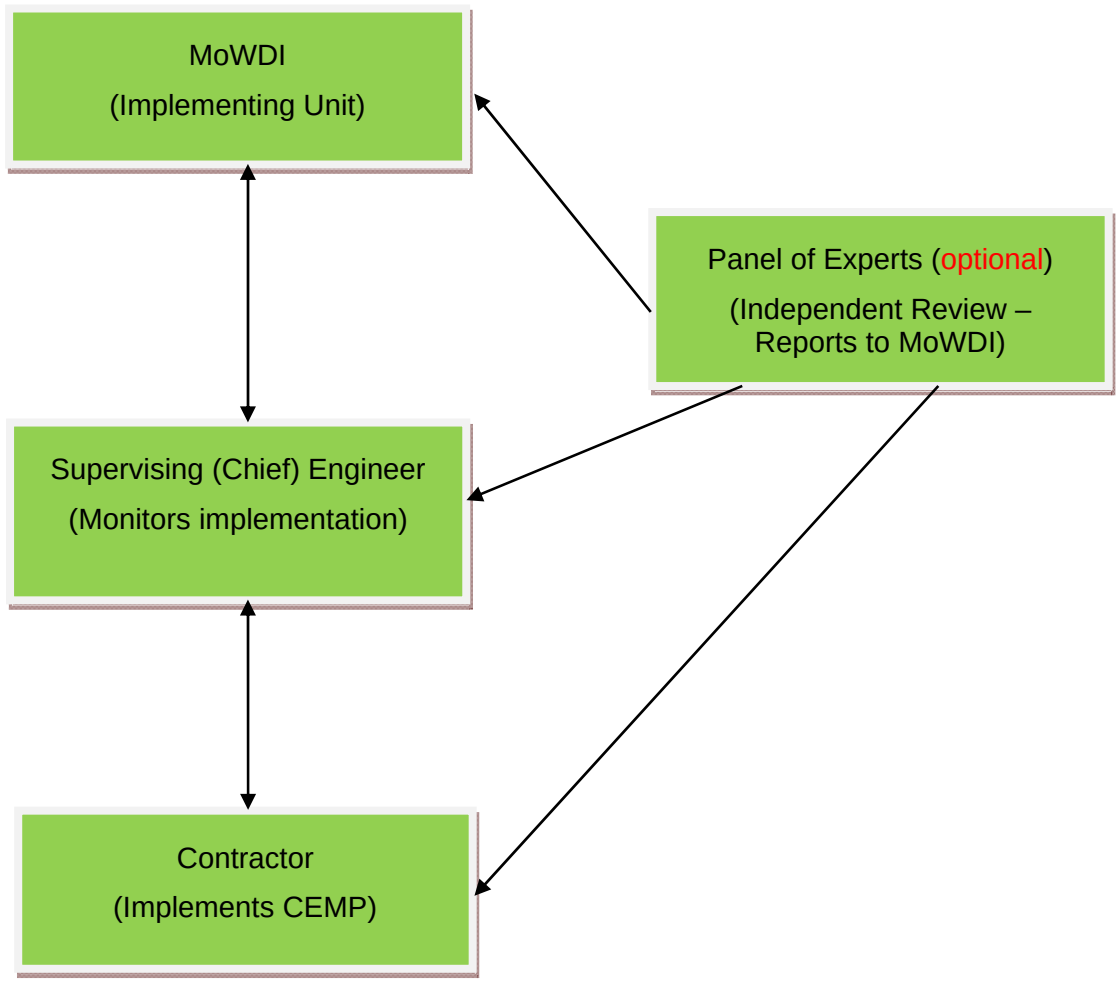


Figure 37. EMP Organisation Chart

8.5.1 Environmental Training

Table 52 outlines the proposed training for MoWDI staff and dam operating staff as well as employees of the Contractor. The training is aimed at the practical aspects of environmental monitoring and management.

TABLE 52. TRAINING FOR MOWDI AND CONTRACTOR STAFF

Timeframe	Training Recipients	Mode of Training	Environmental Aspects to be Covered	Training Conducting Agency
Prior to construction	MoWDI Environmental and supervision Staff	Lecture System Workshops Group Discussion Visit to case study	• Environmental and social overview • Environmental and social regulations & acts • Environmental, social and health issues associated with water supply dam projects • Environmental Management	Environmental and Social Specialists, Supervision Consultant

Timeframe	Training Recipients	Mode of Training	Environmental Aspects to be Covered	Training Conducting Agency
			Plans • Requirements of the Resettlement Plan • Environmentally sound construction management • Risk assessment and management	
After mobilisation and prior to construction	Contractor's Staff	Seminar Workshop Lectures	• Environmental and social overview • Environmental impact assessment • Environmental Management Plan implementation • Requirements of the Resettlement Plan • Environmental and social regulations & Acts • Environmental pollution associated with water supply dam projects • Environmentally sound construction management • Water supply dam projects and environmental issues	Environmental and Social Specialists, Supervision Consultant MoWDI Environmental Staff
Prior to operation of the refurbished Barrage	Barrage Operation/Maintenance Staff	Seminar Workshop Lectures	• Environmental Management Plan implementation • Environmental flows • Environmental pollution associated with water supply projects • Best environmental practices	Environmental and Social Specialists, Supervision Consultant MoWDI Environmental staff, Environmental flow Specialist

8.6 Environmental Reporting

8.6.1 Reporting System

The MoWDI shall be responsible for the implementation of the ESMP and for compliance auditing. The Supervising Engineer (SE) will be responsible for the day to day monitoring of environmental performance of the Construction Contractor and for monthly reporting of environmental performance which is to be submitted to the MoWDI.

