GOVERNMENT OF MALAWI

MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT

SHIRE VALLEY IRRIGATION PROJECT

Environmental and Social Impact Assessment (ESIA) and Pest Management Plan (PMP) for the Shire Valley Irrigation Project (SVIP)

Final Baseline Report

May 2016

BRLi, Nîmes France

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List of Acronyms

ADD	Agricultural Development Division
Ca	Calcium
CBOs	Community Based Organizations
CMIP	Common Management Information Protocol
COB	Coyne et Bellier
EC	Electrical Conductivity
EFR	Environmental Flow Requirement
EIA	Environmental Impact Assessment
ESCOM	Electricity Supply Commission of Malawi
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESP	Exchangeable Sodium Percentage
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Discussion Group
FS	Feasibility Study
GCM	Global Climate Model
GIEMS	Global Inundation Extent from Multi-Satellites
GoM	Government of Malawi
Ha	Hectares
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
KRC	Korea Rural Corporation
LNP	Lengwe National Park
Masl	Meters above sea level

Mg	Magnesium
MWR	Majete Wildlife Reserve
MK	Malawian Kwacha (1$ US equals +/-700 MK)
MoAIWD	Ministry of Agriculture, Irrigation and Water Development
MoNEA	Ministry of Natural and Environmental Affairs
N	Nitrogen
NWDP	National Water Development Project
P	Phosphorus
pH	Soil Reaction
PMP	Pest Management Plan
PPP	Public Private Partnership
RCP	Representative Concentration Pathways
SRBMP	Shire River Basin Management Program
SVIP	Shire Valley Irrigation Project
TFS	Technical Feasibility Study
TORs	Terms of Reference
SRTM	Shuttle Radar Topography Mission
UNESCO	United Nations Education Scientific and Cultural Organization
WASVIP	Water Availability for Shire Valley Irrigation Project
WRB	World Reference Base for Soil Resources
WRIS	Water Resources Investment Strategy
WWFA	Water Wells For Africa

Glossary

Aggradation: Aggradation is the term used in geology for the increase in land elevation, typically in a river system, due to the deposition of sediment. Aggradation occurs in areas in which the supply of sediment is greater than the amount of material that the system is able to transport.

Biodiversity: biological diversity in an environment as indicated by numbers of different species of plants and animals (Merriam Webster Dictionnary, 2016)

Pediment: A pediment is a gently sloping erosion surface or plain of low relief formed by running water in arid or semiarid region at the base of a receding mountain front. A pediment is underlain by bedrock that is typically covered by a thin, discontinuous veneer of soil and alluvium derived from upland areas. Much of this alluvial material is in transit across the surface, which takes place in pattern of shifting small streams and sheetfloods which are erosive and depositional at the same time. Although mostly described in (semi) arid environments, pediments are now believed not to be restricted to dry areas and to be able to be found in any climate, cold or warm, wet or dry. Of special importance is the function of a pediment as an intermediate or transition zone between the hill or mountain front and an outer aggradation zone which extends beyond the pediment and is a zone of deposition.

Physiography: Physiography is the overall study of physical features of the earth's surface, notably the physical processes that produce and change patterns of rocks, oceans, weather, and global flora and fauna patterns. The emphasis of physiography in this report is on interrelated patterns of geology, landscape (geomorphology) and soils.

Argic horizon: The argic horizon is a subsurface horizon with distinct higher clay content than the overlying horizon. The textural differentiation may be caused by an alluvial accumulation of clay; predominant pedogenetic formation of clay in the subsoil; destruction of clay in the surface horizon (Soil Nomenclature from World Reference Base).

Calcic horizon: The calcic horizon is a horizon in which secondary calcium carbonate ($CaCO_3$) has accumulated in a diffuse form (calcium carbonate present only in the form of fine particles of less than 1 mm, dispersed in the matrix) or as discontinuous concentrations (pseudomycelia, cutans, soft and hard nodules, or veins). The accumulation may be in the parent material or in subsurface horizons, but it can also occur in surface horizons (Soil Nomenclature from World Reference Base).

Cambic horizon: The cambic horizon is a subsurface horizon showing evidence of alteration relative to the underlying horizons. Diagnostic criteria include that a cambic horizon has soil structure or absence of rock structure in half or more of the volume of the fine earth and shows evidence of alteration in one or more of the following: a. higher Munsell chroma (moist), higher value (moist), redder hue, or higher clay content than the underlying or an overlying layer; or b. evidence of removal of carbonates or gypsum; or c. presence of soil structure and absence of rock structure in the entire fine earth (Soil Nomenclature from World Reference Base).

Mollic horizon: The mollic horizon is a well-structured, dark-coloured surface horizon with a high base saturation and a moderate to high content of organic matter (Soil Nomenclature from World Reference Base).

Natric horizon: The natric horizon is a dense subsurface horizon with distinct higher clay content than the overlying horizon or horizons. It has a high content in exchangeable Na and/or Mg (Soil Nomenclature from World Reference Base).

Plinthic horizon: A plinthic horizon is a subsurface horizon that consists of an Fe-rich (in some cases also Mn-rich), humus-poor mixture of kaolinitic clay (and other products of strong weathering, such as gibbsite) with quartz and other constituents, and which changes irreversibly to a layer with hard nodules, a hardpan or irregular aggregates on exposure to repeated wetting and drying with free access of oxygen (Soil Nomenclature from World Reference Base).

Salic Horizon: A salic horizon is a surface horizon or a subsurface horizon at a shallow depth that contains high amounts of readily soluble salts, i.e. salts more soluble than gypsum. A salic horizon has: at some time of the year an electrical conductivity of the saturation extract (ECe) at 25 °C of a. ≥ 15 dS m-1; or b. ≥ 8 dS m-1 (when pH water of the saturation extract is ≥ 8.5) (Soil Nomenclature from World Reference Base).

Vertic horizon: The vertic horizon is a clayey subsurface horizon that, as a result of shrinking and swelling, has slickensides (polished and grooved ped surfaces that are produced by aggregates sliding one past another) and wedge-shaped structural aggregates. It contains 30 % or more clay throughout and has a thickness of 25 cm or more. When dry, vertic horizons show cracks of 1 cm or more wide (Soil Nomenclature from World Reference Base).

Slag: remains generated by high temperature metallurgical activity. When people smelt ore into metal or work metal by heating it, the process produces left-overs, or slag, which is usually discarded.

Protected area: national parks, wildlife reserves and forest reserves are protected areas under the Malawi National Parks and Wildlife Act (1992)

1. INTRODUCTION

This report is a Baseline report for the Environmental and Social Impact Assessment (ESIA) for the Shire Valley Irrigation Project (SVIP) (the “assignment”). The client is the Ministry of Agriculture, Irrigation and Water Development (the “Client”). Korea Rural Corporation (KRC) is the consultant in charge of the Feasibility Study (FS). BRLi is the consultant in charge of the ESIA.

Project background and rationale

The Project consists on developing 42,500 ha of net area of land for gravity irrigated agriculture in the Lower Shire River Valley, in Malawi. The project will take place in two districts: Chikwawa and Nsanje districts.

According to the Terms of References (ToRs), the Project rationale comes from the countries high dependence on rain-fed agriculture for food production. Due to uncertainties of rain-fed agriculture, the Government of Malawi intends to develop irrigated agriculture in the Lower Shire Valley on the West bank of the Shire River. The GoM has requested financial assistance from the World Bank (WB) and the African Development Bank (AfDB) for the preparation of proposed Shire Valley Irrigation Project (SVIP). Accordingly, the World Bank and African Development Bank are supporting the Government with the preparation of comprehensive studies required to appraise the technical feasibility, economic viability, and environmental and social sustainability of the SVIP.

Objective of the Project

The Project objective is “to sustainably enhance incomes and food security of about 100,000 households in Chikwawa and Nsanje Districts through increased agricultural productivity and profitability by establishing market-linked smallholder farming ventures and professionally operated irrigation services in 42,500 ha of lands”.

Objective of the ESIA

The objectives of the ESIA and PMP are well defined in the ToRs (through a list of 37 requirements). This assignment has to comply with the national policies regarding impact assessment as well as the World Bank triggered safeguard policies. In addition, the AfDB environmental and social standards, the International Finance Corporation (IFC) Performance Standards will be applicable, when relevant. Measures developed under this assignment will inform the Client and upcoming technical studies about ways to mitigate impacts and enhance positive effects of the Project. The ESIA will be based on the Feasibility Study description of the Project. Several reports are produced under the assignment:

- The Inception report that provides details about the schedule and upcoming activities ;
- This final Baseline report;
- A draft ESIA that includes a draft ESMP (Environmental and Social Management Plan);
- A draft Pest Management Plan (PMP) report ;
- Draft final ESIA, ESMP and PMP reports;
- Final ESIA, ESMP and PMP reports.

Objectives of this Baseline report

The objectives of the Baseline report is to:

- Inform SVIP and various stakeholders and consultants about the baseline situation in the Study area, both on environmental and socioeconomic perspectives. This baseline is based on desktop studies as well as field surveys.
- Fulfill the requirements of the ToRs.

At time of the Baseline report writing, two reports were available from the FS consultant: the final Inception report (October 2015) and the Options Assessment Report May 25th 2016. Therefore, this Baseline report is based on available information from these two reports. In addition, this Baseline report will not describe the Project in depth, as this will be done in the ESIA once the Option Assessment Report is finalized.

The ToRs request BRLi to critically review the feasibility study. At this stage Options Assessment report was critically reviewed for two fields that are dealt with in the report: hydrology and soil. The goal is to provide KRC with a first set of recommendations before the full ESIA is completed.

The impact assessment with development of mitigation measures based on FS project layout will be done in the ESIA.

PRESENTATION OF THE TEAM OF EXPERTS

This report was written by several experts, all of which participate in a Baseline mission in January-February 2016:

- Eric Deneut: Terrestrial Ecologist, montage of the ESIA
- Robert Matengula: Rural Sociologist specialist
- Arie Remmelzwaal: Soils Specialist
- Stephane Delichere: Hydrologist
- Alfred Maluwa: Aquatic Ecology expert
- Noemie Arazi: Cultural Heritage Specialist
- Pierre Gazin: Environmental Health Specialist
- Dominique Olivier: Integrated Pest Management Specialist

Gilles Pahin is the team leader.

PRESENTATION OF THE PROJECT

As mentioned in the latest version of the Options Assessment report (Korea Rural Corporation May, 2016), the Project consists of:

- A water intake at Kapichira reservoir, the highest topographic point of the scheme, on the right bank of the Shire River, upstream from the training dike and the fuse dike, on the opposite side of the water intake of ESCOM for the hydropower station. ESCOM powerplant as a capacity of 132 MW. The by-passed section between the reservoir and the powerplant is very short (a few hundreds meters). An environmental flow of 30-50m^3/s is currently released from the dam spillway to sustain the Kapichira falls, important touristic attraction of the Majete Wildlife Reserve.
- The water intake will extract a certain amount of water from the Shire River (the reservoir) to distribute water by gravity to the scheme. Based on the Options Assessment Repot (May, 2016) the value of the water abstraction is 50m^3/s. The first phase will require 25m^3/s for the irrigation, and the remaining 25m^3/s is required for phase II. The Map Study area show the main Project features.
- Three canals:
  - Feeder canal with a total length of 46.8 km

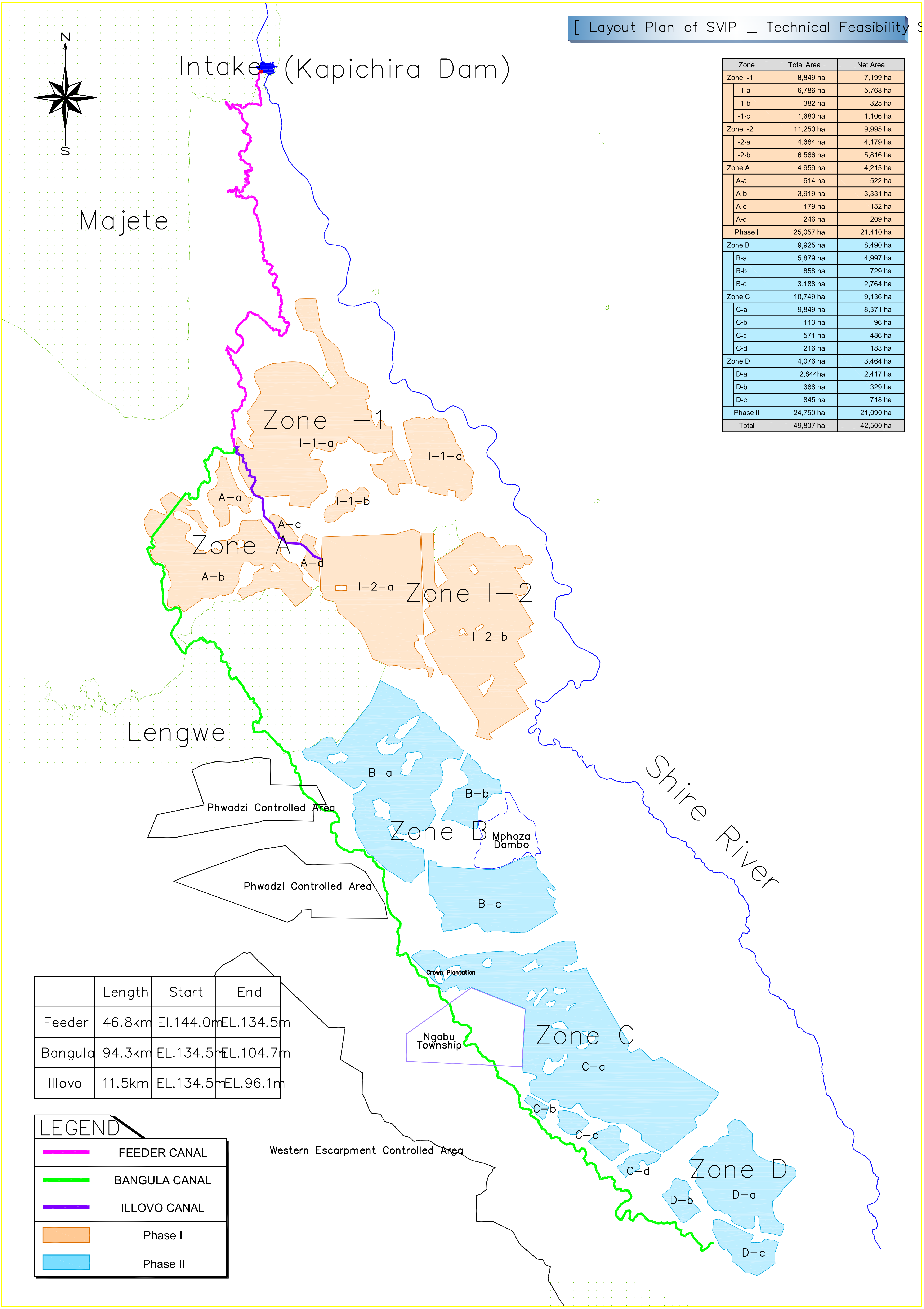
  - Illovo canal with a total length of 11.5 km
  - Bangula canal with a total length of 94.3 km
- Several irrigated areas as shown in the following figure: Phase 1 consist of three zones:
  - Zone I-1: 8,849ha (total area, including access roads and right of ways)
  - Zone I-2: 11,250ha (total area) (which is made of Illovo estate)
  - Zone A: 4,959ha (total area)
- Phase 2 consists of three zones:
  - Zone B: 9,925ha (total area) (which is partly made of Illovo estate)
  - Zone C: 10,749ha (total area)
  - Zone D: 4,076ha (total area)

With current layout, the feeder canal will cross about 1 km of the Majete Wildlife Reserve and 13km of the Lengwe National Park.

The Feasibility Study (FS) for the Project is still in progress and will most likely be finalized after the ESIA. It is undertaken by Korea Rural Corporation in Joint Venture with Dasan Consultants co., LTD., GK Works Civil and Structural Engineers.

The latest available data from the Project are shown in the following figure.