8.6.2 Non-compliance Reporting

Where the Environmental staff of the MoWDI or SE observe activities or conditions at Project construction sites or on adjoining sites which do not comply with the requirements of the ESMP, as incorporated under the construction contract documents, they shall forthwith make a written report to the SE to the Contract. On no account shall the Environmental staff give directions to any contractor, employed under a Contract with the MoWDI, in relation to any non-compliance. The report shall define the non-compliance with the ESMP and shall note the time and date of the non-compliance. Based on the report, the SE to the Contract can issue instructions to the Contractor to forthwith instigate procedures to correct the non-compliance and to avoid any recurrence of such non-compliance or to stop work until compliance is achieved. The SE to the Contract shall confirm in writing to the Manager from MoWDI as soon as practicable after correction of the non-compliance.

8.6.3 ESMP Audit Reporting

As mentioned previously the MoWDI will be responsible for undertaking environmental audits for the Project. Audit reports should be undertaken every six months and submitted to the Project's Panel of Expert's if one is established or alternatively to EAD. Environmental audits should report on progress with the ESMP and the effectiveness of the environmental monitoring and management program in minimising or avoiding adverse social and environmental impacts from the Project. The ESMP may be reviewed and revised, as necessary, based on the findings of an audit.

8.6.4 Reporting on In-voluntary Resettlement

Reporting on the activities concerning involuntary resettlement involves:

- Internal reporting: Results of all resettlement activities documented and archived by MoWDI, to compile a monthly internal report and a quarterly report for distribution to the Project Steering Committee (PSC) and the Local Liaison Committees (LLCs) or other bodies outlined in the RAP.
- External reporting: Reporting to all stakeholders on Project-related matters, primarily through Project structures; reporting to an external monitoring agent and an Evaluation Panel; and undertaking a Completion Audit.

8.6.5 Implementation Schedule

Table 7 in Section 7 of the ESMP Report provides an implementation schedule for the monitoring and mitigation measures. This schedule will be reviewed and revised at least every six months during the construction period and on an annual basis during Project operation.

9 Recommendations / Conclusion

There is a strong economic justification for the refurbishment of Kamuzu Barrage. The enhanced reliability of flows downstream would benefit downstream water users, most notably hydropower generation, urban water supply, and irrigation, which would boost the economy of Malawi. Furthermore, there would be job opportunities for local communities during construction work.

Many of the adverse impacts will be of a temporary nature during the construction phase and can be managed to acceptable levels with implementation of the recommended mitigation measures in the ESMP for the Project such that the overall benefits from the Project will greatly outweigh the adverse impacts. The cost of mitigation and monitoring measures (including implementation of the Project's RAP) is USD 1,391,982. Long term impacts are mainly related to the flow releases from the Barrage and provided an operating regime which takes into account social, economic and environmental needs downstream, is maintained then these impacts can be managed acceptably.

Long term impacts may also occur upstream of the refurbished Barrage but the impacts are limited because the range of the levels that can be regulated by the Barrage are within the natural fluctuations of the Lake / River levels. The environmental boundary conditions which will be incorporated into Barrage operation will also limit Barrage impacts. Subject to adoption of these boundary conditions and the mitigation measures outline in the Project's ESMP, it is recommended that the Project proceed based on an increase of 40 cm in the regulating capacity of Kamuzu Barrage corresponding to a Lake Malawi level of 475.72 masl.

9.1 Key Actions to be Implemented

- Revised operating rules for Kamuzu Barrage taking into account environmental requirements both upstream and downstream of the Barrage (prepared by the Design Consultant).
- Implementation of the relocation and compensation program as outlined in the Project's Resettlement Action Plan.
- HIV/Aids awareness campaign for communities and contract workers.
- Preparation of a disaster preparedness and response plan dealing with flood management as well as Barrage failure.
- Implementation of environmental monitoring plan as outlined in Section 8 of this Report.
- Referral of the ESIA to the Governments of Mozambique and Tanzania in accordance with the SADC revised Protocol on Shared Watercourses;
- Establish a Panel of Experts to oversee construction, Barrage safety and environmental management.

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10.2 Maps/Aerial Photos/Images

The following maps were obtained from the Department of Surveys, Lilongwe:

Malawi 1:50 000 topographic map sheet 1535 A1: Liwonde

Malawi 1:50 000 topographic map sheet 1435 C1: Lake Malombe West

Malawi 1:50 000 topographic map sheet 1435 C2: Lake Malombe

Malawi 1:50 000 topographic map sheet 1435 C4: Naifulu

Appendix 1: List of Consulting Staff

Foreign Key Professional Staff	
Team Leader / EIA Expert	Michael Holics
Regional / Local Key Professional Staff	
Water Resources / Hydrology Engineer	Barasa Irenius Wandera
Civil Engineer	Japhet Rutere
Fisheries Expert	Fanuel Kapute
Wildlife Expert	Cuthbert Nahonyo
Ecologist	Michiel Karl Reinecke
Social Expert	Annastella Kaijage
Legal Expert	Titus Mvalo
Administration Support Staff	
Secretary	Evelyn Mwasi

In order to support the Project Team and to complete the EIA study within the Consultancy timeframe of 10 months, the Consultant has also mobilised the following additional local staff:

EIA / Wildlife Specialist	Felix Kalowekamo
Water Quality Specialist	Austin Mtethiwa
Social Specialist	Emmily Kamwendo
Social Specialist	Murphy Kajumi

Appendix 2: Stakeholders Consulted

Details of meetings including dates held, meeting summaries and names of attendees are provided in Volume 2 of the Resettlement Action Plan.

Stakeholder Level	Consultation Type	Consulted Stakeholders
National Government Officials	Public Meetings	• Ministry of Agriculture, Irrigation, Water Development (Proponent) • Department of Environmental Affairs • National Water Development Board (NWDP) • Roads Authority • Department of National Parks and Wildlife
	Individual Meetings	• Ministry of Agriculture and Food Security • Department of Surveys • Roads Fund • Ministry of Land and Housing • Department of Environmental Affairs
District/Regional Officials/Organisations	Public Meetings	• Southern Region Water Board • Liwonde National Park • Blantyre Water Board • Liwonde Town Council • Liwonde Town Planning Office • Environmental District Officer, Machinga District • Office of the President and Cabinet- Liwonde • Office of the President and Cabinet – Machinga District Council • Executive Officer, Machinga District • Executive Officer- Liwonde Town • Marine Police, Liwonde
	Individual Meetings	• Nukula Power Station • Blantyre Water Pumping Station, Blantyre Water Board • Marine Police Unit, Liwonde • District Commissioner, Machinga District Council • Director of Planning and Development, Machinga District Council • Environmental District Officer, Machinga District Council • District AIDS Coordinator, Machinga District Council • District Lands Officer, Machinga • District Commissioner, Balaka District Council • Director of Planning and Development, Balaka District Council • District Lands Officer, Balaka District Council • Logistics Officer, Balaka District Council • Director of PWP, Balaka District • Assistant Disaster Management Officer, Balaka District Council • District Commissioner, Mangochi District Council • District Commissioner, Machinga District Council

Stakeholder Level	Consultation Type	Consulted Stakeholders
		• Director of Planning and Development, Machinga District • Acting Regional Commissioner for Physical Planning, Zomba District • Planning Technician Regional Lands Physical Planning Office, Zomba
District Councils	Focus Group Discussion	• Blantyre o Director of Planning & Development o District Forestry Officer o District Fisheries Officer o District Water Development Officer o District Land Officer o Irrigation Engineer
		• Zomba o Environmental District Officer o Monitoring & Evaluation Officer o District Labour Officer o District Fisheries Officer (Fisheries) o District Agriculture Development Officer o Senior Assistant Information Officer (SAIO) o Disaster Management Officer (Disaster)
		• Chikhwawa o Monitoring & Evaluation Officer o District Fisheries Officer o District Aids Coordinator o Transport Officer o Assistant District Registrar o District Forestry Officer o Environmental District Officer o Acting Lands Officer o Assistant Disaster Reduction Officer
		• Nsanje o District Commissioner o Monitoring & Evaluation Officer o Crops Officer o Fisheries Officer o Lands Resources Officer o District Agricultural Development Officer o Head Clerk o Irrigation Officer

Stakeholder Level	Consultation Type	Consulted Stakeholders
		• Balaka o Assistant District Forestry Officer o Lands Officer o Senior Agriculture Lands Resources and Crops Officer o Acting Agriculture Extension and Development Officer o Assistant District Disaster Risk Management Officer o Logistical Officer
		• Mangochi o Lands Officer o Disaster Management Officer o District Agriculture Development Officer o Irrigation Officer o District Fisheries Officer o District Forestry Officer o Monitoring & Evaluation Officer o Environmental District Officer
		• Salima o Director of Planning and Development o M & E Officer o Assistant District Registrar o Environmental Health Officer o Senior Assistant Land Conservation Officer o District Forestry Officer o Lands Desk Officer o District Water Officer
		• Machinga o Director of Planning and Development o Assistant District Disaster Risk Management Officer o Lands Officer o Deputy District Water Officer
Businesses	Individual Meetings	• SUCOMA Sugar Plantation
Environmental Groups	Public Meetings	• Wildlife Environment Society of Malawi (WESM)
Non- government organisations	Public Meetings	• Participatory Development Initiative (PDI)
	Individual Meetings	• GOAL Malawi • Churches Action in Relief and Development (CARD) • Save the Children