[Layout Plan of SVIP _ Technical Feasibility S



Zone	Total Area	Net Area
Zone I-1	8,849 ha	7,199 ha
I-1-a	6,786 ha	5,768 ha
I-1-b	382 ha	325 ha
I-1-c	1,680 ha	1,106 ha
Zone I-2	11,250 ha	9,995 ha
I-2-a	4,684 ha	4,179 ha
I-2-b	6,566 ha	5,816 ha
Zone A	4,959 ha	4,215 ha
A-a	614 ha	522 ha
A-b	3,919 ha	3,331 ha
A-c	179 ha	152 ha
A-d	246 ha	209 ha
Phase I	25,057 ha	21,410 ha
Zone B	9,925 ha	8,490 ha
B-a	5,879 ha	4,997 ha
B-b	858 ha	729 ha
B-c	3,188 ha	2,764 ha
Zone C	10,749 ha	9,136 ha
C-a	9,849 ha	8,371 ha
C-b	113 ha	96 ha
C-c	571 ha	486 ha
C-d	216 ha	183 ha
Zone D	4,076 ha	3,464 ha
D-a	2,844ha	2,417 ha
D-b	388 ha	329 ha
D-c	845 ha	718 ha
Phase II	24,750 ha	21,090 ha
Total	49,807 ha	42,500 ha

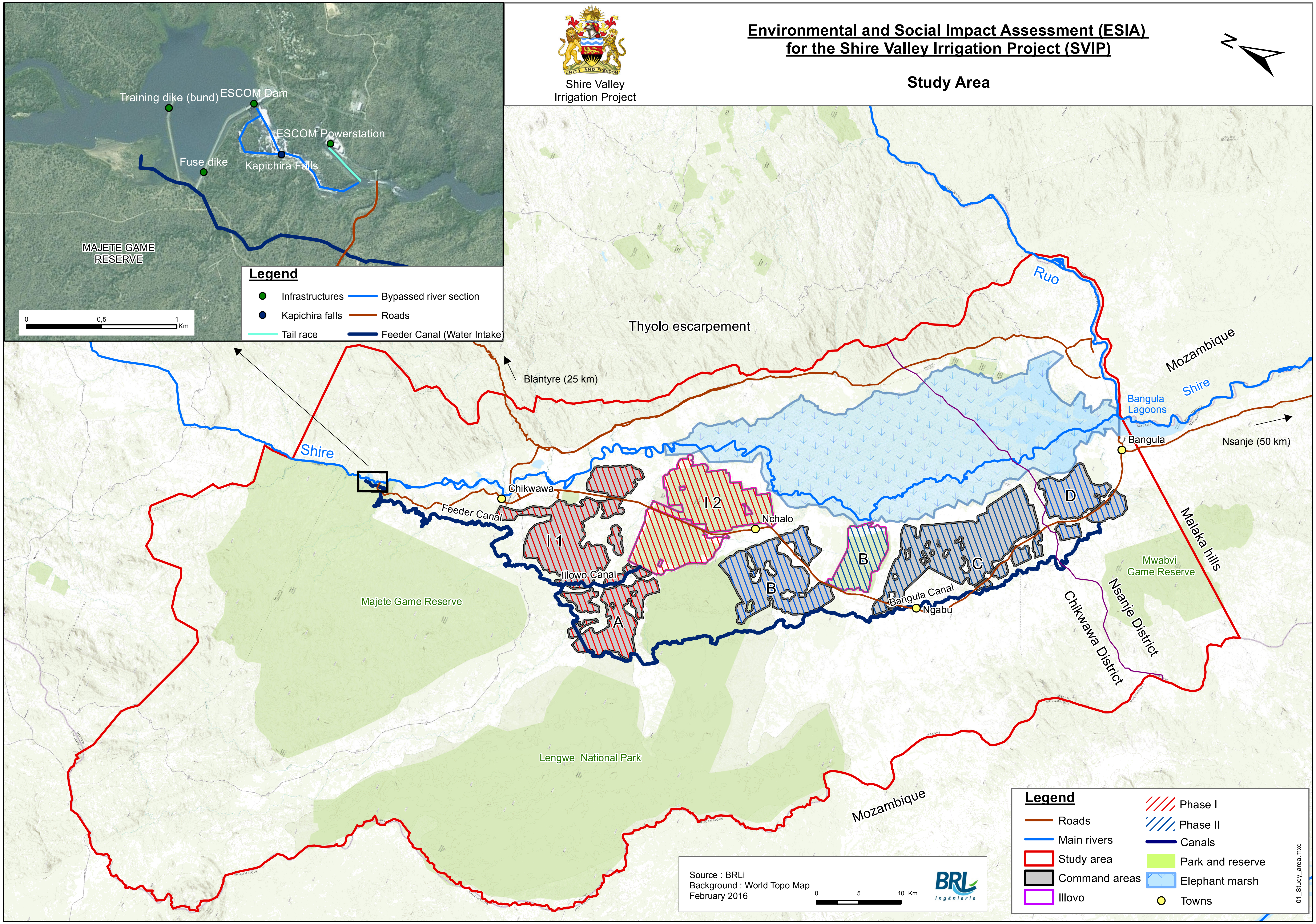
	Length	Start	End
Feeder	46.8km	El.144.0m	EL.134.5m
Bangula	94.3km	EL.134.5m	EL.104.7m
Illovo	11.5km	EL.134.5m	EL.96.1m

2. STUDY AREA

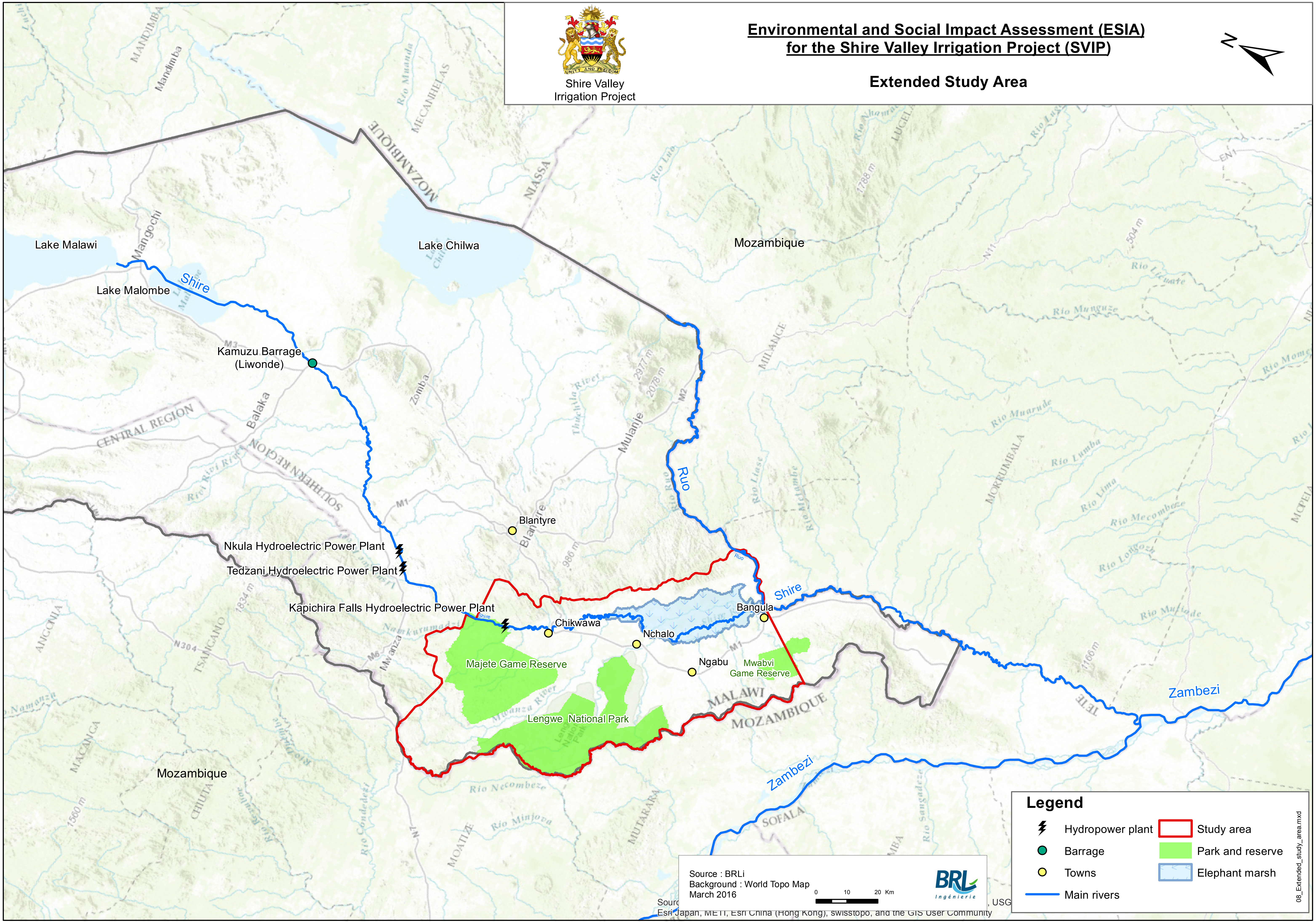
The consultant has delineated a study area based on the actual description of the Project and field visits during both the Inception mission (2015) and the Baseline mission (2016). The Study area is a geographical area that includes all the Project components as well as the boundaries of potentially affected geographical areas.

Baseline study has allowed to re-affirm the study area presented in the Inception report. The Study area includes all phases and zones of the Project as well as the right-of-way of all canals. It starts, at its northernmost limit, at Majete Wildlife Reserve and ends at its southernmost limit after Elephant Marsh at Bangula. It includes most of Chikwawa district and a part of Nsanje district. On a hydrological perceptive, the Study area is included in the Lower Shire River valley. It includes the Ruo River confluence with Shire River and all rivers feeding the Elephant marsh (both on the right and left banks of the marsh). The following map shows the Study area.

In addition, an Extended Study area is defined in this report. It includes all infrastructures and major waterbodies that influences the hydrology downstream of Lake Malawi: Lake Malombe, Kamuzu barrage (Liwonde barrage), and the Nkula, Tedzani and Kapichira Escom hydropower plants. The Map next page shows the Extended Study area.



Environmental and Social Impact Assessment (ESIA)
for the Shire Valley Irrigation Project (SVIP)
Study Area
Shire Valley
Irrigation Project
UNITY AND FREEDOM
N
Training dike (bund)
ESCOM Dam
ESCOM Powerstation
Fuse dike
Kapichira Falls
MAJETE GAME RESERVE
Legend
Infrastructures
Kapichira falls
Tail race
Bypassed river section
Roads
Feeder Canal (Water Intake)
0
0,5
1
Km
Thyolo escarpement
Blantyre (25 km)
Ruo
Mozambique
Shire
Bangula Lagoons
Bangula
Nsanje (50 km)
Shire
Chikwawa
Feeder Canal
I 1
I 2
Nchalo
Illowo Canal
A
B
B
C
D
Bangula Canal
Ngabu
Malaka hills
Mwabvi Game Reserve
Nsanje District
Chikwawa District
Majete Game Reserve
Lengwe National Park
Mozambique
Source : BRLi
Background : World Topo Map
February 2016
0
5
10
Km
BRL ingénierie
Legend
Roads
Main rivers
Study area
Command areas
Illovo
Phase I
Phase II
Canals
Park and reserve
Elephant marsh
Towns
01_Study_area.mxd



Environmental and Social Impact Assessment (ESIA)
for the Shire Valley Irrigation Project (SVIP)
Extended Study Area
Shire Valley
Irrigation Project
Lake Malawi
Lake Malombe
Lake Chilwa
Mozambique
Shire
Kamuzu Barrage
(Liwonde)
CENTRAL REGION
SOUTHERN REGION
MOZAMBIQUE
Blantyre
Nkula Hydroelectric Power Plant
Tedzani Hydroelectric Power Plant
Kapichira Falls Hydroelectric Power Plant
Chikwawa
Nchalo
Bangula
Ngabu
Ruo
Majete Game Reserve
Lengwe National Park
Mwabvi
Game Reserve
MALAWI
MOZAMBIQUE
Zambezi
Mozambique
Legend
Hydropower plant
Barrage
Towns
Main rivers
Study area
Park and reserve
Elephant marsh
Source : BRLi
Background : World Topo Map
March 2016
0 10 20 Km
BRL Ingénierie
08_Extended_study_area.mxd

3. STRUCTURE OF THE BASELINE REPORT

This Baseline report is divided in several chapters. It first presents the physical environment as it allows understanding the elements that dictate human settlements and environmental challenges and constraints. It then presents the social and economic baseline situation that are guided by the physical environment (such as climate, local hydrology, water availability, the type of soil, etc.). It presents the ecology of the Study area and the various natural receptors of modifications that the Project will bring.

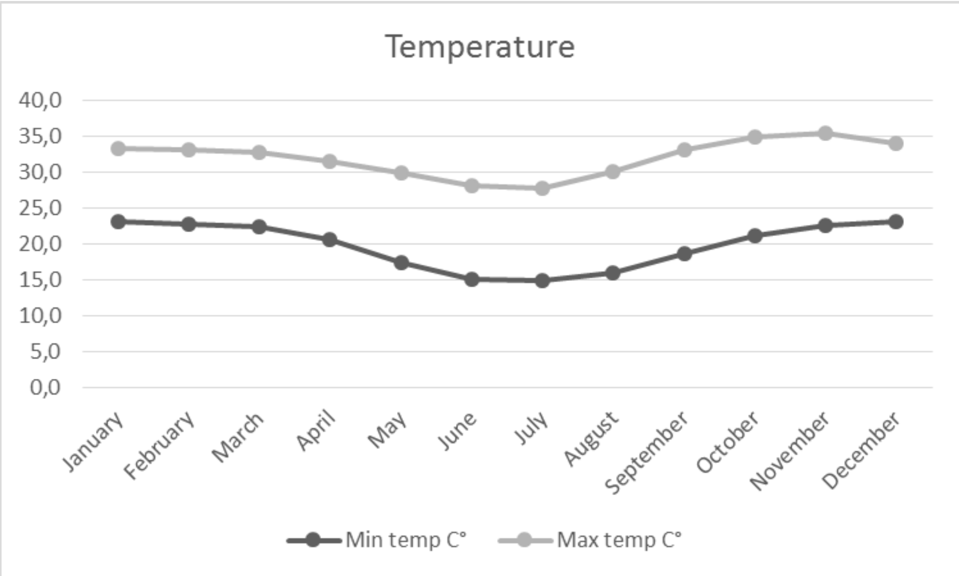
4. PHYSICAL ENVIRONMENT

4.1 CLIMATE

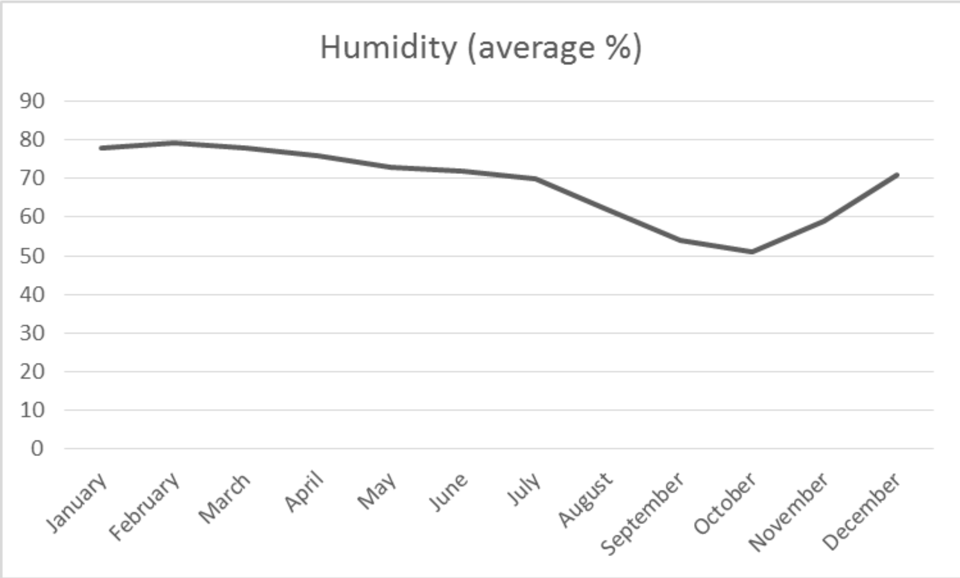
The study area has a tropical climate marked by hot temperatures and two distinctive seasons: the dry and the rainy seasons.

The dry season starts in May and ends in October while the rainy season starts in November and ends in April.

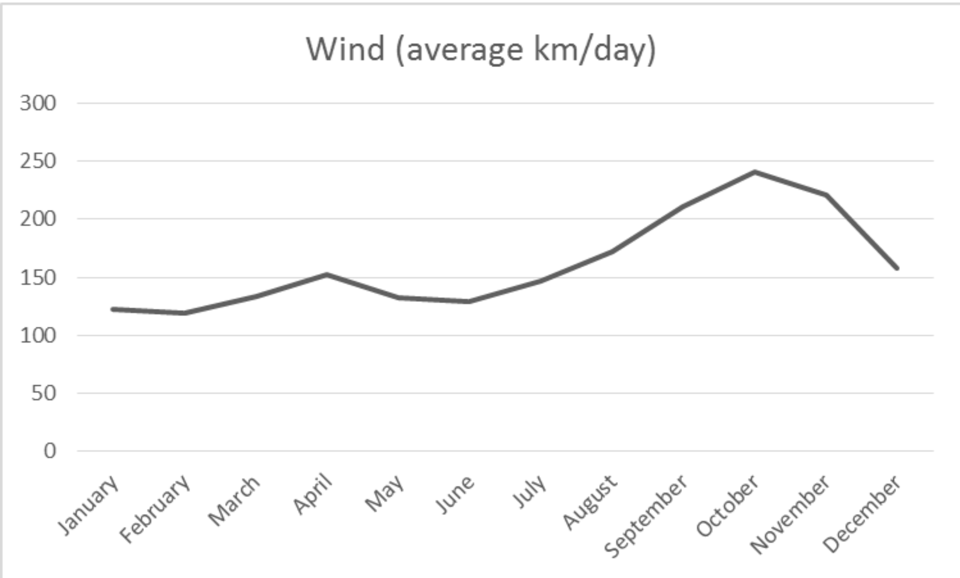
The following graphs show the main figures related to climate: temperature, humidity, rainfall and sunshine duration. Data are taken form Nchalo Illovo, Makanga Station (from 1971 to 2014).



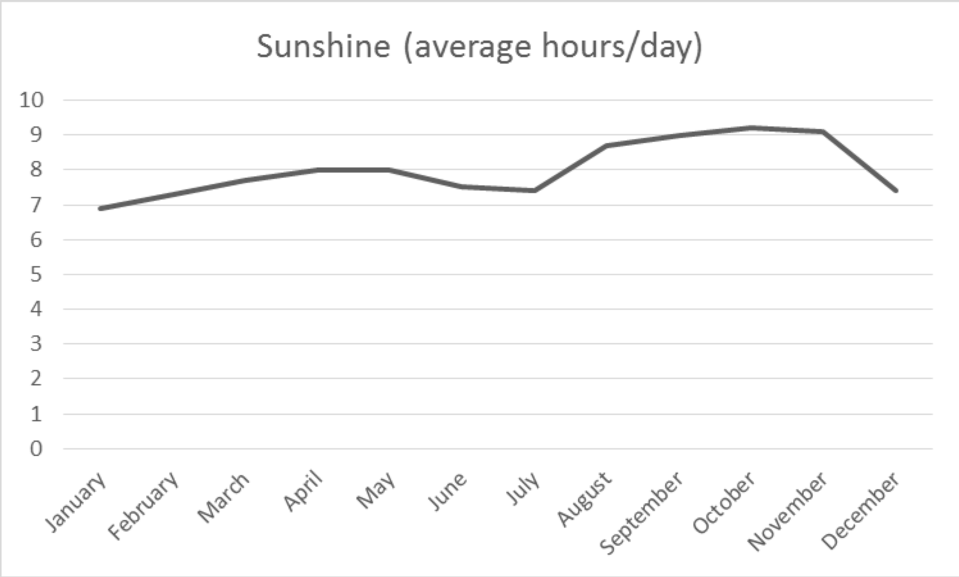
Source: Nchalo Illovo, Makanga Station (1971-2014)



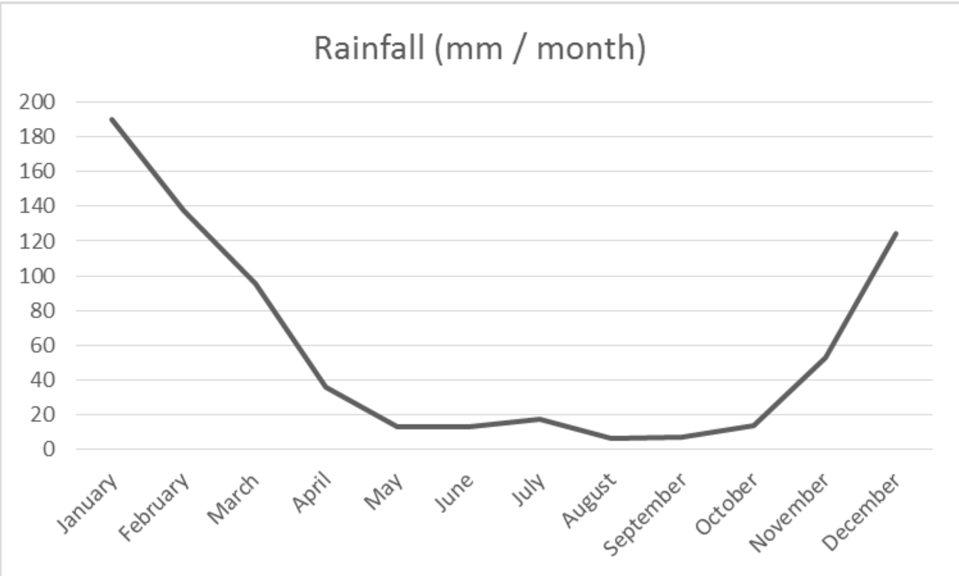
Source: Nchalo Illovo, Makanga Station (1971-2014)



Source: Nchalo Illovo, Makanga Station (1971-2014)



Source: Nchalo Illovo, Makanga Station (1971-2014)



Source: Nchalo Illovo, Makanga Station (1971-2014)

Effective rainfall and evapotranspiration

In the field of agriculture, the notion of effective rainfall is important as it subtracts from the amount of rainfall, the amount of water that is unusable for crop (for plant intake) due to rapid evaporation (not enough time to reach roots) deep percolation or rapid runoff to surface water. In the Study area, effective rainfall is, on a yearly average, 48% lower than rainfall, which mean that only 52% of rainfall is effective rain (BRLi, 2015).