Stakeholder Level	Consultation Type	Consulted Stakeholders
		• Chikhwawa Diocese WALA Program • Population Services International - Malawi
Community Members	Public Meetings	Public meetings were held in the following communities: • GVH Chimphwembwe, Nsanje • GVH Mphamba, Nsanje • GVH William, Blantyre • GVH Ngwaya, Blantyre • GVH Nseule, Blantyre • GVH Mpilisi, Balaka • GVH Chimwala, Mangochi • GVH Dalamkwanda, Salima • GVH Nyamula, Nsanje • GVH Mlooka, Zomba • GVH Chabwera, Machinga
Community leaders	Focus Group Discussion	Focus group discussions were held with Group Village Head (GVH) representatives from the following communities: • Various parts of Nsanje: GVH Tengani GHV Mpangira Sub-Traditional Authority Tengani GVH Nyanthumbi GVH Dumba Sub-Traditional Authority Malemia GVH Chikhawo GVH Dinala GVH Mbangu GVH Magulugulu GVH Malemia 1 GVH Malemia 2 GHV Mthumba GVH Mchacha GVH Kalumbi Senior GVH Kachere GVH Chazuka GVH Mpomba GVH Chiphwembwe • GVH Chimphwembwe, Nsanje • Ulemu Village, Chikhwawa • GVH Kachakwala, Blantyre • GVH Masinde, Blantyre • GVH Chabwera, Machinga • GVH Mlooka, Zomba • GVH Mtuwa, Mangochi • GVH Kunkhongo, Salima

Stakeholder Level	Consultation Type	Consulted Stakeholders
Community Members- Women	Focus Group Discussion	Focus group discussions with women from the following Group Village Heads (GVH) and individual villages: • GVH Mnembe, Nsanje • GVH Nyamula, Nsanje • GVH Ngabu, Nsanje • GVH Mbenje, Nsanje • GVH Namila, Chikhwawa • Ulemu Village, Chikhwawa • Njeleza Village, Chikhwawa • GVH Chiphazi, Chikhwawa • GVH Masinde, Blantyre • GVH Kachakwala, Blantyre • GVH Ngwaya, Blantyre • GVH Mlooka, Zomba • GVH Liundi, Machinga • GVH Chabwera, Machinga • GVH Maliro, Mangochi • GVH Kunkhongo, Salima
Community- Members- Men	Focus Group Discussion	Focus group discussions with men from the following communities: • GVH Mbenje-1, Nsanje • GVH Mnembe 2, Nsanje, 12 men (not in same community as GVH Mnembe1) • GVH Nyamula, Nsanje • GVH Mphamba, Nsanje • Namila Village, Chikhwawa • Njeleza Village, Chikhwawa • GVH Masinde, Blantyre • GVH Liundi, Machinga • GVH Mtuwa, Mangochi
Community Members	Socio Economic Survey	Conducted in all eight Project affected districts, details listed in Table 3, Volume 2 of the RAP.
Community Members	Project Affected Person (PAP) Census	Conducted in the construction footprint for the Project, details listed in Table 4, Volume 2 of the RAP.

Appendix 3: EIA Study ToR Workshop

Workshop on Presentation of ToR for Independent EIA for Upgraded Kamuzu Barrage

Monday 12th September 2011

Sunbird Lilongwe Hotel, Kamuzu Procession Rd, Lilongwe

ATTENDANCE REGISTER

No	Name	Organisation/Position	Telephone No.	E-mail Address
1	Modesta B Kanjaye	MAIWD Director(Water Resources)	0888853188 01773762	mbkanjaye@malawi.net
2	Zachary M Kasomekera	NWDP/MAIWD Program Manager	0999915194	zkasomekera@gmail.com
3	Allan Kaziputa	Environmental Affairs SEO	0999225699	allankaziputa@yahoo.co.uk
4	Rex Kanjedza	MAIWD Principal Water Resources Officer	0888876595	rexkanjedza@yahoo.co.uk
5	Peter Makwinja	Roads Authority Environmental Specialist	0888202426	pmakwinja@ra.org.mw
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PDI	Participatory Development Initiative
EAD	Environmental Affairs Department
MAIWD	Ministry of Agriculture, Irrigation and Water Development
NWDP	National Water Development Program
SRWB	Southern Region Water Board
WESM	Wildlife Environment Society of Malawi

Comments from ToR Workshop

GROUP 1

- EIA Team needs to know Malawi EIA process therefore should consult EAD
- Social Issues are not coming out very clearly
- Land use should not only focus on aerial pictures, also need to consult Liwonde ADD and Ministry of Lands
- Impact of other stakeholders on water resources (e.g. ESCOM on water intake) needs review
- Baseline of all initiatives along Project area
- Clear early warning system should be linked to operation – ensure protection of people
- Delineation of impact area needs – reconsideration (Mozambique and Tanzania)
- National Parks – need to know inundated areas for proper input
- Consider positive impacts of floods e.g. in Lower Shire
- Operational impacts – critically considered
- Sena Development corridor needs review (re: Shire Zambezi waterway)
- Get and Review EIA reports along Shire, L Malombe and L Malawi
- Effects of water fluctuations on sand bars (as key habitats) along Shire River
- CRITICAL – EIA team to have maps ASAP
- Waste Management not coming out clearly – construction and weed
- Some mitigation may require assessment e.g. weed disposal/ management
- EMP to have input from local communities