Evapotranspiration is the process by which water is transferred from the land to the atmosphere by evaporation from soil and transpiration by plant, it therefore designates water losses. In the Study area, the balance between rainfall (intake) and evapotranspiration (offtake) only shows a surplus of water between February and April. In the dry season, soil moisture drops to zero. Surplus of water only occurs when the soil is saturated after the first heavy rains. Overall, the region is semi-arid, meaning that the Study area generally suffers from a soil moisture deficit (Per Aagaard, 2012).

4.2 LOCAL TOPOGRAPHY

The description of the topography of the Study area helps to understand the physical environment in which the Project will take place.

The Study area is included in the Lower Shire Valley, which covers the southernmost part of the Shire River after Kapichira falls.

The Study area starts at the Escom reservoir just upstream of the Kapichara falls. At this point, where the water intake will be located, the altitude is 144 masl.

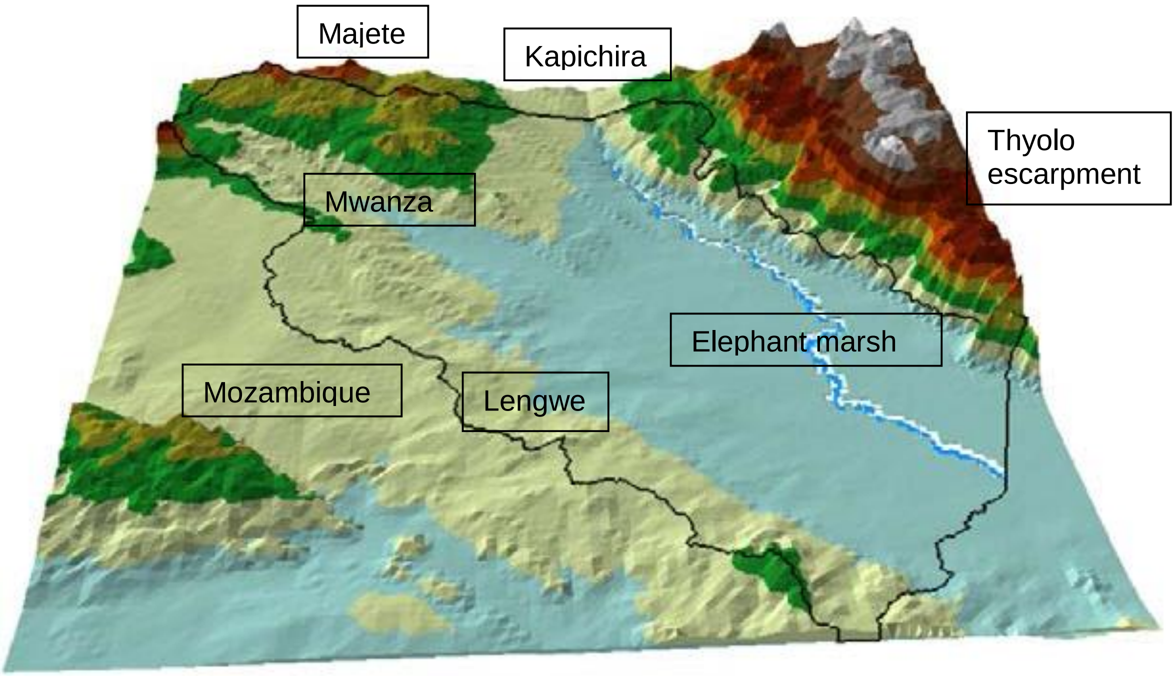
After the reservoir, the Shire River flows down the dam spillway and Kapichira falls, the altitude drops of about 10 meters and the Shire in incised in a gorge 10 additional meters below ground level. The Lower Shire plain is the only area in Malawi where the elevation is below 150 masl.

Local topography is characterized by the following features:

- The Shire River, with gentle slopes after the Kapichira falls and flowing in the middle of the Study area. The river's valley has formed a vast central low land wetland called Elephant marsh surrounding the Shire River and receiving its water during the rainy season.
- Majete Wildlife Reserve in the North has a few hills reaching up to 780 masl. Majete escarpment marks the end of Majete to the North West where the Mwanza, an important tributary to Shire River, flows in a large valley.
- On the Shire left bank (to the North East): the Thyolo Escarpment with steep slopes has the highest hills of the area with summits up to 1,5000 masl. Short seasonal streams with small watersheds originate in this area and quickly empty their water in the Elephant marsh during flash floods.
- To the South East, Mulaka Hills that range in the 300s masl. These hills are located in Nsanje district.
- To the West, in Lengwe National Park, the topography is flatter with spares hills (Thambani Hills, the Salambidwe Hill, the Marangwe Range and the Matundwe Range) that climb up to 300 masl. This area marks the limit of the watershed between the Zambezi River (to the West, in Mozambique) and the Shire River (to the East).

The feeder canal roughly follows the 145 m topographic contour line toward the plain. The following figure shows the topography of Chikwawa district (Nsanje District and Mulaka Hills are not shown) Mozambique is on the left.

Figure 1 Topography of Chikwawa district



Source: Montjerezi, 2012

4.3 RIVER GEOMORPHOLOGY

The study area is included in the Lower Shire catchment from the Kapichira Hydroelectric Power Station reservoir (downstream the confluence with the Mkurumazdi River) to the end of Elephant Marsh (downstream the confluence with the Ruo River).

The Lower Shire has two distinct morphological facies:

- From Kapichira to Chikwawa, the Shire River covers a distance about 20 km falling below the surrounding land flanked by alluvial terraces.
  - The right-bank tributaries include the following intermittent rivers originating from the Majete Escarpment: Mwambezi, Masakale, Kadeya and Manyumwa.
  - The main left-bank tributary is the perennial river called Likhubula which originates from the Thyolo Escarpment.
- From Chikwawa to Chiromo, the Shire River covers a distance of about 100 km through a broad alluvial plain constituted by tertiary unconsolidated sediments.
  - The right-bank tributaries include the following intermittent rivers originating from the Thambani Hills, the Salambidwe Hill, the Marangwe Range and the Matundwe Range (in Lengwe NP area): Nthumba, Nkombedzi wa Fodya, Phwadzi, Namikalango, Nyakamba, Mikombo Chibuala, Mafume, Lalanje and Thangadzi West. The Mwanza River is the main right-bank tributary, it is intermittent and flows from the Mount Xalacongue and pours its waters into the Shire River at Nchalo.
  - The left-bank tributaries include the following intermittent rivers originating from the Thyolo Escarpment (including the Cholomwani Hills and the Kalulu Hills): Mwamphanzi, Nkhuzi, Nanzolo, Nkhate, Chilengo, Livunzu, Mulunga Wang ono, Wankwazi, Kalulu, Mbazi, Nkwezo, Milole, Milole Mwana, Mankhala, Kalulu, Thangadzi East, Chinolo, Chidima, and Phalamanga. The Ruo River is the main left-bank tributary, it is perennial and flows from the Mulanje Mountain and pours its waters into the Shire River at Chiromo.

As observed during the baseline mission then confirmed by satellite imagery analysis, the river beds of the Lower Shire River and its tributaries are very mobile in the alluvial plain regarding the highly erosive and spreadable soil characteristics: river bed can move, split, deepen or dig of several meters after severe floods. Sheetflood erosion is also taking place (Figures 2 and 3).

Figure 2 River Bed Split in the Nkombedzi Wa Fodya River

Photo Credit ©2016 BRLi

Figure 3 River Bed Digging and Deepening by Erosion in the Namikalango

Photo Credit ©2016 BRLi

The overall Lower Shire River Basin from Kapichira Dam to Chiromo Bridge (including Ruo River) covers a drainage area of about 11 470 km².

The main morphological characteristics (area, perimeter and Gravelius compactness coefficient) of the sub-basins are given in the Table 1.

The Gravelius compactness coefficient is defined as the ratio between the perimeter of the sub-basin and the circumference of the circle with the same area. This index is determined from a topographic map by measuring the perimeter of the watershed and its surface. It is close to 1 for a catchment of almost circular and therefore compact form; but greater than 1 when the basin is of elongated shape.

Table 1 Morphological Characteristics of the Lower Shire Tributaries

	River Basin	Area (km²)	Perimeter (km)	Gravelius Coefficient
Main Right-Bank Tributaries	Mwambezi	169	103	2.2
	Masakale	107	87	2.4
	Nthumba	202	126	2.5
	Mwanza	1844	436	2.9
	Nkombedzi Wa Fodya	1057	249	2.2
	Namikalango	180	106	2.2
	Nyakamba	107	98	2.7
	Chibuala	141	95	2.3
	Mafume	96	95	2.7
	Lalanje	99	95	2.7
	Thangadzi West	407	149	2.1
Main Left-Bank Tributaries	Likhubula	600	181	2.1
	Mwamphanzi	312	150	2.4
	Nkhuzi	24	40	2.3
	Nkhate	57	57	2.1
	Chilengo	79	65	2.1
	Mulunga Wang ono	20	39	2.5
	Mulunga Wamkurd	27	42	2.3
	Wankwazi	20	32	2.0
	Mbazi	63	54	1.9
	Nkwezo	13	22	1.7
	Milole Mwana	23	38	2.2
	Kalulu	14	22	1.7
	Chinolo	10	32	2.9
	Chidima	5	17	2.1
	Thangadzi East	53	66	2.5
	Ruo	4828	523	2.1

Source: BRLi, 2016

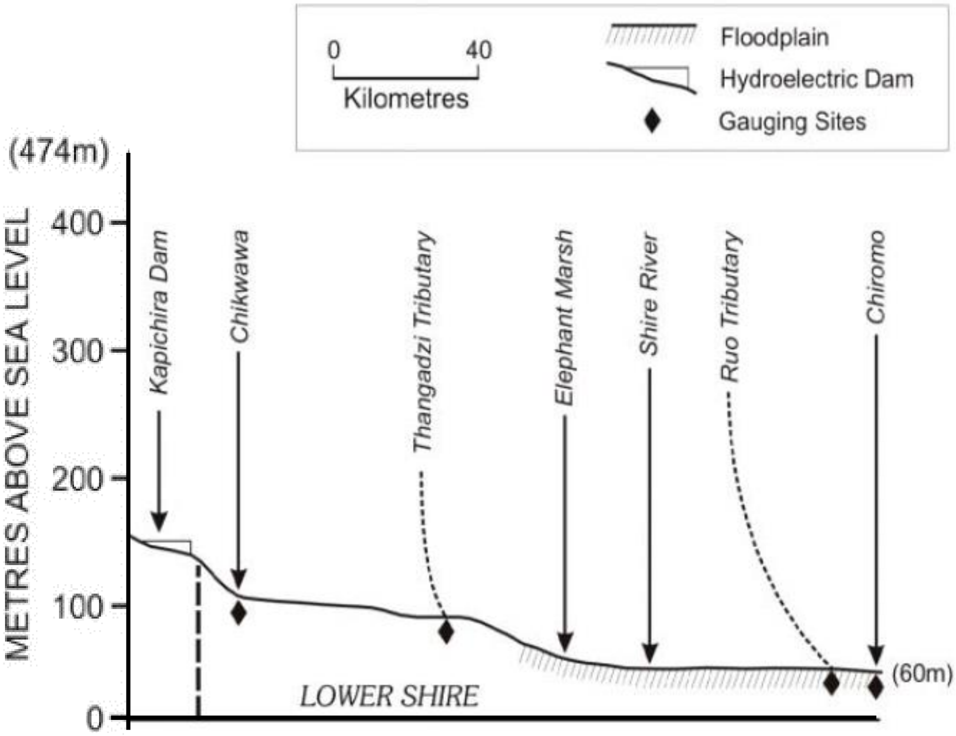
With the exception of the Likhubula, Mwamphanzi and Ruo, the left-bank tributaries of the Shire River are smaller than the right-bank ones.

The Gravelius compactness coefficient is superior to 1.5 for all the sub-basins, and to 2 in almost all cases. This underlines that the watersheds of the tributaries have lengthened shapes which fosters the spreading of surface runoff.

Figure 4 shows the Lower Shire River Profile from Kapichira Dam (147 masl.) to Chiromo Bridge (60 masl.).

The average slope of the Lower Shire River is extremely gentle of about 1‰.

Figure 4 Lower Shire River Profile from Kapichira Dam to Chiromo Bridge



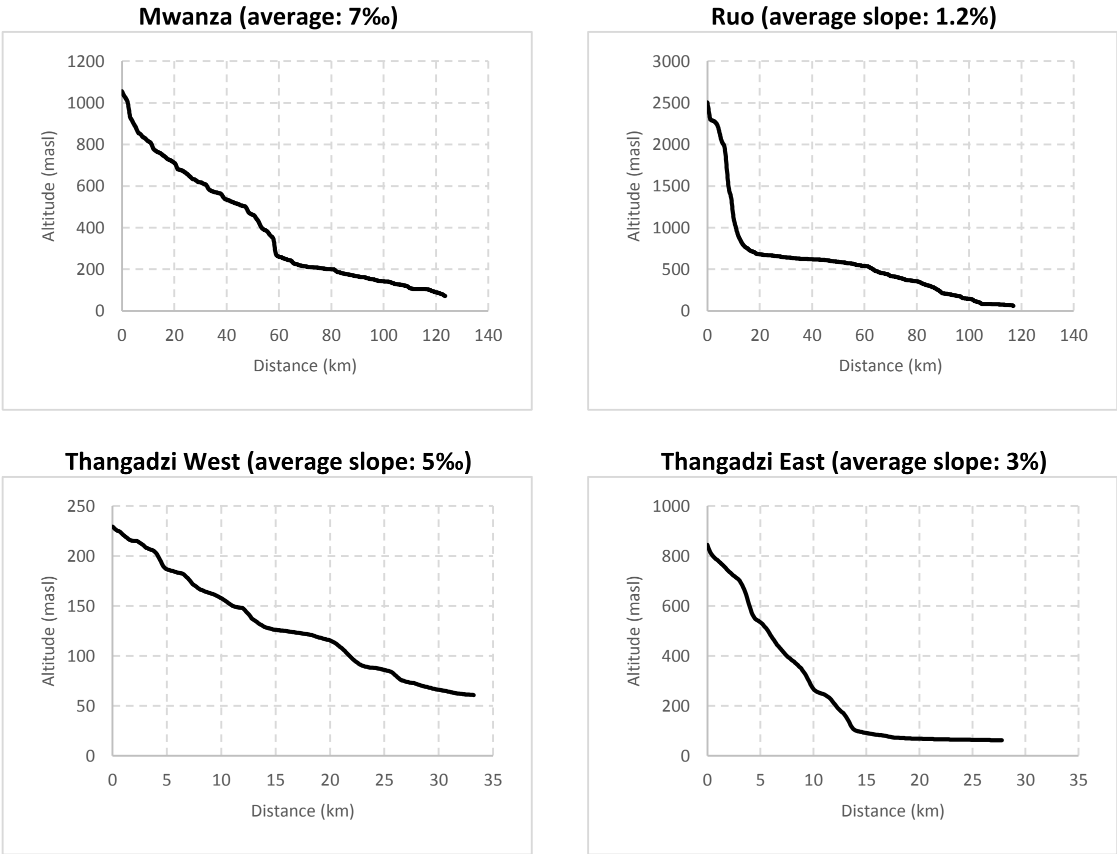
Source: NWRMP, 1986

The Figure 5 shows the profile delineations based on Shuttle Radar Topography Mission, SRTM[1] of 4 representative tributaries: Mwanza, Ruo, Thangadzi West and East.

The average slopes and the slope breaks between the escarpments and the plain are more marked for the left-bank tributaries which accelerates the surface runoff.

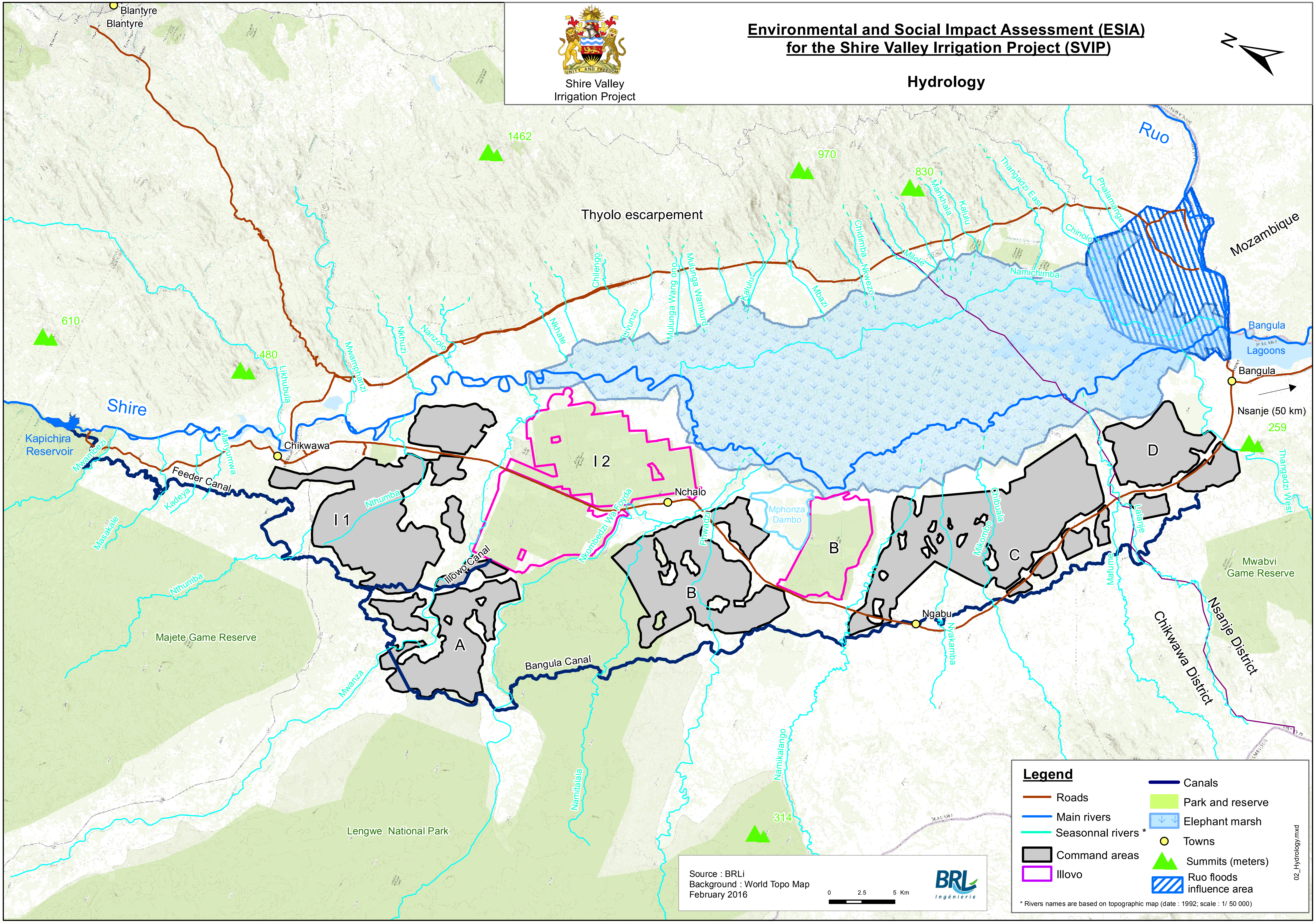
1 Jarvis, A., H.I. Reuter, A. Nelson, E. Guevara, 2008, Hole-filled SRTM for the globe Version 4, available from the CGIAR-CSI SRTM 90m Database (http://srtm.csi.cgiar.org).

Figure 5 River Profiles of Mwanza, Ruo, Thangadwi West and East



Source: BRLi, 2016

The main rivers network are shown on the map next page.


Environmental and Social Impact Assessment (ESIA)
for the Shire Valley Irrigation Project (SVIP)
Hydrology
Shire Valley
Irrigation Project
UNITY AND FREEDOM
Blantyre
Thyolo escarpement
Ruo
Mozambique
Shire
Kapichira
Reservoir
Chikwawa
Nchalo
Ngabu
Bangula
Bangula
Lagoons
Nsanje (50 km)
Feeder Canal
Illovo Canal
Bangula Canal
I 1
I 2
A
B
B
C
D
Mphonza
Dambo
Majete Game Reserve
Lengwe National Park
Mwabvi
Game Reserve
Chikwawa District
Nsanje District
1462
970
830
610
480
259
314
Likhubula
Mwamphanzi
Nkhuzi
Nanzolo
Nkhate
Chilengo
Livunzu
Mulunga Wang ono
Mulunga Wamkulu
Kalulu
Mbazi
Chidimba
Nkwezo
Mankhala
Katulu
Thangadzi East
Phalamanga
Chinolo
Namichimba
Milole
Mwambezi
Manyumwa
Kadeya
Nthumba
Masakale
Mwanza
Nkombedzi Wa Fodya
Phwadzi
Chibuala
Mikombo
Lalanje
Mafume
Thangadzi West
Nyakamba
Namikalango
Namitalala
Legend
Roads
Main rivers
Seasonnal rivers *
Command areas
Illovo
Canals
Park and reserve
Elephant marsh
Towns
Summits (meters)
Ruo floods
influence area
* Rivers names are based on topographic map (date : 1992; scale : 1/ 50 000)
Source : BRLi
Background : World Topo Map
February 2016
0 2.5 5 Km
BRL
Ingénierie
02_Hydrology.mxd

4.4 RIVER HYDROLOGY

The hydrology of the Study area is dominated by the outflows from Lake Malawi, which flows through Lake Malombo and feeds the Shire River.

WATER RESOURCES

The flow in the Shire River is highly regulated by the water level in Lake Malawi, in conjunction with the lake's natural outflow controls (a sand bar at 471.5 m above sea level , across the mouth of the Shire), and by the artificial influence of the Kamuzu Barrage at Liwonde (ATKINS, 2011).

There are several hydropower stations and dams on the Shire River between the Lake Malawi and the Kapichira Falls: the Nkula, Tedzani and Kapichira hydropower stations. The justification for building the Kamuzu Barrage as a control gate at Liwonde was to mitigate the possibilities of failure to maintain the design flow of 170 m³/sec for hydropower in the middle reach of the Shire River. The barrage is designed to reduce the risk to an acceptable level, by retaining water when the Lake level is relatively high and by releasing it at times when the level would otherwise have been too low (Kumambala, 2009).

Moreover, there are two major water abstraction points that also influence the flow in the Shire River at Kapichira (NORPLAN, 2013):

- Irrigation scheme of Mtengula: 5 m³/s for peak water demand.
- Drinking water supply for Blantyre Water Board: 2 m³/s maximum including possible extension.

The Shire River runoff at Kapichira is therefore highly influenced by the flow regulation of the Lake Malawi and Kamuzu Barrage and water abstractions for irrigation of Mtengula and drinking water supply for Blantyre (ATKINS, 2011) and (SMEC, 2014).

To take into account this upstream influence and to be consistent with the FS, the following flow estimates have been considered for the water resources assessment (Tables 2 and 3):

- ATKINS (2011) for the upstream part (flow at Kapichira);
- from SMEC (2014) for the downstream part (runoff for Mwanza River, right-bank and left-bank tributaries); and from
- BRLi (2016) for the Ruo River[2].

For the median year (table 2), the average annual flow for Shire River is 395 m³/s at Kapichira Dam and 489 m³/s at Chiromo Bridge.

For the quinquennial (5 years, table 3) dry year, the average annual flow for Shire River is 242 m³/s at Kapichira Dam and 287 m³/s at Chiromo Bridge.

[2] A GR2M hydrological model was implemented (Mouehli, 2003). The calibration was made with the historical time series discharge for the Ruo River at Sinoya South (4721 km²). The statistic calculations were made for the reference period from 1979-2009 as in (JICA, 2014) and (SMEC, 2014).

Table 2 Water Resources in the Lower Shire River Basin for Median Year

Q50 (m³/s)	Shire at Kapichira	Shire River from Kapichira to Chikwawa	Mwanza River	Right-Bank Tributaries except Mwanza River	Left-Bank Tributaries except Ruo River	Ruo River	Shire River at Chiromo (including Ruo River)
	138,031 km²	569 km²	1844 km²	2118 km²	2144 km²	4794 km²	149,500 km²
Nov	306	1.3	0.0	0.0	0.3	13.8	321
Dec	401	1.7	9.4	9.1	13.2	98.3	533
Jan	442	1.8	25.9	22.7	31.4	158.0	682
Feb	457	1.9	28.4	26.7	38.5	195.1	748
Mar	437	1.8	18.5	14.6	28.4	149.1	649
Apr	437	1.8	8.8	6.9	13.9	81.6	550
May	441	1.8	3.9	3.1	6.2	33.8	490
Jun	411	1.7	1.8	1.5	2.9	22.7	442
Jul	387	1.6	0.8	0.6	1.3	16.3	408
Aug	364	1.5	0.4	0.3	0.6	12.4	379
Sep	337	1.4	0.2	0.1	0.3	7.3	346
Oct	315	1.3	0.1	0.1	0.1	9.7	326
An.	395	1.6	8.2	7.1	11.4	66.5	489
Min.	306	1.3	0.0	0.0	0.1	7.3	321
Max.	457	1.9	28.4	26.7	38.5	195.1	748
Dry (Jun-Nov)	353	1.5	0.6	0.4	0.9	13.7	370
Wet (Dec-May)	436	1.8	15.8	13.9	21.9	119.3	609

Sources: ATKINS, 2011; SMEC, 2014 and BRLi, 2016

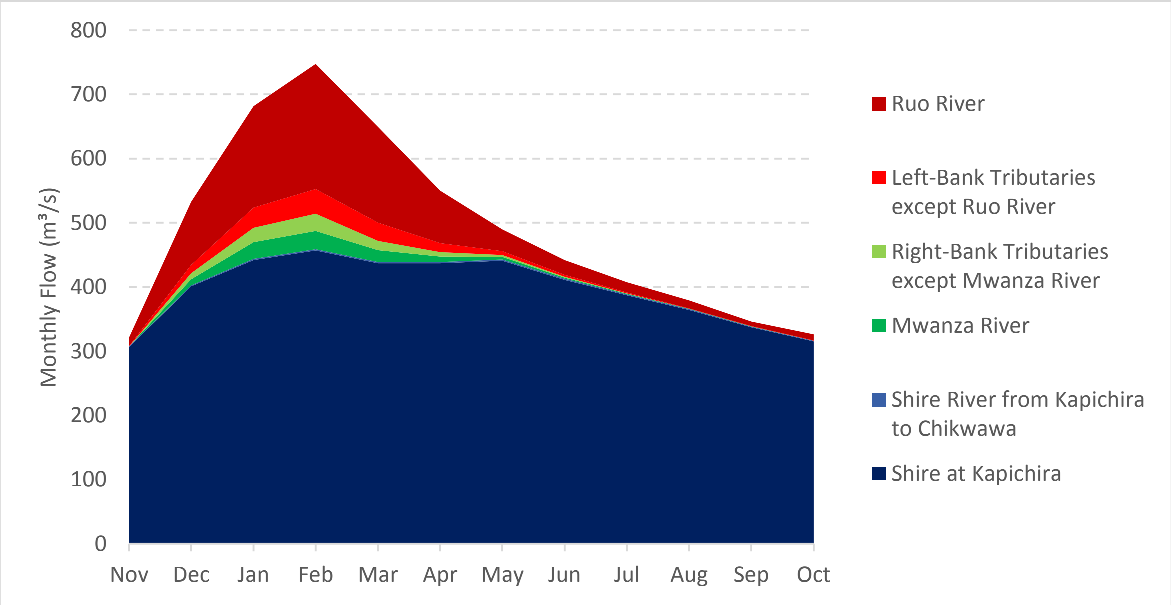
Table 3 Water Resources in the Lower Shire River Basin for Quinquennial Dry Year

Q80 (m³/s)	Shire at Kapichira	Shire River from Kapichira to Chikwawa	Mwanza River	Right-Bank Tributaries except Mwanza River	Left-Bank Tributaries except Ruo River	Ruo River	Shire River at Chiromo (including Ruo River)
	138,031 km²	569 km²	1844 km²	2118 km²	2144 km²	4794 km²	149,500 km²
Nov	181	0.7	0.0	0.0	0.0	8.1	190
Dec	267	1.1	0.0	0.0	0.4	45.8	314
Jan	280	1.2	12.6	2.9	14.5	88.1	399
Feb	308	1.3	8.5	6.3	14.4	111.5	450
Mar	253	1.0	5.9	2.6	6.7	79.0	348
Apr	269	1.1	2.8	1.2	3.3	46.2	324
May	329	1.4	1.2	0.5	1.4	26.7	360
Jun	243	1.0	0.6	0.3	0.7	15.7	261
Jul	226	0.9	0.3	0.1	0.3	12.0	240
Aug	201	0.8	0.1	0.1	0.2	7.6	210
Sep	173	0.7	0.1	0.0	0.0	3.9	178
Oct	172	0.7	0.0	0.0	0.0	3.4	176
An.	242	1.0	2.7	1.2	3.5	37.3	287
Min.	172	0.7	0.0	0.0	0.0	3.4	176
Max.	329	1.4	12.6	6.3	14.5	111.5	450
Dry (Jun-Nov)	199	0.8	0.2	0.1	0.2	8.4	209
Wet (Dec-May)	284	1.2	5.2	2.3	6.8	66.2	366

Sources: ATKINS, 2011; SMEC, 2014 and BRLi 2016

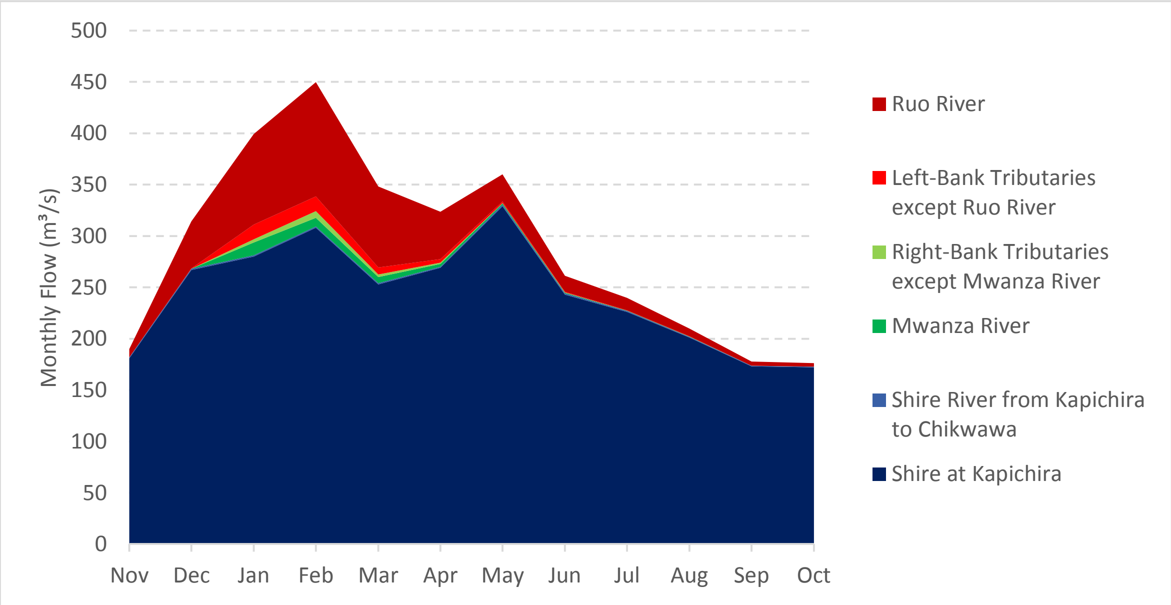
Figures 6 and 7show the decomposition of the hydrograph for Shire River at Chiromo Bridge between the different sub-basins for median, year and quinquennial dry year.

Figure 6 Dichotomy of the Hydrograph for Shire River at Chiromo Bridge in Median Year



Sources: ATKINS, 2011; SMEC, 2014 and BRLi 2016

Figure 7 Dichotomy of the Hydrograph for Shire River at Chiromo Bridge in Quinquennial Dry Year



Sources: ATKINS, 2011; SMEC, 2014 and BRLi 2016

Two peak flows are observed in the Lower Shire River during the hydrological year: the first peak occurs in January and the second one in May. The second peak is more pronounced in dry year than median year.

Tables 4 and 5 give the contribution percentages in the total water discharge for the Shire River at Chiromo Bridge, for the whole year, the dry period (from December to May), the wet period (from June to November) and the annual peak flow, of the following three different parts of the Shire River Basin:

- The Shire River at Kapichira Dam (upstream part of the Lower Shire River Basin).
- The tributaries of the Shire River from Kapichira Dam to Chiromo Bridge, including Mwanza River but not Ruo River (downstream part of the Lower Shire River Basin).
- The Ruo River at Chiromo Bridge.

Table 4 Contribution Percentages in the Total Water Discharge for the Shire River at Chiromo Bridge in Medium Year

Q50	Shire River at Kapichira Dam (138,031 km²)	Tributaries of the Shire River from Kapichira Dam to Chiromo Bridge including Mwanza (1,669 km²)	Ruo River at Chiromo Bridge (4,794km²)
Whole Year	81%	6%	14%
Dry Period (Dec-May)	95%	1%	4%
Wet Period (Jun-Nov)	72%	9%	20%
Peak	61%	13%	26%

Sources: ATKINS, 2011; SMEC, 2014 and BRLi, 2016

Table 5 Contribution Percentages in the Total Water Discharge for the Shire River at Chiromo Bridge in Quinquennial Dry Year

Q80	Shire River at Kapichira Dam (138,031 km²)	Tributaries of the Shire River from Kapichira Dam to Chiromo Bridge including Mwanza (1,669 km²)	Ruo River at Chiromo Bridge (4,794km²)
Whole Year	84%	3%	13%
Dry Period (Dec-May)	95%	1%	4%
Wet Period (Jun-Nov)	78%	4%	18%
Peak	73%	7%	25%

Sources: ATKINS, 2011; SMEC, 2014 and BRLi, 2016

The upstream part of the basin at Kapichira Dam controls approximately 80% of the average annual flow of the whole basin at Chiromo Bridge. The intermediary part of the basin from Kapichira to Chiromo (including Mwanza but not Ruo) only contributes for about 5%. The remaining 15% are driven by the Ruo River.

During the dry season, 95% of the total flow at Chiromo are controlled by the upstream basin at Kapichira. The contribution of the intermediary basin is close to nil and the inflow of the Ruo River brings about 5%.