GROUP 2

- Impacts of the Project on the livelihood for fishing communities around or along the Shire River more especially at the barrage
- What impacts will the Project have on river bank structures such as water supply in-take, lodges, hotels and sanitation structures?
- Impacts of fluctuation of water level in Liwonde National Park – affecting all wildlife and their habitats
- Downstream collection of crocodile's eggs and their habitats

GROUP 3

A. SCOPE OF SOCIAL AND ENVIRONMENTAL ISSUES

- Assess whether design and operation meets various water-user needs downstream e.g. Blantyre Water Board, Irrigation schemes etc.
- Carry out assessment of land to be affected after re-designing of the Barrage

B. STAKEHOLDER CONSULTATION

- Consult BWB, ESCOM, Illovo, Irrigation projects downstream
- The Shire-Zambezi Waterway (Ministry of Transport)

C. LOCAL, REGIONAL DEVELOPMENTS AFFECTING KAMUZU BARRAGE

- The Shire-Zambezi Waterway
- Shire Valley Irrigation Scheme Proposed construction of Hydro-electric Power dams along the Songwe River
- Need to find out what development projects in Mozambique can be affected by the Barrage

Appendix 4: Workshop on Presentation of Draft EIA Study Findings

Attendance Register, Workshop on Presentation of Draft Environmental and Social Reports, Independent EIA for Upgraded Kamuzu Barrage, Thursday 20th September, 2012, Hippo View Lodge, Liwonde

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Key Issues/Questions Raised during the Consultative Workshop on Presentation of the Draft Reports

No	Issue/ Question	Response / Suggestion to Issue
1	How will the Project ensure that the weed boom is not clogged?	It will be built on an angle, which will follow the main flow of the Shire River and a mechanical arm will be deployed to remove the weeds.
2	What is the total estimated cost of the Project?	Preliminary cost estimate by the Design Consultant was USD28 million.
3	What was the extent of the study area?	The EIA study area included Lake Malawi to the Elephant Marsh and the confluence of the Shire and Ruo Rivers.
4	The ESIA needs to include maps to show inundation of areas as a result of Barrage operation.	The ESIA and Vegetation Specialist Reports contain maps based on the Design Consultant's hydraulic model and high resolution colour aerial photography.
5	What warning signs will be put in place and how will the Barrage operators communicate with the communities?	Consideration is being given to use of existing Disaster Management Committees in each District. Suggestion: formation of a River alliance and providing civil protection committees with cell phones to enhance communication. Early warning system should also include radio announcements e.g. announcements to be made during the presentation of weather forecasts.
6	What will be the effects upstream of operating the gates at the proposed increased water level, especially for Blantyre Water Board since they have a water intake immediately upstream of the Barrage?	A provisional sum of USD 50,000 has been included in the budget for the Project to relocate the water intake.
7	Requested that the Project undergoes public disclosure to ensure public participation	Issue to be taken up by the Ministry of Water Development and Irrigation. The ESIA and RAP documents will also be publically disclosed as part of the environmental assessment process being conducted by EAD.
8	The current Barrage has a road bridge on it, how will the reconstruction be done?	Staged construction of the new road deck on the downstream side of the existing structure will minimize disruption to traffic.
9	Issue of a fish ladder	Some fish ladders have been built in Malawi but there is no information on their effectiveness. Even if a fish ladder was included, its effectiveness would be limited because of the natural barrier to fish movement by Kholombidzo and other falls downstream of the Barrage. Also the Barrage gates are opened fully when there are extreme low and high flows in the Shire River and under such situations the Barrage is unlikely to be a barrier. Suggestion: Needs to be adequately addressed in the ESIA to clarify it.
10	During the dry season, don't you think that lake Malawi will be losing water due to the possible opening and closing of the Barrage gates?	The purpose of the Barrage is to provide more regulated flows in the Shire River during the dry season therefore Malawi Lake levels will be lowering during this time.
11	On the adverse effects for the Project, have efforts been made to rank the effects so that efforts are made on more pressing issues	The significance of impacts has been determined and used as a basis for developing mitigation measures outlined in the ESMP.
12	Environmental monitoring of the Liwonde NP- what exactly will be monitored?	The areal extent and health of floodplain vegetation will be monitored to determine long term impacts of Barrage operation. This is further clarified in the ESMP.
13	Overall analysis, is this Project positive or negative?	The national (more reliable hydropower generation), regional (improved transport across the Barrage) and local benefits (employment and transport) are greater than the adverse impacts from the Project. In terms of social and environmental impacts the Consultant

No	Issue/ Question	Response / Suggestion to Issue
		recommends that the Project proceed subject to implementation of the mitigation measures outlined in the ESMP.
14	It is unclear from the presentation how mitigation measures will be enforced, e.g. for environmental monitoring, what will be the measures to address the problem should say emissions go beyond the Environmental Monitoring and Management Plan.	The ESMP includes monitoring and auditing requirements as well as procedures to follow in non-compliance with the ESMP.
15	On the adverse effects, what exactly is included in Health effects? Has the issue of increased HIV and AIDS as a result of influx of workers to the area been considered?	Health effects have been considered during construction and operation phases. Mitigation measures with respect to HIV and AIDS has been included in the ESMP for the Project.
16	Protective buffer zones along lake foreshores and the Shire River are not being enforced. There is also confusion on the actual width of buffer zones.	The MoWDI is aware of the problem and is looking at what can be done to improve the situation.
17	The spelling of “Nukula” needs to be corrected to “Nkula” in the ESIA	It will be corrected.
18	The ESIA needs to highlight issue of the weed boom separately from that of the Barrage	The impact of the weed boom has been assessed as part of the overall Project.
19	What is the next step in the environmental assessment process?	The ESIA/ESMP/RAP will be submitted to the MoWDI and once accepted will be forwarded to EAD for public disclosure and determination as to whether the Project can proceed.

Appendix 5: Water Quality Data

Raw data for the dry season

Sampling Point	Temp °C	pH	DO (mg/L)	Cond (µS/cm)	Turb (NTU)	TDS (mg/L)	Sal (g/L)	Depth (cm)	Sech (cm)	Chl a (mg/L)	BOD (mg/L)	P (µg/L)	Hard (mg/L)	Sulph (mg/L)	TSS (mg/L)	N (mg/L)
S3	24.513	7.993	5.525	0.239	42.075	0.155	0.100	2.050	38.500	18.377	3.433	17.277	94.467	14.667	1.767	0.160
S3	24.500	8.110	5.575	0.238	41.025	0.155	0.100	1.663	46.000	18.373	3.433	16.803	94.267	15.310	1.700	0.140
S3	24.538	7.950	5.400	0.239	42.100	0.155	0.100	2.200	38.500	18.640	3.500	17.907	94.567	14.587	1.767	0.147
S4	24.500	8.063	6.020	0.239	63.425	0.155	0.100	3.120	52.500	15.987	3.000	15.420	87.233	13.067	1.433	0.137
S4	24.475	8.010	6.070	0.239	62.475	0.155	0.100	3.250	58.750	15.893	3.000	15.503	87.567	13.100	1.233	0.117
S4	24.475	8.100	5.820	0.239	52.650	0.155	0.100	2.500	52.750	16.007	3.000	15.550	87.467	13.197	1.267	0.120
S5	24.615	8.010	6.698	0.238	43.700	0.155	0.100	2.538	64.000	24.287	4.100	23.350	99.500	16.103	1.767	0.197
S5	24.628	8.200	6.920	0.238	40.800	0.155	0.100	2.500	78.250	24.320	4.200	23.697	99.467	15.907	1.867	0.190
S5	24.620	8.093	5.623	0.238	43.500	0.155	0.100	1.833	63.000	24.297	4.200	23.603	99.400	15.927	1.800	0.197
S3=upstream of Barrage; S4=downstream of Barrage; S5=upstream of ESCOM weed trapper																

NB: Depth denotes the depth at which water samples were taken.

Raw data for the wet season

Sampling Point	Temp ^{0}C	pH	DO (mg/L)	Cond (µS/cm)	Turb (NTU)	TDS (mg/L)	Sal (g/L)	Depth (cm)	Sechi (cm)	Chl a (mg/L)	BOD (mg/L)	P (µg/L)	Hard (mg/L)	Sulph (mg/L)	TSS (mg/Ll)	N (mg/L)	Coliform (CFU/100ml)
S1	28.64	7.34	8.50	0.23	66.00	0.15	0.10	2.15	60.00	21.52	4.80	15.84	122.96	14.79	2.88	0.17	130.00
S1	28.42	7.50	8.83	0.23	64.30	0.15	0.10	1.75	45.00	22.03	4.60	15.23	126.60	14.61	2.70	0.15	114.00
S1	28.59	7.51	8.47	0.23	58.40	0.15	0.10	1.80	55.00	22.13	4.80	15.19	126.39	14.82	2.80	0.16	115.25
S2	30.67	7.68	8.86	0.18	46.70	0.19	0.10	1.65	51.75	28.57	5.20	22.99	128.64	16.17	2.45	0.22	124.50
S2	30.65	7.67	8.86	0.18	51.90	0.19	0.10	1.70	50.00	26.94	5.20	22.28	131.06	16.37	2.43	0.22	123.00
S2	30.68	7.69	8.84	0.18	46.70	0.19	0.10	1.60	50.00	28.56	5.28	22.16	130.65	16.46	2.53	0.21	124.75
S3	29.28	7.45	7.56	0.23	44.90	0.13	0.10	1.45	44.00	20.94	4.50	15.19	102.27	14.75	1.93	0.14	144.00
S3	29.26	7.47	7.58	0.23	44.88	0.13	0.10	1.60	47.75	21.69	4.40	15.33	104.76	14.28	2.10	0.12	151.00
S3	29.27	7.49	7.55	0.23	44.90	0.13	0.10	1.50	45.00	21.44	4.40	15.22	103.78	14.92	2.13	0.13	150.50
S4	26.23	5.61	8.05	0.20	122.00	0.13	0.10	1.90	71.00	24.78	4.80	15.75	131.27	15.31	2.48	0.14	105.00
S4	26.30	5.60	8.06	0.20	118.00	0.13	0.10	1.70	68.00	25.11	4.95	15.79	134.53	15.33	2.55	0.13	99.50
S4	26.23	5.62	8.04	0.20	120.00	0.13	0.10	1.70	70.00	25.09	4.80	15.66	131.04	15.39	2.50	0.14	105.00
S5	27.44	6.21	8.12	0.19	72.00	0.12	0.10	1.90	64.75	22.58	4.15	14.36	128.51	14.86	1.80	0.10	99.50
S5	28.24	6.23	8.10	0.19	76.00	0.12	0.10	1.70	69.00	22.52	4.10	14.47	128.82	14.87	1.73	0.11	93.00
S5	28.31	6.25	8.13	0.19	77.00	0.12	0.10	1.70	65.00	95.00	4.6	0.04	128.52	14.26	22.55	0.10	14.91