During the wet season, about 75% of the total flow at Chiromo are controlled by the upstream basin at Kapichira. The contribution of the intermediary basin counts for about 5% to 10% and the inflow of the Ruo River rises up to 20% and to 25% of the peak flow.

Thus, on the one hand, the Elephant Marsh hydrological behaviour during the dry season is almost entirely driven by the upstream basin of the Shire River at Kapichira and consequently the main leverage for action to satisfy the minimum environmental flow for Elephant Marsh is the Kamuzu Barrage.

On the other hand, during the wet season, the Elephant Marsh inundation is mainly due to the Shire River but also to the Ruo River that brings more than the quarter of the inflow in the wetlands.

FLOODING

Floods inundate low-lying areas such as Lower Shire Valley and particularly in Chikwawa and Nsanje Districts which are more vulnerable to floods than higher elevated areas.

The places that are more exposed to the flood risk include the floodplains of the Mwanza, Nkombedzi-wa-fodya, Thangadzi West and Lalanje on the west bank of the Shire River and the places close to the confluence of the Ruo and the Shire rivers, especially Sankhulani, Makhanga and Bangula; and low-lying areas along the banks of the Shire River from Chiromo to Nsanje.

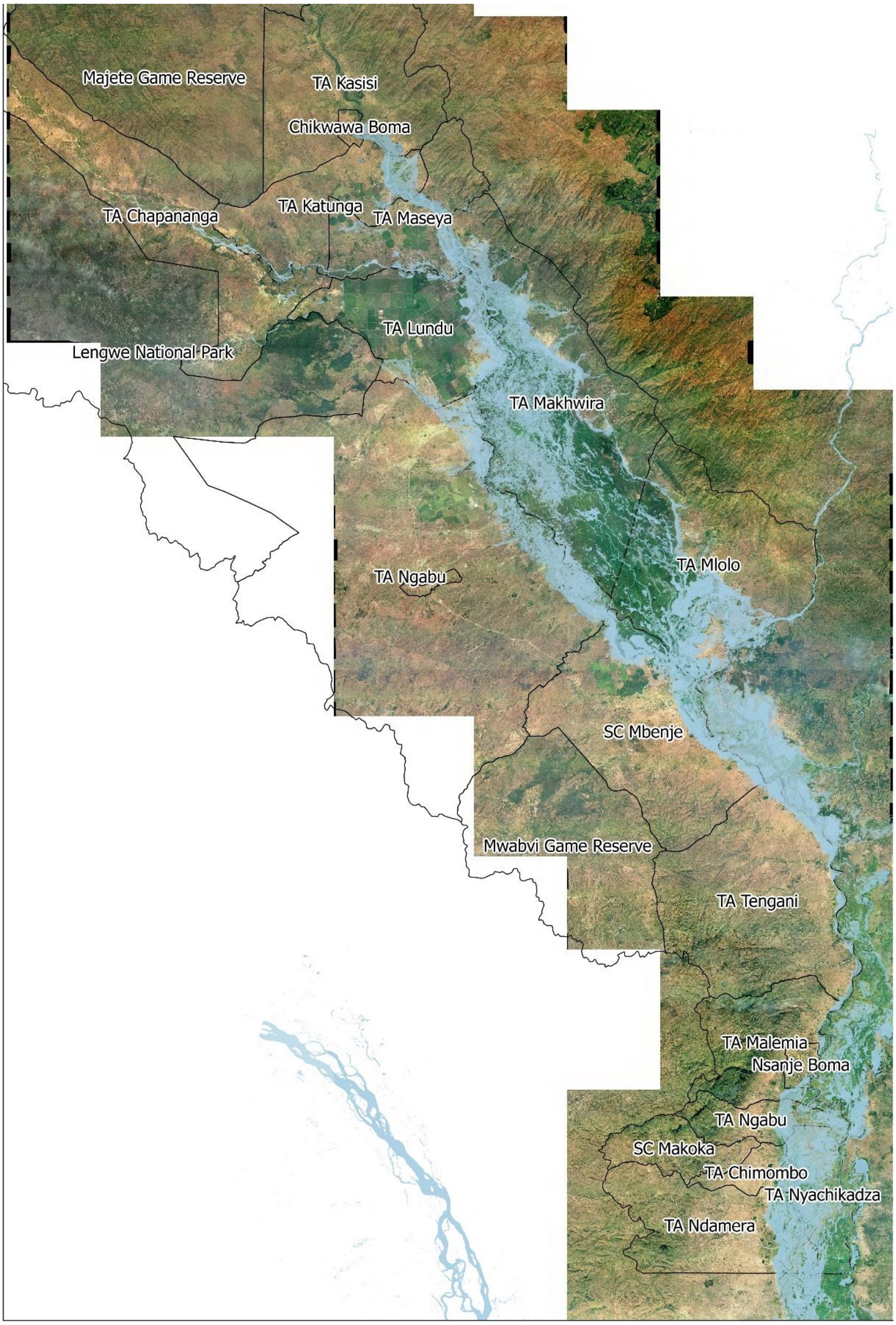
Flooding problems in the lower stretches of the Shire River and the Ruo River floodplain (Elephant Marsh) are due to the concomitance of the high-flow periods of both water courses (see previous section). The flood phenomenon is characterized by a slow dynamics with peak flow durations of one to three months.

By inundating 265 km² mainly inside the Elephant marsh and by stranding more than 20,000 people, the floods of January 2015 were the most severe and the more devastating floods in living memory in the Shire Valley. The following figures show the extent of floods.

Figure 8 Aerial View of the Shire River and Ruo River at Chiromo Bridge and of the Elephant Marsh Floodplain during the Floods of January 2015

Photo Credit ©2015 WWFA

Figure 9 Extend of January 2015 flood (in blue)



Source: BRLi, Aurecon 2015

Due to the flow intensity of the Ruo River cascading from the Mulanje Mountain, its inflow in the Shire River is forced back at the confluence of the two rivers. The buildup of water pressure exerts an immense force on the Bangula - Makhanga road embankment, often breaching the road, as it was the case in January 2015. One year later, during the baseline mission in January 2016, it was observed that the bridge was still not rebuilt, as shown in Figure 10 below.

Figure 10 Broken Bridge over the Shire River at Chiromo

Photo Credit ©2016 BRLi

Flooding problems that occur within the sub-basins of the Lower Shire River tributaries are partly a consequence of sediment deposition in river channels, reservoirs and floodplains, which originate from degraded catchments. As a result, there is substantial loss of arable land and damage to irrigation infrastructure. The flood phenomenon is characterized by fast dynamics with peak flow durations from few hours to few days and it can be described as “flash floods”.

The Mwanza River causes flooding over a very wide area, extending to and covering the low-lying areas of the Lengwe National Park, the Illovo Sugar Estates and villages around Tomali, Beleu and others. In less than 24 hours, the flow can pass from zero to more than 100 m³/s as observed for the flash flood that occurred January 27th 2016 during the baseline mission (Pictures 10 and 11).

Figure 11 Mwanza River at the Bridge of the M1 National Road, completely dry the January 26th 2016

Photo Credit ©2016 BRLi

Figure 12 Mwanza River at the Bridge of the M1 National Road, completely overflowed the January 27th 2016

Photo Credit ©2016 BRLi

IMPACT OF CLIMATE CHANGE

Climate change can impact the hydrological conditions through changes in precipitation and evapotranspiration. Due to the large surface area of Lake Malawi as compared to the catchment area, the Shire River is more vulnerable to increased evaporation than most rivers of Malawi.

The IPCC Fifth Assessment Report[3] summarizes the results of 42 different Global Circulation Models (GCMs) in the regional summary for Africa (IPCC, 2013). Table 6 below and the Figures 13,14,15 and 16 on the next pages shows the changes on an annual basis, + 2.1°C increase in temperature at the horizon 2100 and between -2% and -5% decrease in precipitation.

These simulations are based on the RCP4.5[4] emission scenario characterized by:

- Greenhouse gas emission: medium-low mitigation.
- Agricultural area: very low for both cropland and pasture.
- Air pollution: Medium.

Table 6 Temperature and Precipitation Projections by the CMIP5 Global Models for South Africa Region (source: IPCC, 2013)

RCP4.5			Temperature (°C)					Precipitation (%)				
REGION	MONTH[a]	Year	min	25%	50%	75%	max	min	25%	50%	75%	max
Southern Africa	DJF	2035	0.6	0.7	0.9	1.1	1.3	−11	−4	−2	0	3
		2065	1.0	1.4	1.7	2.0	2.6	−19	−5	−3	−1	4
		2100	1.1	1.8	2.1	2.7	3.3	−19	−7	−3	1	5
	JJA	2035	0.5	0.8	0.9	1.0	1.5	−18	−9	−4	−1	9
		2065	1.1	1.5	1.7	2.0	2.5	−29	−13	−8	−3	4
		2100	1.4	1.8	2.1	2.6	3.3	−29	−18	−9	−3	12
	Annual	2035	0.6	0.8	0.9	1.0	1.4	−13	−5	−2	0	4
		2065	1.1	1.5	1.7	2.1	2.6	−15	−7	−4	−1	4
		2100	1.4	1.8	2.1	2.7	3.3	−20	−7	−5	−1	5

The figures shown are averages over the South Africa region (Seneviratne et al., 2012) of the projections by a set of 42 global models for the RCP4.5 scenario. The area-mean temperature and precipitation responses are first averaged for each model over the 1986–2005 period from the historical simulations and the 2016–2035, 2046–2065 and 2081–2100 periods of the RCP4.5 experiments. Based on the difference between these two periods, the table shows the 25th, 50th and 75th percentiles, and the lowest and highest response among the 42 models, for temperature in degrees Celsius and precipitation as a percent change.

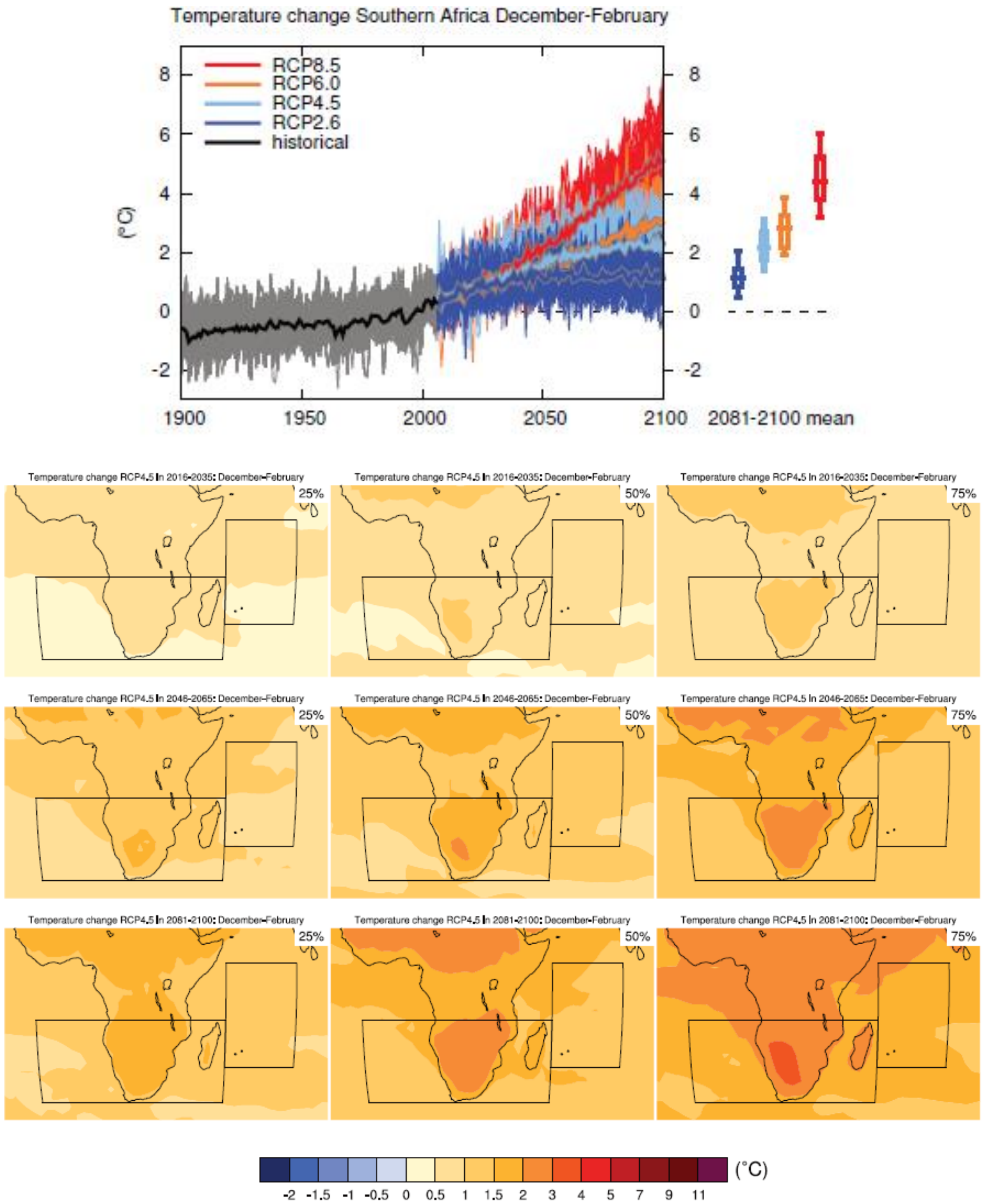
On one hand, the available climate projections for the Shire River basin at the horizon 2100 do not give grounds for changing the average estimates for flow and runoff. This is partly due to the fact that the Shire/Lake Malawi lies in the transition zone between South Africa climatology and East African climatology, and this probably adds a level of uncertainty.

However, on the other hand, it must be expected that the variability (which is already large) increases, and that the extremes (both floods and droughts) will be more pronounced.

[3] IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

[4] Stabilization without overshoot pathway to 4.5 W/m2 (~650 ppm CO2 eq) at stabilization after 2100 (Clarke et al. 2007; Smith and Wigley 2006; Wise et al. 2009) — GCAM

Figure 13 Time Series and Maps of Temperature Change Southern Africa December-February

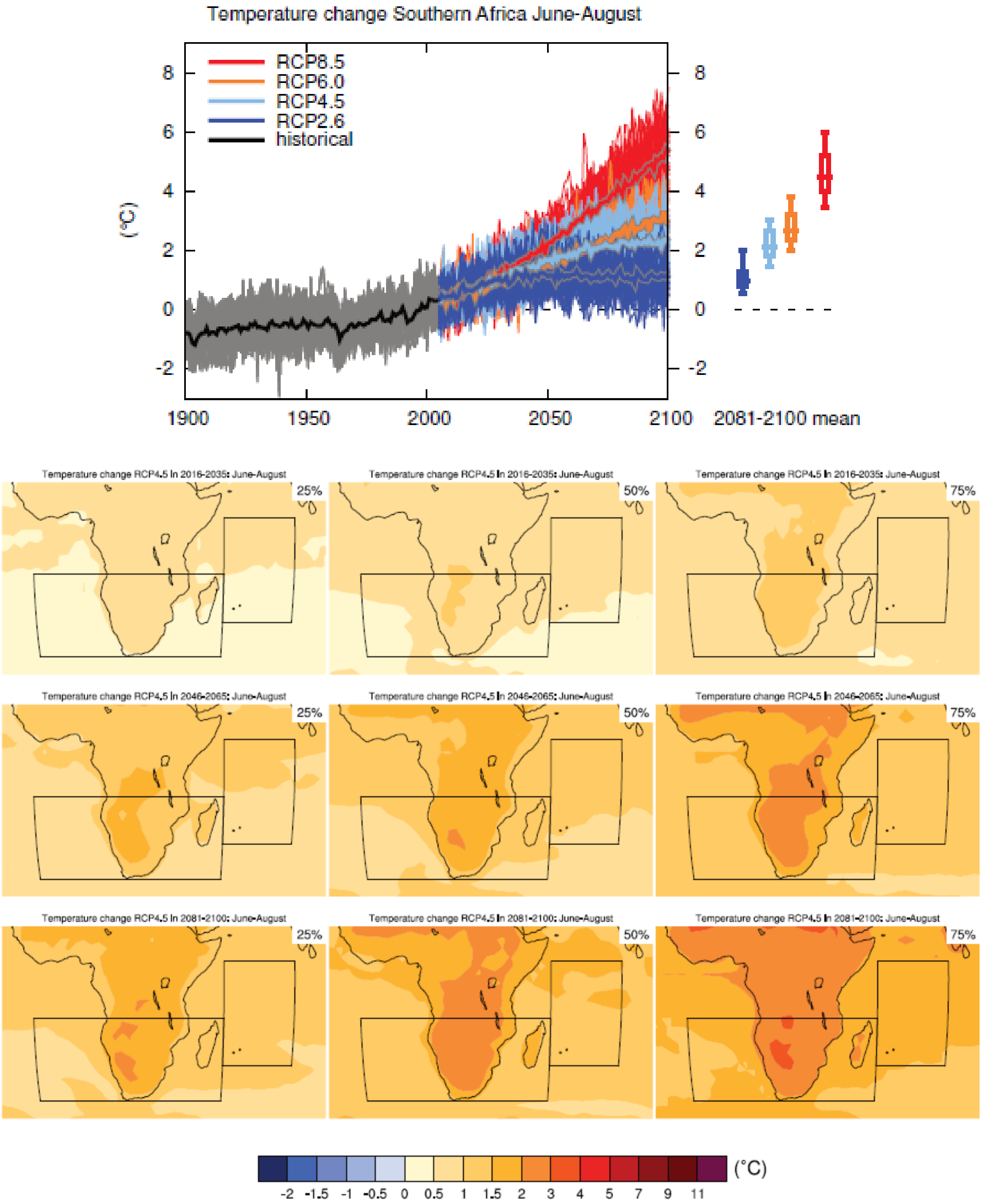


(Top left) Time series of temperature change relative to 1986–2005 averaged over land grid points in Southern Africa (35°S to 11.4°S, 10°W to 52°E) in December to February. (Top right) Same for sea grid points in the West Indian Ocean (25°S to 5°N, 52°E to 75°E). Thin lines denote one ensemble member per model, thick lines the CMIP5 multi-model mean. On the right-hand side the 5th, 25th, 50th (median), 75th and 95th percentiles of the distribution of 20-year mean changes are given for 2081–2100 in the four RCP scenarios.

(Below) Maps of temperature changes in 2016–2035, 2046–2065 and 2081–2100 with respect to 1986–2005 in the RCP4.5 scenario. For each point, the 25th, 50th and 75th percentiles of the distribution of the CMIP5 ensemble are shown; this includes both natural variability and inter-model spread. Hatching denotes areas where the 20-year mean differences of the percentiles are less than the standard deviation of model-estimated present-day natural variability of 20-year mean differences.

Source: IPCC, 2013

Figure 14 Time Series and Maps of Temperature Change Southern Africa June-August

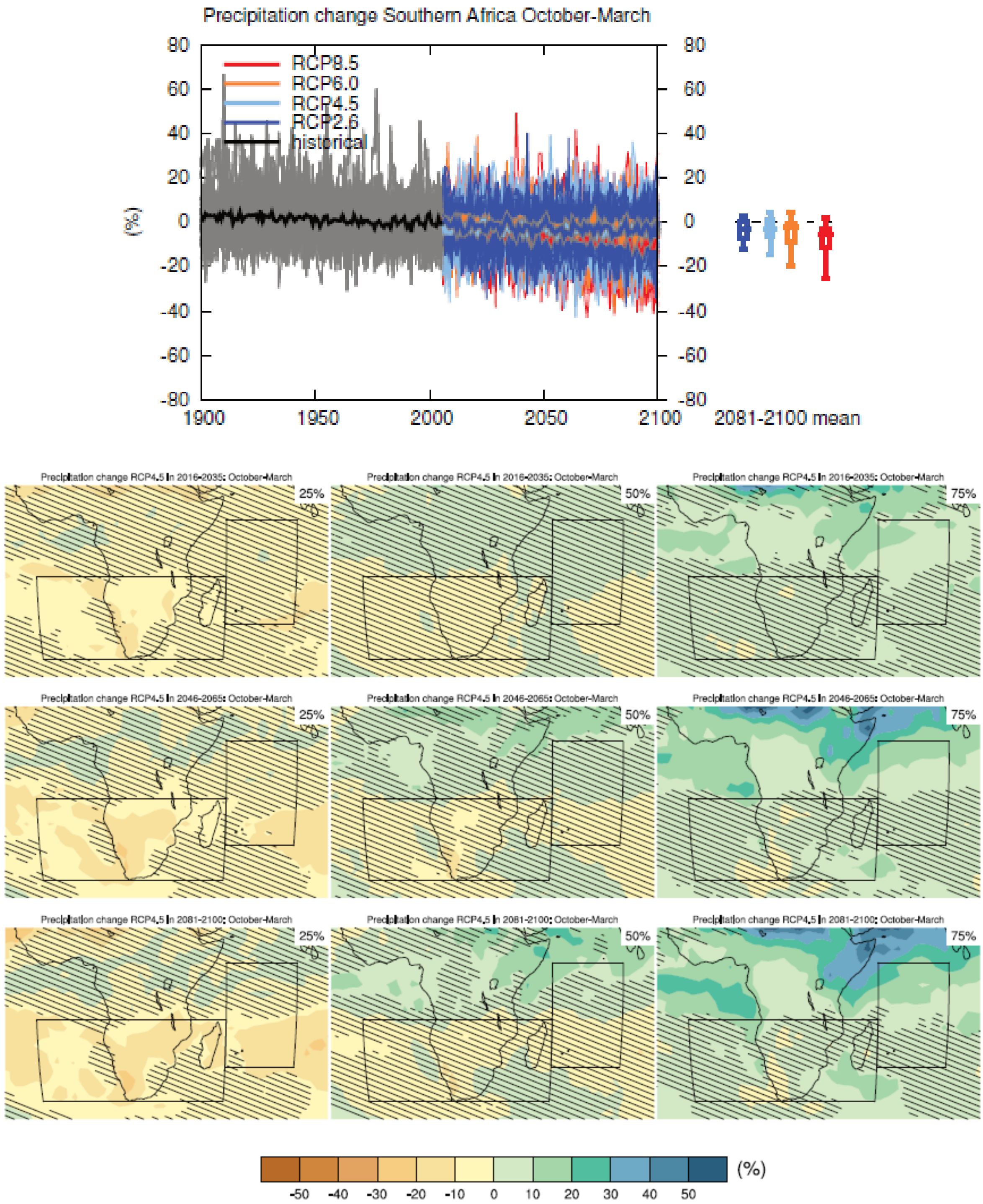


(Top left) Time series of temperature change relative to 1986–2005 averaged over land grid points in Southern Africa (35°S to 11.4°S, 10°W to 52°E) in June to August. (Top right) Same for sea grid points in the West Indian Ocean (25°S to 5°N, 52°E to 75°E). Thin lines denote one ensemble member per model, thick lines the CMIP5 multi-model mean. On the right-hand side the 5th, 25th, 50th (median), 75th and 95th percentiles of the distribution of 20-year mean changes are given for 2081–2100 in the four RCP scenarios.

(Below) Maps of temperature changes in 2016–2035, 2046–2065 and 2081–2100 with respect to 1986–2005 in the RCP4.5 scenario. For each point, the 25th, 50th and 75th percentiles of the distribution of the CMIP5 ensemble are shown; this includes both natural variability and inter-model spread. Hatching denotes areas where the 20-year mean differences of the percentiles are less than the standard deviation of model-estimated present-day natural variability of 20-year mean differences.

Source: IPCC, 2013

Figure 15 Time Series and Maps of Precipitation Change Southern Africa October-March

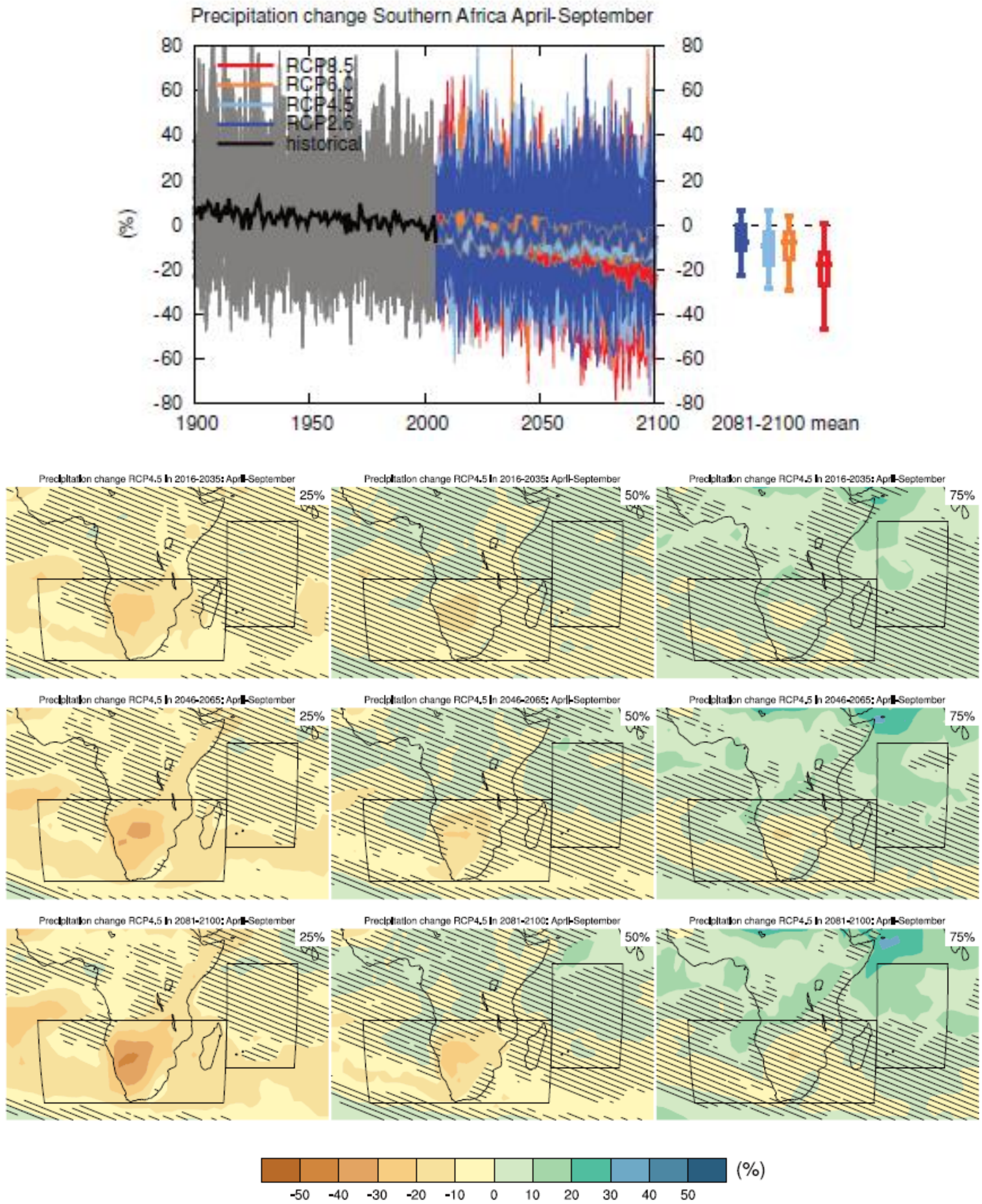


(Top left) Time series of relative change relative to 1986–2005 in precipitation averaged over land grid points in Southern Africa (35°S to 11.4°S, 10°W to 52°E) in October to March. (Top right) Same for sea grid points in the West Indian Ocean (25°S to 5°N, 52°E to 75°E). Thin lines denote one ensemble member per model, thick lines the CMIP5 multi-model mean. On the right-hand side the 5th, 25th, 50th (median), 75th and 95th percentiles of the distribution of 20-year mean changes are given for 2081–2100 in the four RCP scenarios.

(Below) Maps of precipitation changes in 2016–2035, 2046–2065 and 2081–2100 with respect to 1986–2005 in the RCP4.5 scenario. For each point, the 25th, 50th and 75th percentiles of the distribution of the CMIP5 ensemble are shown; this includes both natural variability and inter-model spread. Hatching denotes areas where the 20-year mean differences of the percentiles are less than the standard deviation of model-estimated present-day natural variability of 20-year mean differences.

Source: IPCC, 2013

Figure 16 Time Series and Maps of Precipitation Change Southern Africa June-August



(Top left) Time series of relative change relative to 1986–2005 in precipitation averaged over land grid points in Southern Africa (35°S to 11.4°S, 10°W to 52°E) in April to September. (Top right) Same for sea grid points in the West Indian Ocean (25°S to 5°N, 52°E to 75°E). Thin lines denote one ensemble member per model, thick lines the CMIP5 multi-model mean. On the right-hand side the 5th, 25th, 50th (median), 75th and 95th percentiles of the distribution of 20-year mean changes are given for 2081–2100 in the four RCP scenarios.

(Below) Maps of precipitation changes in 2016–2035, 2046–2065 and 2081–2100 with respect to 1986–2005 in the RCP4.5 scenario. For each point, the 25th, 50th and 75th percentiles of the distribution of the CMIP5 ensemble are shown; this includes both natural variability and inter-model spread. Hatching denotes areas where the 20-year mean differences of the percentiles are less than the standard deviation of model-estimated present-day natural variability of 20-year mean differences.

Source: IPCC, 2013

4.5 ELEPHANT MARSH HYDROLOGY

4.5.1 Data Collection and Processing

This assessment is based on a characterization of inundated areas, which is defined as areas where the water is above the ground level with a depth sufficient to temporarily cover plants. As explained in sections on wetland ecology, the Elephant marsh has been delineated based on a standardized method. The method is not based on the level of inundation but rather on the presence of hygrophilous plant species (wetland plant species) although inundation due to surface water inputs is the main contributor of water to the system.

The following data were collected:

- Landsat 8[5] images for 2014 and 2015.
- GIEMS-D15[6] pixels (high-resolution global inundation map at a pixel size of 15 arc-seconds).

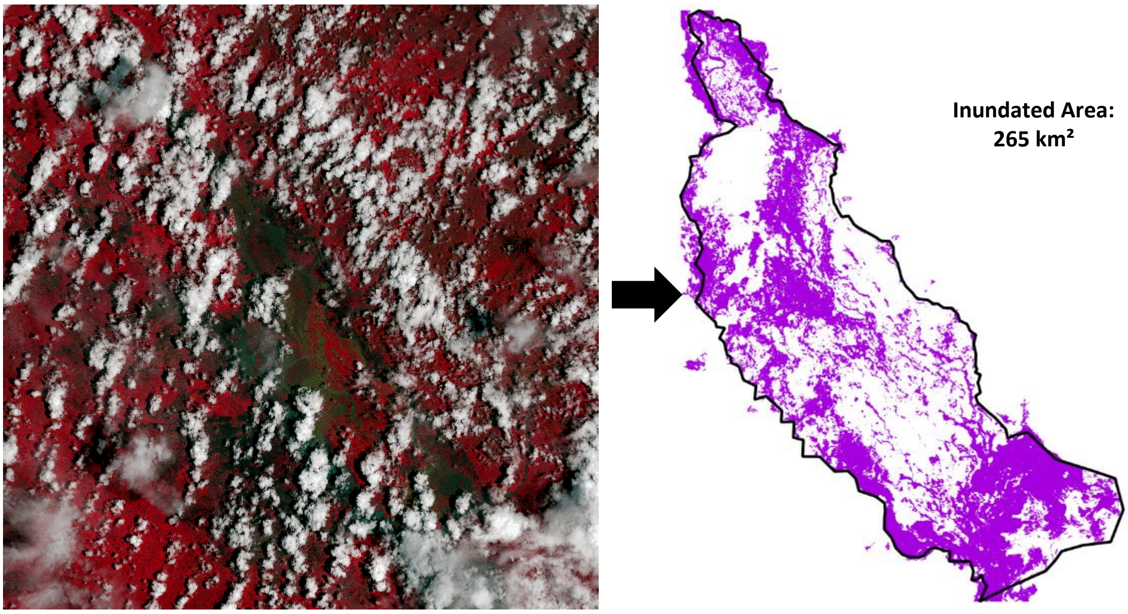
The Landsat 8 images were processed to estimate the inundated area of the Elephant Marsh for the floods of January/February 2015 that are the most severe and the more devastating floods in living memory in the Shire Valley and for the very severe drought of 2015 (minimum in November), as shown in Figures 17 and 18.

[5] Landsat imagery courtesy of NASA Goddard Space Flight Center and U.S. Geological Survey

[6] Fluet-Chouinard E., Lehner B., Rebelo L.M., Papa F., Hamilton S.K. (2015): Development of a global inundation map at high spatial resolution from topographic downscaling of coarse-scale remote sensing data. Remote Sensing of Environment 158: 348-361. dx.doi.org/10.1016/j.rse.2014.10.015

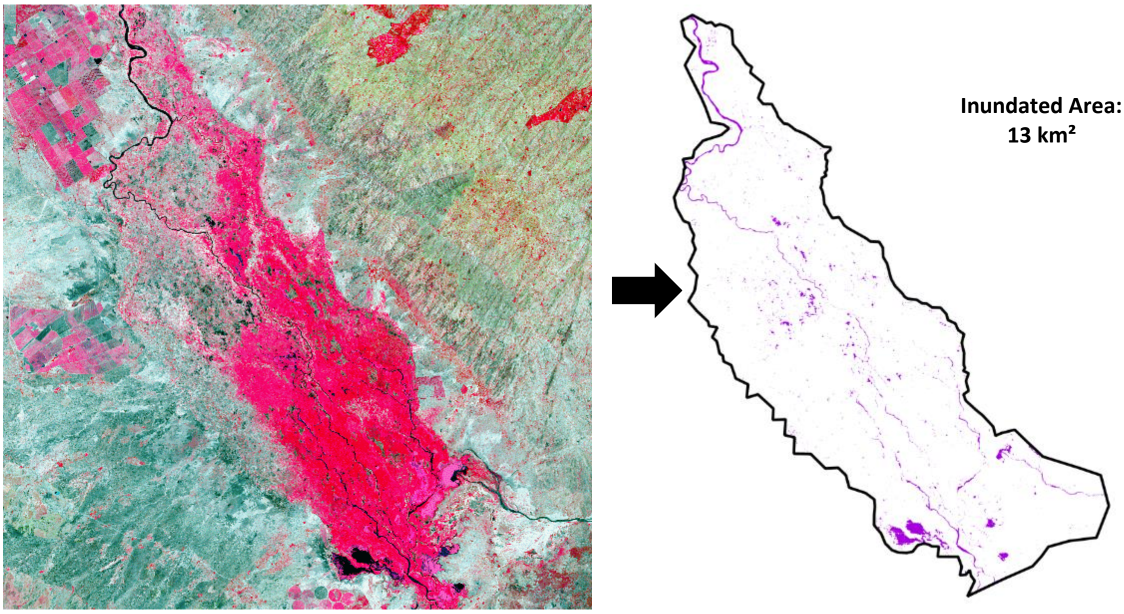
Prigent, C., Papa, F., Aires, F., Rossow, W. B. & Matthews, E. (2007). Global inundation dynamics inferred from multiple satellite observations, 1993-2000. Journal of Geophysical Research, 112(D12107), 1-1

Figure 17 Inundated Area of the Elephant Marsh in January/February 2015



Source: NASA/USGS, 2015 – data processing by BRLi, 2016

Figure 18 Inundated Area of the Elephant Marsh in November 2015



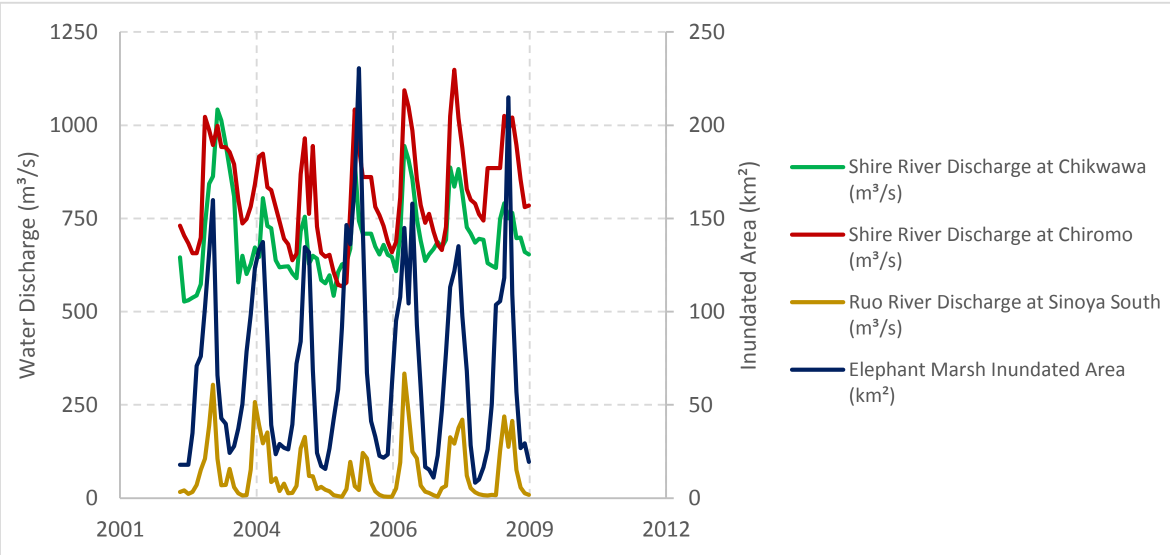
Source: NASA/USGS, 2015 – data processing by BRLi, 2016

The GIEMS-D15 pixels were processed to analyse the trends of the Elephant Marsh inundated area from 2002 to 2009 and the correlation with flow time series of Shire River at Chikwawa (station code: 1L12), Shire River at Chiromo (1G1) and Ruo River at Sinoya South (14D1), as shown in Figures 19 and 19.