NB: Depth denotes the depth at which the water was sampled

Appendix 6: Shire River Fish Species

The list below is comprehensive and covers the entire Shire River system fish species above and/or below the Kapichira and other falls that serve as a bio-geographic divide between the Lake Malawi and the Zambezi River system fish faunas.

Species	Family	Local name	Habitat	Status
Amphilius platychir	Amphiliidae	?	Demersal	Native
Anguilla nebulosa	Anguillidae	Mkunga	Demersal	Native
Aplocheilichthys johnstoni	Poeciliidae	?	Benthopelagic	Native
Aplocheilichthys katangae	Poeciliidae	?	Benthopelagic	Native
Astatotilapia calliptera	Cichlidae	?	Benthopelagic	Native
Barbus afrohamiltoni	Cyprinidae	Matemba	Benthopelagic	Native
Barbus arcislongae	Cyprinidae	Matemba	Benthopelagic	Native
Barbus atkinsoni	Cyprinidae	Matemba	Benthopelagic	Native
Barbus johnstonii	Cyprinidae	Ngumbo	Benthopelagic	Native
Barbus kerstenii kerstenii	Cyprinidae	Matemba	Benthopelagic	Native
Barbus lineomaculatus	Cyprinidae	Matemba	Benthopelagic	Native
Barbus macrotaenia	Cyprinidae	Matemba	Benthopelagic	Native
Barbus microcephalus	Cyprinidae	Matemba	Benthopelagic	Native
Barbus paludinosus	Cyprinidae	Matemba	Benthopelagic	Native
Barbus radiatusaurantiacus	Cyprinidae	Matemba	Benthopelagic	Native
Barbus trimaculatus	Cyprinidae	Matemba	Benthopelagic	Native
Barbus viviparus	Cyprinidae	Matemba	Benthopelagic	Native
Brycinus imberi	Alestiidae	Nkhalala	Demersal	Native
Chiloglanis neumanni	Mochokidae	?	Benthopelagic	Native
Chilotilapia rhoadesii	Cichlidae	Gundamwala	Benthopelagic	Native
Clarias gariepinus	Clariidae	Mlamba	Benthopelagic	Native
Clarias ngamensis	Clariidae	Mlamba	Demersal	Native
Clarias theodorae	Clariidae	Mlamba	Demersal	Native
Cyathochromis obliquidens	Cichlidae	?	Benthopelagic	Native
Dimidiochromis kiwinge	Cichlidae	Mbaba	Benthopelagic	Native
Dimidiochromis strigatus	Cichlidae	Mbaba	Benthopelagic	Native
Hemigrammopetersius barnardi	Alestiidae	?	Pelagic	Native
Hemitilapia oxyrhyncha	Cichlidae	Mbaba	Benthopelagic	Endemic
Hippopotamyrus discorhynchus	Mormyridae	Mphuta	Demersal	Native
Hydrocynus vittatus	Alestiidae	?	Demersal	Native
Irvineia orientalis	Schilbeidae	?	Demersal	Native
Labeo altivelis	Cyprinidae	?	Benthopelagic	Native
Labeo cylindricus	Cyprinidae	Ningwi	Benthopelagic	Native
Leptoglanis rotundiceps	Amphiliidae	?	Demersal	Native
Malapterurus shirensis	Malapteruridae	?	Benthopelagic	Native
Marcusenius macrolepidotus	Mormyridae	?	Demersal	Native
Marcusenius nyasensis	Mormyridae	?	Demersal	Native
Micralestes acutidens	Alestiidae	?	Pelagic	Native
Mormyrops anguilloides	Mormyridae	?	Demersal	Native
Mormyrus longirostris	Mormyridae	Samwamowa	Demersal	Native