Figure 19 Inundated Area of the Elephant Marsh from 2002 to 2009

Source: Estellus, 2015 – data processing by BRLi, 2016

Figure 20 Inundated Area of the Elephant Marsh and Flow for Shire River at Chikwawa and Chiromo and for Ruo River at Sinoya South from 2002 to 2009



Sources: Estellus, 2015; ATKINS, 2011 and BRLi, 2016

4.5.2 Hydrological Baseline and Trends on the Elephant Marsh

As previously explained concerning the hydrology of Elephant Marsh:

- During the dry season, the Elephant Marsh hydrological behaviour is almost entirely driven by the upstream basin of the Shire River at Kapichira (95% of the inflow) and consequently the main leverage for action to warranty a minimum environmental flow for Elephant Marsh is the Kamuzu Barrage.
- During the wet season, the Elephant Marsh hydrological behaviour is mainly due to the Shire River (75% of the inflow) but also to the Ruo River that brings more than the quarter of the inflow in the wetlands.

INUNDATED AREA

For an average year, the inundated area of the Elephant Marsh varies between 20 km² at the minimum during the dry season to 160 km² at the peak during the wet season (calculations based on the GIEMS-D15 time series from 2002 to 2009).

The correlation coefficients were calculated between the annual maximum inundated area of the Elephant Marsh and the peak flow time series of Shire River at Chikwawa (station code: 1L12), Shire River at Chiromo (1G1) and Ruo River at Sinoya South (14D1), as given in the Table 7 below. This allows to describe the influence of Shire and Ruo at the peak of the inundation (when the inundation is maximum)

Table 7 Correlation Coefficients between the Annual Maximum Inundated Area of the Elephant Marsh and the Annual Peak Flows of Shire and Ruo Rivers

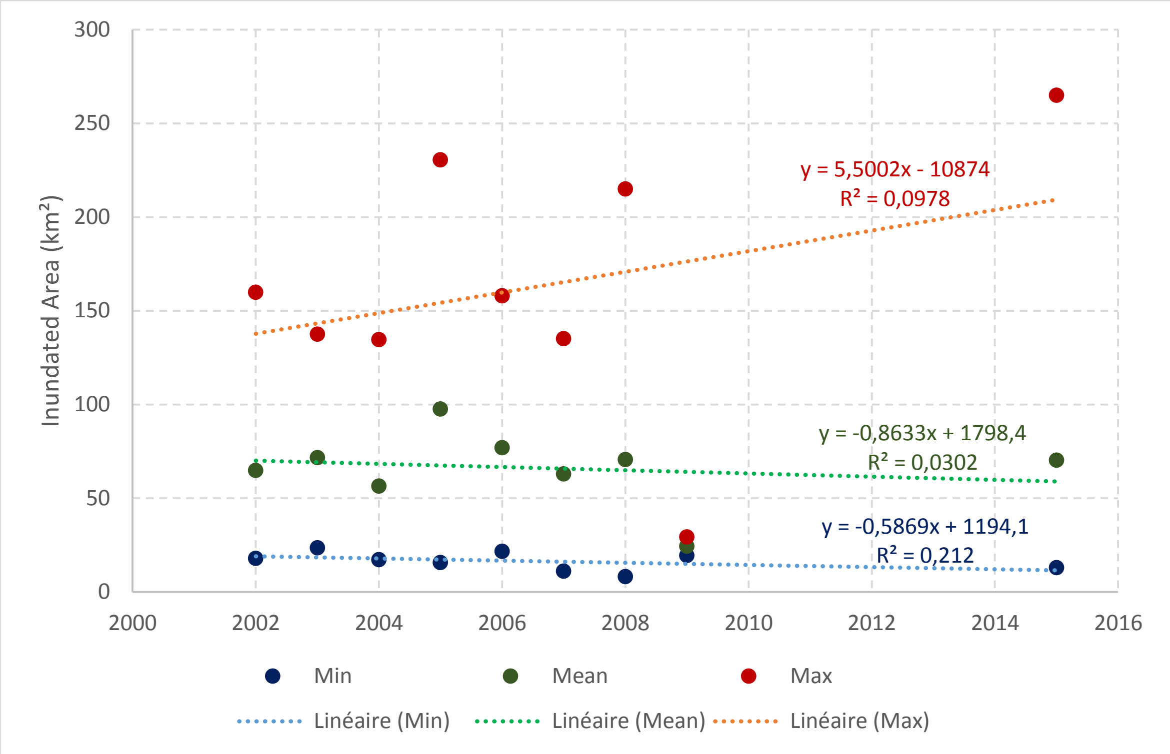
Correlation Coefficient	Part of the discharge responsible for Elephant Marsh inundated area
Shire River Discharge at Chikwawa	52%
Shire River Discharge at Chiromo	66%
Ruo River Discharge at Sinoya South	44%

Sources: Estellus, 2015; ATKINS, 2011 and BRLi, 2016

The results given in the Table 7 above shows that, at the peak of inundation of the Elephant Marsh (maximum inundation area), the contribution of Shire and Ruo are almost with equal explanatory factors. Shire brings constant water to the system and with higher proportion than Ruo (95 % during the dry season and 75% during the wet season), but when the inundation is at its peak, Ruo is almost equally responsible (44%) for surface area of inundated area than Shire (52-66%)

As shown in the Figure 21 below, unfortunately there is no clear trend that emerges regarding the annual average, minimum or maximum of the Elephant Marsh inundated area during the period from 2002 to 2009, and 2015. It should be noted that the year 2015 has the record for the maximum observed value with 265 km² while the record for the minimum 8 km² is in 2008.

Figure 21 Trends of the Annual Average, Minimum and Maximum of the Elephant Marsh Inundated Area from 2002 to 2009, and 2015



Sources: Estellus, 2015; ATKINS, 2011 and BRLi, 2016

OTHER INFLUENCES ON THE WETLAND

As presented in the section on wetland ecology, inundated areas are sometimes also influenced by other factors than hydrology, such as embankment of Shire meanders (either by sand bars deposit or by manmade dikes). In addition, the contribution of seepages and groundwater to the wetland hydrology is unknown as there are currently no study available regarding groundwater hydrology.

4.6 SHIRE RIVER WATER QUALITY

Shire River water quality has been dealt with in the following studies:

- Water, Waste & Environment Consultants (2013) Shire River Basin Management Programme (Phase I) Project Final Environmental and Social Assessment Report.
- Atkins (2011) Water Resources Investment Strategy. Component 1 – Water Resources Assessment. Government of the Republic of Malawi.

Unfortunately, in these studies the level of information provided about the sampling methods does not allow to rely on their analysis as explained here below.

According to Atkins (2011), the presence of high levels of Iron (Fe) and Total Suspended Solids (TSS, mainly silt) in the Shire River makes water unsuitable for irrigation due to the risk of damage to equipment by causing clogging and deterioration of equipment or through stimulating algal growth, which in turn clogs valves, pipelines or filtering equipment. The presence of heavy load of silt will also necessitate constant mechanical removal at the water intake. Nitrate and phosphate, common pollutants in agricultural areas, were not identified as key water quality determinands causing poor or unsuitable water. Unfortunately, Atkins (2011) talks about “current water results” in the report but does not provide them.

Water, Waste & Environment Consultants (2013) presents three different water quality results in their report:

- Results for the Shire River from an old study from Saka and Ambali (1999)
- Results for the Shire River from an old study from Lakudzala et al. (1999).
- Results for Shire tributaries, although nothing is said about the origin of the data (they were collected during the rainy season in 2012).

Some results are shown in the following tables.

Table 8 1999 water quality for Shire River

Sample location	pH	Phosphates (mg/l)	Nitrates (mg/l)
Chikwawa bridge (Shire River)	7.28	1.12	1.12
Nchalo (Shire River)	7.42	2.94	0.94
Chiromo bridge (Shire River)	7.60	0.55	0.55

Source: adapted from Water, Waste & Environment Consultants (2013) quoted from Saka and Ambali (1999)

Table 9 1999 Water quality for Shire River

	Parameter (mg/l)				
	Sulfate SO_4^{2-}	Nitrate NO_3^-	Phosphate PO_4^{3-}	Lead (Pb)	Mercury (Hg)
Shire River upstream from confluence with Illovo flood control drain	14.9	<0.01	Not detected	1.0	Not detected
Illovo effluent water on flood control drain	2.7	<0.01	Not detected	Not detected	Not detected
Shire River downstream confluence with Illovo flood control drain	2.7	<0.01	Not detected	0.96	Not detected
Shire River downstream of Illovo	5.4	<0.01	Not detected	Not detected	Not detected

Source: adapted from Water, Waste & Environment Consultants (2013) quoted from Lakudzala et al (1999)

Due to their dates (17 years old), these results cannot be considered reliable anymore.

One time data were also collected at various points in Shire tributaries during the rainy season of 2012. Due to the high flow variability of these tributaries, these data are not ideal for an analysis of water quality. The following table presents the results, it shows that turbidity and total suspended solids have high figures, tributaries can indeed transport large quantities of material during the rainy season.

Table 10 2016 water quality at some Shire tributaries

Sample	TDS (ppm)	TSS (ppm)	Turbidity (NTU)	Nitrate NO_3^- (mg/l)	Phosphate PO_4^{3-}(mg/l)
Mwanza river	44.98	794	253	0.765	10.80
Lower Mwanza river	84.75	2205	2813	2.875	6.87
Likhubula river	158.50	715	101	2.600	1.67
Mkulumadzi river	42.90	1150	895	0.945	1.300
Mkudzi river	155.50	439	242	1.588	3.05
Mwamphanzi river	78.00	630	402	1.625	1.57

Source: adapted from Water, Waste & Environment Consultants (2013)

There are no data for coliforms (fecal and total) although given the high population density, coliforms are a potential issue.

These water quality data have to be compared to water quality standards for aquatic ecosystem. Unfortunately, Malawi does not have any guidelines for water quality for the safeguard of ecosystems. The closest country that has such guidelines is South Africa as shown in table 11 (South Africa Department of Water Affairs and Forestry, 1996). Both Nitrate and Phosphate are important criteria since the area is intensively cultivated. In addition, parameters related to turbidity are also important since the area is subject to flash floods with high loads of sediments. The tributary rivers are Mesotrophic according to Water, Waste & Environment Consultants (2013) results for phosphate and nitrate. Mesotrophic systems are usually productive with a risk of nuisance growth of aquatic plant but low risk of toxic algal blooms. TSS values for tributary rivers are higher than the normal background concentration which also limits suitability of habitats. According to these guidelines, TDS can only be assessed using long term water quality follow-up.

Table 11 South Africa guidelines for aquatic ecosystem

Nitrate NO_3^- (mg/l)	< 0.5 mg/l Oligotrophic conditions	0.5 - 2.5 mg/l Mesotrophic conditions	2.5 - 10 mg/l Eutrophic conditions	> 10 mg/l Hypertrophic conditions
Phosphate PO_4^{3-} (mg/l)	< 5 mg/l Oligotrophic conditions	5 - 25 mg/l Mesotrophic conditions	25 - 250 mg/l Eutrophic conditions	> 250 mg/l Hypertrophic conditions
TSS	Background concentration is < 100 mg/l Any increase in TSS concentrations must be limited to < 10 % of the background TSS concentrations at a specific site and time			
TDS	Concentrations should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year; **and** the amplitude and frequency of natural cycles in TDS concentrations should not be changed.			

Regarding drinking water, Malawi has standards that are close to those from the World Health Organization. Given the baseline situation in the valley with high human pressure on water resources, domestic use standards for surface water are not attainable especially for turbidity, fecal coliform and total coliform, it is therefore not recommended to drink water from any surface water.

4.7 SOIL, EROSION, SEDIMENT TRANSPORT AND GEOLOGY

4.7.1 Introduction

The Lower Shire valley is densely populated with over one million people living in the two most southern districts of Malawi, namely Chikwawa and Nsanje. Chikwawa and Nsanje districts form the Shire Valley Agricultural Development Division (SVADD) covering about 684,000ha. The large population pressure on the area causes severe erosion and degradation of land and water resources. In this context, the ESIA ToRs has requested to provide with a baseline characterization of soil in the Study area. In addition, this section present the local geology and describes the pattern of erosion and sediment transport.

4.7.2 Method

4.7.2.1 On site mission

In order to characterize soils in the Study area, the consultant Soil Specialist carried out a field mission from January 24 to 30, 2016. He met with relevant specialists from the Agricultural Department in Chikwawa, as well as other specialists in the ADD of the Project area. The Soil Specialist also met several times with the Team Leader and Soils Expert of the Korean Rural Corporation (KRC) executing the Feasibility Study and spent time on site with them for soil surveys.

The soil profiles that were inspected on site were unfortunately largely filled with recent flood waters. However, provisional classification was possible for the following soil type: Vertisols (three), Gleyic Cambisol, Chromic Luvisol, Eutric Luvisol, Haplic Calcisol/Calcic Luvisol.

4.7.2.2 Review of existing information

The availability of soils information has been checked from all possible sources. Relevant information has been obtained from Illovo Sugar at Nchalo, covering all their irrigation estates - however no soil maps were made available. A selection of existing older soils reports and maps has been obtained from KRC. Only limited new information was presented by KRC. Some additional data have been obtained from Kasinthula Smallholder Cane Growers and other sources. No relevant information could be obtained from the local Department of Agriculture in Chikwawa. Relevant information is as follows:

- Early Soil Surveys and Introduction of FAO Systems (1960-1991)
- Soils Information from CODA based on SOGREAH (1992-2008)
- Soils Information from Illovo (2015)
- Soil mapping of the Technical Feasibility Study (2016)
- Socio-economic Profile of Chikwawa District (Govt. Malawi, 2011)

These sources are further described in the sections hereunder.

4.7.3 Analysis of Available Soil Map and Information

This section presents an analysis of available soil information and maps.

The following table will ease understanding of the terms used in this section.

Table 12 Definition of soil types

Reference Soil Group (RSG)	Main Soil Characteristics
Alluvial	Alluvial soils are made of material left by the water of rivers and floods.
Arenosols	Arenosols comprise sandy soils, including soils developed in residual sands after in situ weathering of usually quartz-rich sediments or rock, and soils developed in recently deposited sands.
Calcisols	Calcisols accommodate soils having a substantial secondary accumulation of lime. Calcisols are common in highly calcareous parent materials and widespread in arid and semi-arid environments.
Cambisols	Cambisols combine soils with at least an incipient subsurface soil formation. Transformation of parent material is evident from structure formation and mostly brownish discoloration, increasing clay percentage, and/or carbonate removal.
Fluvisols	Fluvisols comprise soils developed in recent fluvial deposits, including lacustrine and marine Environment. No groundwater and no high salt contents in the topsoil; many Fluvisols under natural conditions are flooded periodically. Profiles with evidence of stratification; weak horizon differentiation but a distinct topsoil horizon may be present.
Gleysols	Gleysols comprise soils saturated with groundwater for long enough periods to develop reducing conditions resulting in gleyic properties. This pattern is essentially made up of reddish, brownish or yellowish colours at aggregate surfaces and/or in the upper soil layers, in combination with greyish/bluish colours inside the aggregates and/or deeper in the soil.
Leptosols	Leptosols are very shallow soils over continuous rock and soils that are extremely gravelly and/or stony. Leptosols are azonal soils and particularly common in mountainous regions.
Lixisols	Lixisols comprise soils that have a higher clay content in the subsoil than in the topsoil as a result of pedogenetic processes (especially clay migration) leading to an argic subsoil horizon. Lixisols have a high base saturation and low-activity clays at certain depths.
Luvisols	Luvisols are soils that have a higher clay content in the subsoil than in the topsoil as a result of pedogenetic processes (especially clay migration) leading to an argic subsoil horizon. Luvisols have high-activity clays throughout the argic horizon and a high base saturation at certain depths.
Nitisols	Nitisols are deep, well-drained, red, tropical soils with diffuse horizon boundaries and a subsurface horizon with more than 30 percent clay and moderate to strong angular blocky structure elements that easily fall apart into characteristic shiny, polyhedric (nutty) elements.
Phaeozems	Phaeozems accommodate soils of relatively wet grassland and forest regions in moderately continental climates. They have dark, humus-rich surface horizons and have a high base saturation in the upper meters of the soil.
Planosols	Planosols are soils with a light-coloured, surface horizon that shows signs of periodic water stagnation and abruptly overlies a dense slowly permeable subsoil with significantly more clay than the surface horizon.
Plinthosols	Plinthosols are soils with plinthite, petroplinthite or pisoliths. Plinthite is an Iron-rich (in some cases also Magnesium-rich), humus-poor mixture of kaolinitic clay (and other products of strong weathering such as gibbsite) with quartz and other constituents that changes irreversibly to a layer with hard nodules, a hardpan or irregular aggregates on exposure to repeated wetting and drying.
Regosols	Regosols are very weakly developed mineral soils in unconsolidated materials that do not have a mollic or umbric horizon, are not very shallow or very rich in gravels (Leptosols), sandy (Arenosols) or with fluvic materials (Fluvisols).