Species	Family	Local name	Habitat	Status
Opsaridium ubangiensis	Cyprinidae	?	Benthopelagic	Native
Opsaridium zambezense	Cyprinidae	?	Benthopelagic	Native
Oreochromis mossambicus	Cichlidae	Makakana	Benthopelagic	Native
Oreochromis placidus placidus	Cichlidae	Chambo	Benthopelagic	Native
Oreochromis shiranus chilwae	Cichlidae	Chambo	Benthopelagic	Native
Oreochromis shiranus shiranus	Cichlidae	Makumba	Benthopelagic	Native
Otopharynx tetraspilus	Cichlidae	?	Demersal	Native
Otopharynx tetrastigma	Cichlidae	Kambuzi	Demersal	Native
Protomelas kirkii	Cichlidae	Kambuzi	Benthopelagic	Native
Protomelas triaenodon	Cichlidae	Kambuzi	Benthopelagic	Native
Protopterus annectensbrieni	Protopteridae	?	Demersal	Native
Pseudocrenilabrus philander dispersus	Cichlidae	?	Benthopelagic	Native
Serranochromis robustus jallae	Cichlidae	Tsungwa	Demersal	Native
Synodontis nebulosus	Mochokidae	?	Benthopelagic	Native
Synodontis njassae	Mochokidae	Nkholokolo	Benthopelagic	Native
Tilapia rendalli	Cichlidae	Chilunguni	Benthopelagic	Native
Trematocranus placodon	Cichlidae	Mbaba	Demersal	Native

Source: http://fish.mongabay.com/data/ecosystems/Shire.htm

Appendix 7: Project Affected Person Entitlement Matrix

Category of PAP	Type of Loss	Entitlements		
		Compensation for Loss of Structures	Compensation for Loss of Land and Other Assets	Compensation for Loss of Income / Livelihood
Property Owners (including those covered by customary law) - Shiri Lodge - Shire Camp - Mr Mwasa - Liwonde Town Council - Mussa Mabuka - Innocent Sanudi - Adine Mponda	Loss of Land	Costs at full replacement value	Land replacement at new site, plus land clearing by the Project	- Cash compensation for crops / trees at replacement cost in scarce season; - Allow sufficient time to harvest crops;
	Loss of Structures Residential or Business	Costs at full replacement value (not depreciated)	Fences (block work, wire, wood) Wells Stores Waste water facilities Connection to utilities Access roads	- For lost income from rented property, pay lump sum cash payment of monthly rental per tenant until the building is replaced;
Residential Tenant / Business Tenant - Eight tenants of Liwonde Town Council Market Shelter	Loss of Rental Accommodation	None	Replacement costs for non-movables	- Disturbance assistance; - Transportation assistance, if relocating; - Rental up to 3 months
	Loss of Premises	None	Replacement costs for non-movables if installation was agreed with owner	None
	Loss of Business	None	None	For loss of business, payment of lost income on a monthly basis based on the previous year's average monthly turnover until the shelter is replaced;
	Loss of Business Income	None	None	Payment of lost income on a monthly basis based on previous years' average monthly income until the shelter is replaced;
	Loss of Salary	None	None	Payment of lost salary on a monthly basis based on previous years' average monthly salary until the shelter is replaced;

Category of PAP	Type of Loss	Entitlements		
		Compensation for Loss of Structures	Compensation for Loss of Land and Other Assets	Compensation for Loss of Income / Livelihood
Encroachers (using land) - Users of the proposed temporary contractor site	Loss of shelter, assets, income revenues and land for cultivation where applicable	Cash compensation for assets and/or income revenue improvements as identified by the census of affected land	Where possible assistance in securing other access to land for growing crops, cash as income revenue subject to approval of Local Authorities – communities	- Cash compensation for trees / crops at replacement cost in scarce season; - Allow sufficient time to harvest crops; - Allow sufficient time to relocate; - For street vendors on rights-of-way, cash compensation for loss of income allow possible access to other vending locations;
Encroachers (living on site)	Loss of Shelter	Compensation at full replacement value for structure; Relocation to resettlement site, with payment of site rent;	None	- Payment in lieu of wages while rebuilding; - Disturbance assistance; - Transport assistance if relocating;
Community	Public Facilities	Compensation at full replacement value for structure; Relocation to resettlement site, with payment of site rent;	Land replacement at new site, plus land clearing by the Project; Waste facilities, connection to utilities and provision of access roads; access to basic infrastructure and social services;	- For loss of business, payment of lost income; - Assistance to access to basic social services; - Provision of alternative temporary facilities during construction, where appropriate;
	Sacred Sites and Graves	None	Land replacement at new site, plus land clearing by the Project	None

Land owners: Those who hold legal tide to the land through official tenure or customary law. Land tenants: Those who are renting land. Land users: This refers to those that are freely using a piece of land but do not have legal title and are not renting the land from anyone. Permanent building: refers to structures constructed in durable materials such cement, bricks and steel. Temporary buildings are usually constructed with local materials.