Reference Soil Group (RSG)	Main Soil Characteristics
Solonchaks	Solonchaks are soils that have a salic horizon with a high concentration of soluble salts at some time in the year. Solonchaks are largely confined to the arid and semi-arid climate zones; many have gleyic properties at some depth. In low-lying areas with a shallow water table, salt accumulation is strongest at the soil surface (external Solonchaks).
Solonetz	Solonetz are soils with a dense, strongly structured, clayey subsurface horizon that has a high proportion of adsorbed Na and/or Mg ions (natric horizon). Solonetz that contain free soda ($Na2CO3$) are strongly alkaline (field pH > 8.5). Other names are alkali soils and sodic soils; most Solonetz have never been reclaimed and are used for extensive grazing or lie idle.
Stagnosols	Stagnosols are soils with a perched water table showing redoximorphic features caused by surface water. Stagnosols are periodically wet and mottled in the topsoil and subsoil, with or without concretions and/or bleaching.
Vertisols	Vertisols are churning, heavy clay soils with a high proportion of swelling clays. They form deep wide cracks from the surface downward when they dry out, which happens in most years. The name Vertisols (from Latin *vertere*, to turn) refers to the constant internal turnover of soil material.

4.7.3.1 Early Soil Surveys and Introduction of FAO Systems (1960-1991)

Soil surveys were already executed during the colonial period. The Atlas of Malawi (1983) shows a soil map based on work from the early 1960's (University of East Anglia, A.Young & P.Brown). The two major soils in the lower part of the Lower Shire Valley are Alluvial Soils and Vertisols (with gleys), being subdivisions of Calcimorphic and Hydromorphic Soils. A different Soil Map of Malawi, however with similar legend approach (based on Young/Brown) was drawn by N.W.Lowole, showing dominant Vertisols around Ngabu, and also further upslope Vertisols associated with coarser gravellly soils.

The Soil Map of the World (FAO-Unesco, 1973) shows prominent units of Vertisols and Eutric Fluvisols (in association with Solonchak) in the Lower Shire valley bottom and Chromic Cambisols in association with Chromic Luvisols on the adjacent lower hill slopes.

The FAO Soil Legend and related Land Evaluation methodology was introduced to Malawi in the 1980's and the country was subsequently systematically mapped using FAO soil classification (Govt. Malawi, 1991).

In 1991, the Gouvernment of Malawi produced a map called the "Malawi Soil Classification Map" (Land Resources Department, MoA) using the FAO soil classification.

4.7.3.2 Soils Information from CODA based on SOGREAH (1992-2008)

Several CODA reports (CODA, 2005-2008) contain important soils information, in particular tender documents with soil map (CODA, 2008). These tender documents contain the results of soil surveys done by SOGREAH (1992), an Australian company using 1975 Soil Taxonomy (Soil Survey Staff, 1975, 1987, 1999) for soil classification as well as FAO Guidelines for Soil Description (1977). The area covered is located South of Chikwawa, around Kasinthula, and only forms Zone I-1 of the current Project (North of Mwanza River, North of Illovo). The soil map is shown in the following Figures 22 and 23.

Figure 22 Zone I-1 Soil Map by CODA (2006) overlaid with current project map

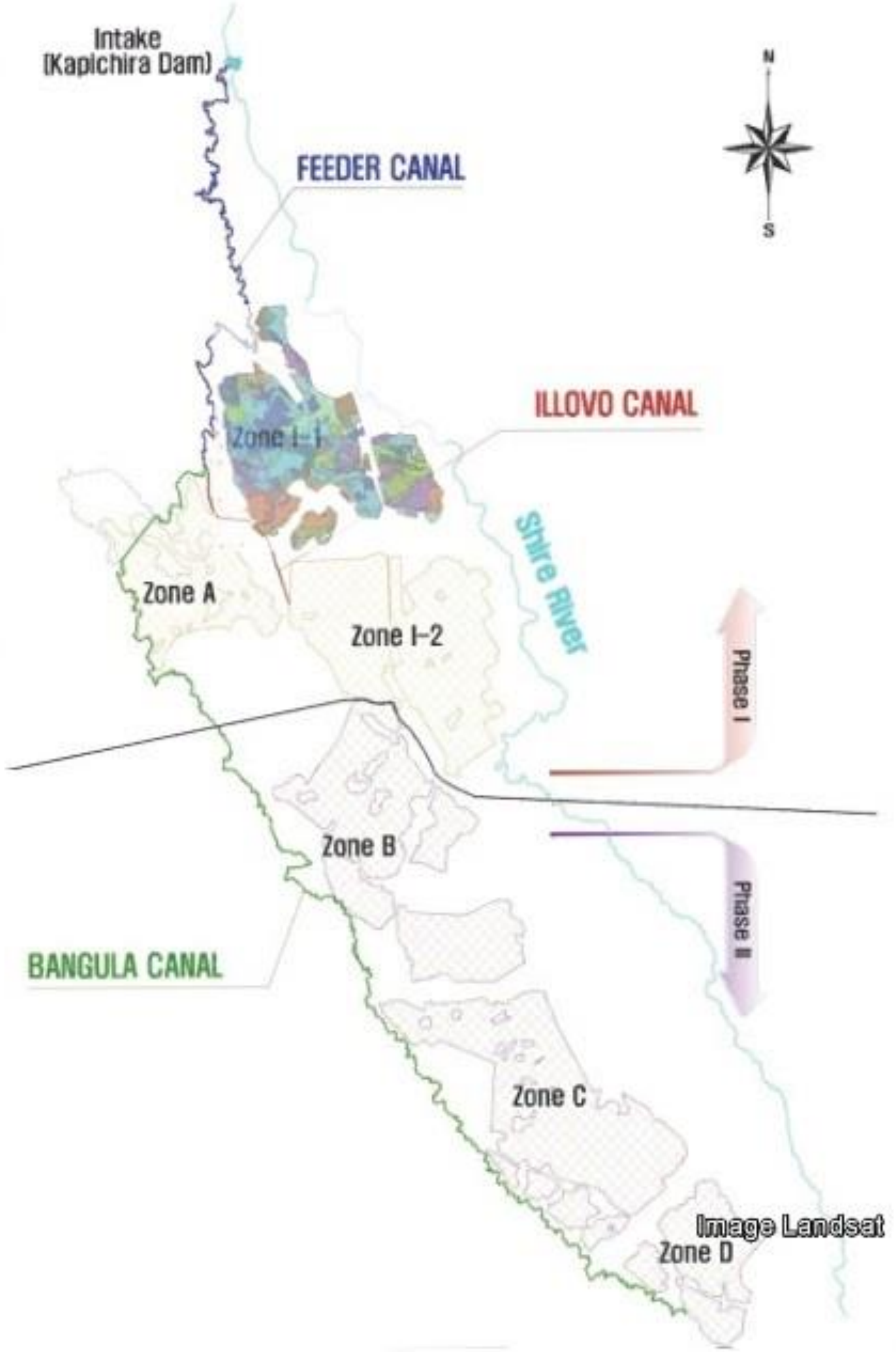
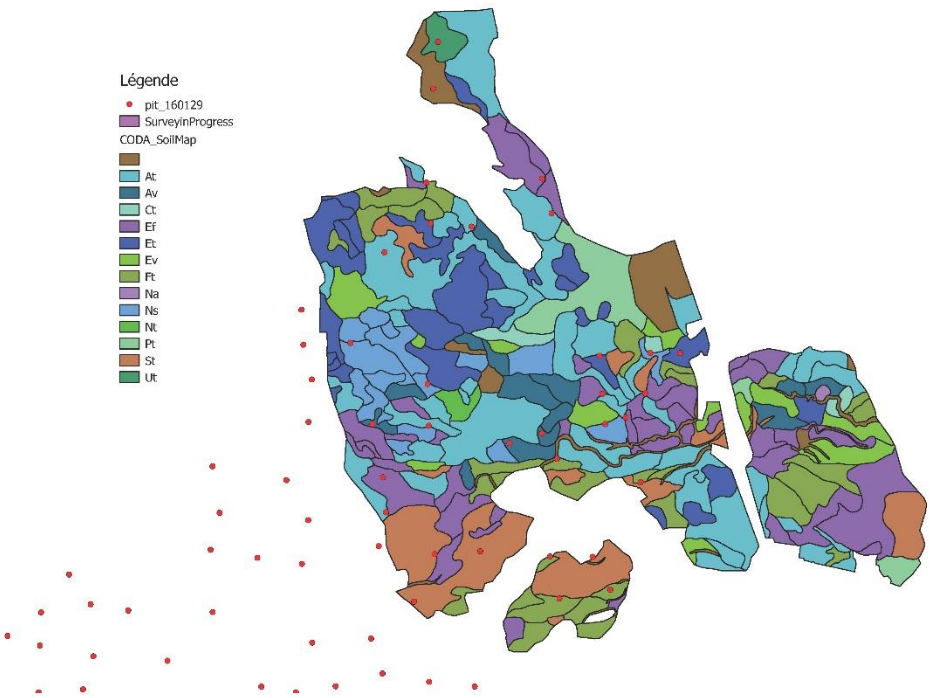


Figure 23 Zone I-1 Soil Map by CODA (2006)



The following table presents the Legend of the Soil Map of the Zone I-1.

Table 13 Soil Map of Zone I-1

Order	Suborder	Great Group	Subgroup	Symbol
Entisol	Fluvent	Ustifluvent	Typic	Ft
	Psamment	Ustispamment	Typic	St
Cambisol	Ochrept	Ustochrept	Typic Fluventic Vertic	Et Ef Ev
Alfisols	Ustalf	Haplustalf	Typic Arenic Vertic	At Ar Av
		Natrustalf	Typic Salorthidic	Nt Ns
Vertisol	Ustert	Chromustert	Typic	Ct
		Pellustert	Typic	Pt

The mapped soil units are linked with physiographic elements, such as three Shire river terraces, alluvium and pediment (see glossary). One would expect different soil patterns over the upper, middle and lower Shire terraces but all three show largely the same soil variety: dominantly Haplustalfs and Ustochrepts with subordinate Ustifluvents. Pediment units have Ustrochrepts as most typical soils. The occurrence of Natrustalfs indicates local presence of soils with high sodium saturation. The dambo west of Kasinthula is the only area where Vertisols were mapped.

Accompanying soil analytical data could not be located; hence a check on classification is not possible. Although the soil map legend presents an interesting approach, clear spatial relationships between physiographic units and soils could not be confirmed.

Another CODA (2006) report (incomplete, without cover page, annexes or maps) entitled “SVIP Soil and Land Survey” presents results of soil investigation carried out in 2005. The report describes and discusses a set of 14 representative soil profiles with analytical data, located in various Project Zones. These profiles are presented as representative soil families and grouped together in main groups, such as fluvic group, salic group and vertic group. Since pit locations are not available, the information remains general. The report describes the overall variation of soils in the Lower Shire valley as deep, medium to fine textured, brown to very dark-grey in colour, and well to very poorly drained. Soils in the uplands and hills are predominantly moderately deep, medium textured, well-drained and yellowish brown (FAO: Cambisols and Luvisols). Slightly saline soils occur mostly in lower positions and depressions; otherwise soils have a slightly acidic to neutral reaction and show a deficiency in phosphor and nitrogen. The soils in the floodplains are predominantly deep medium to fine textured with variable drainage and are classified Fluvisols, Cambisols, Vertisols and Gleysols (FAO). The analyzed soil profiles do not yield alarming data in terms of salinity or alkalinity; included are three clayey profiles (50-60% clay), probably Vertisols, ph <7.5 (very slightly alkaline). This CODA (2006) report also presents results of Land Evaluation following FAO methodology.

4.7.3.3 Soil information by Illovo (2015)

Illovo has established an impressive soil database (Illovo, 2015). The information received includes:

- a summary report with management recommendations based on the results of soil survey and analysis (2013-15) covering the various Illovo Nchalo estates; and
- an excel file with results of soil chemical analysis of a large number of samples from soil profiles (same survey). Illovo soil maps were not made available. Illovo uses the South African Soil Classification (SA Soil Classification Working Group, 1991) which may not always be the most appropriate to define soils in other countries.

Correlation with the World Reference Base (WRB) is made, but not in any detail and the correlation contains unfortunate errors and irregularities. This is largely a result of different WRB and SA approaches in defining and interpreting diagnostic criteria especially the ones related to structure and wetness, and also horizons as argic, cambic and vertic; WRB Nitisols, Albeluvisols and Ferralsols are incorrectly interpreted and out of the question in these alluvial soils; many Arenosols do not fit textural requirements; Luvisols should not be correlated with duplex soils). However, the overall data provide important information on the status of soils and their general distribution over the various Nchalo Estates, and hence also of the defined Phases and Zones of the Shire Valley Irrigation Project.

Illovo (2015) makes three main groups of soils (all soil profiles are described as having alluvium/colluvium parent material):

1. Well drained youthful soils (Cambisols, soil association A) constituting 59% of Estates
2. Black cracking clays (Vertisols, soil association H) comprising 22% of Estates
3. Duplex soils (Luvisols, soil association C) comprising 6% of Estates

The remaining 13% covers a variety of other soils and associations, including Calcisols, Nitisols, Gleysols, and Arenosols.

The above group percentages are weighted averages; the variability over the various estates is very large. For instance, the percentage of Vertisols over the estates is as follows: 5-10% in Nchalo, Kaombe and Kando, 39% in Kasinthula and 76% in Alumenda. 60% of Alumenda. Vertisols have a high water table with gley within 90cm, 17% have an Exchangeable Sodium Percentage (ESP) of >15, however very few profiles qualify as sodic (ESP>15). Clay contents are mostly around 50% and pH averages around 8.5 which is a common value for calcareous Vertisols in poorly drained positions. Salinity is normally low, well under level required for qualification of a salic horizon. Vertisols in estates other than Alumenda have generally somewhat lower pH and ESP values. Vertisols are reported to occur on older terrace deposits South West of Alumenda but also extensively on the lower part of the plain near Alumenda in seasonally or permanently wet areas particularly towards Elephant marsh or dambo area.

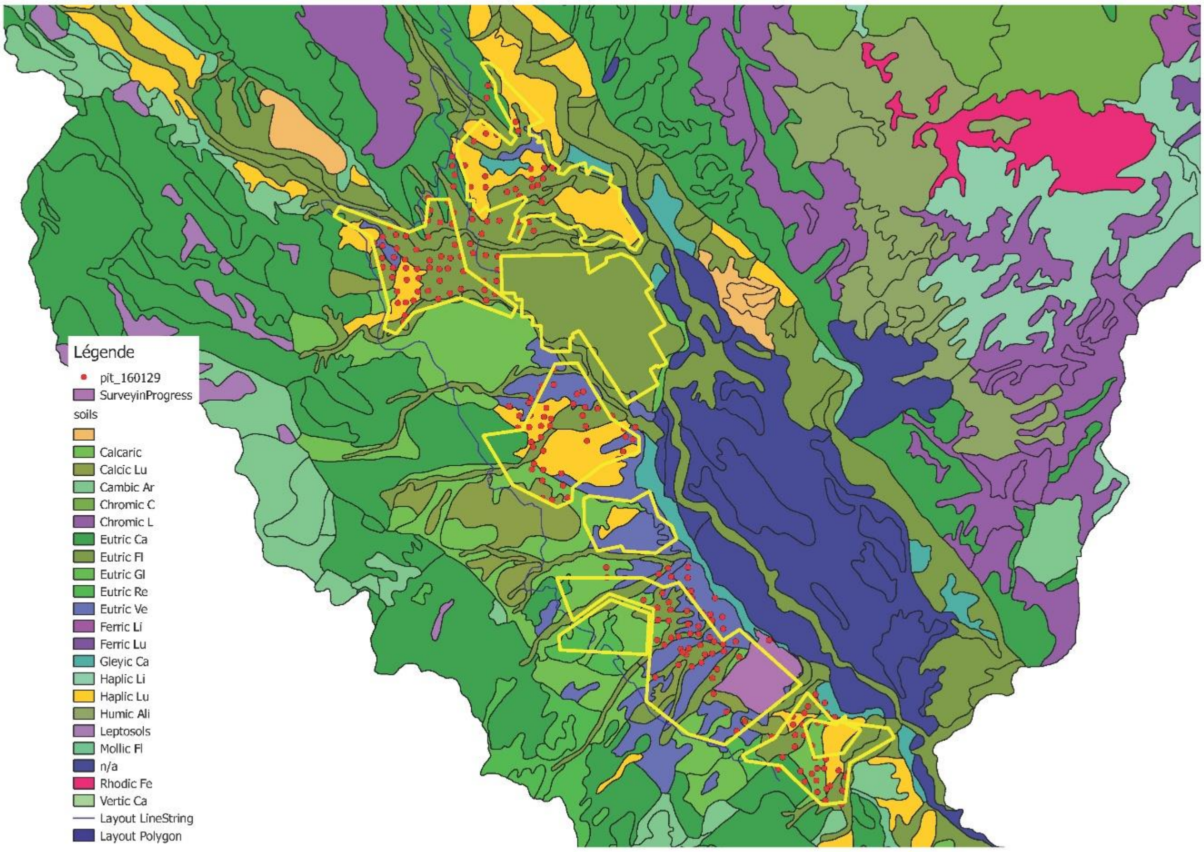
The younger and mostly weakly developed soils such as Cambisols, Arenosols and Gleysols exhibit little profile differentiation and their chemical data do not vary much (see Illovo, 2015). Other moderately developed soils are also reported, such as Luvisols, Nitisols and Calcisols. Some of these soils are highly calcareous soils (Calcisols). Salinity levels diagnostic for a salic horizon were not recorded; apart from one or two profiles the measured Electric Conductivity (EC) remained far from critical EC values. Some soils (Cambisols, Vertisols, Calcisols) may have relatively high sodium levels (ESP>10 and some with ESP>15), and could have developed a natric horizon and classify as Solonetz. However, required other characteristics for a natric (evidence of clay translocation and clay enrichment in B horizon or structure) were not evident from data and descriptions. Although there is no clear evidence of sodic soils (Solonetz), sodicity or alkalinity should always be closely monitored.

4.7.3.4 Soil Mapping of the Technical Feasibility Study (2016)

During first meeting in Blantyre (January 2016), the consultant were informed that KRC had already done about 1300 observations (including 300 pits) and taken about 1100 samples for laboratory analysis. The soil survey was not yet completed, thus more observations are expected to be added.

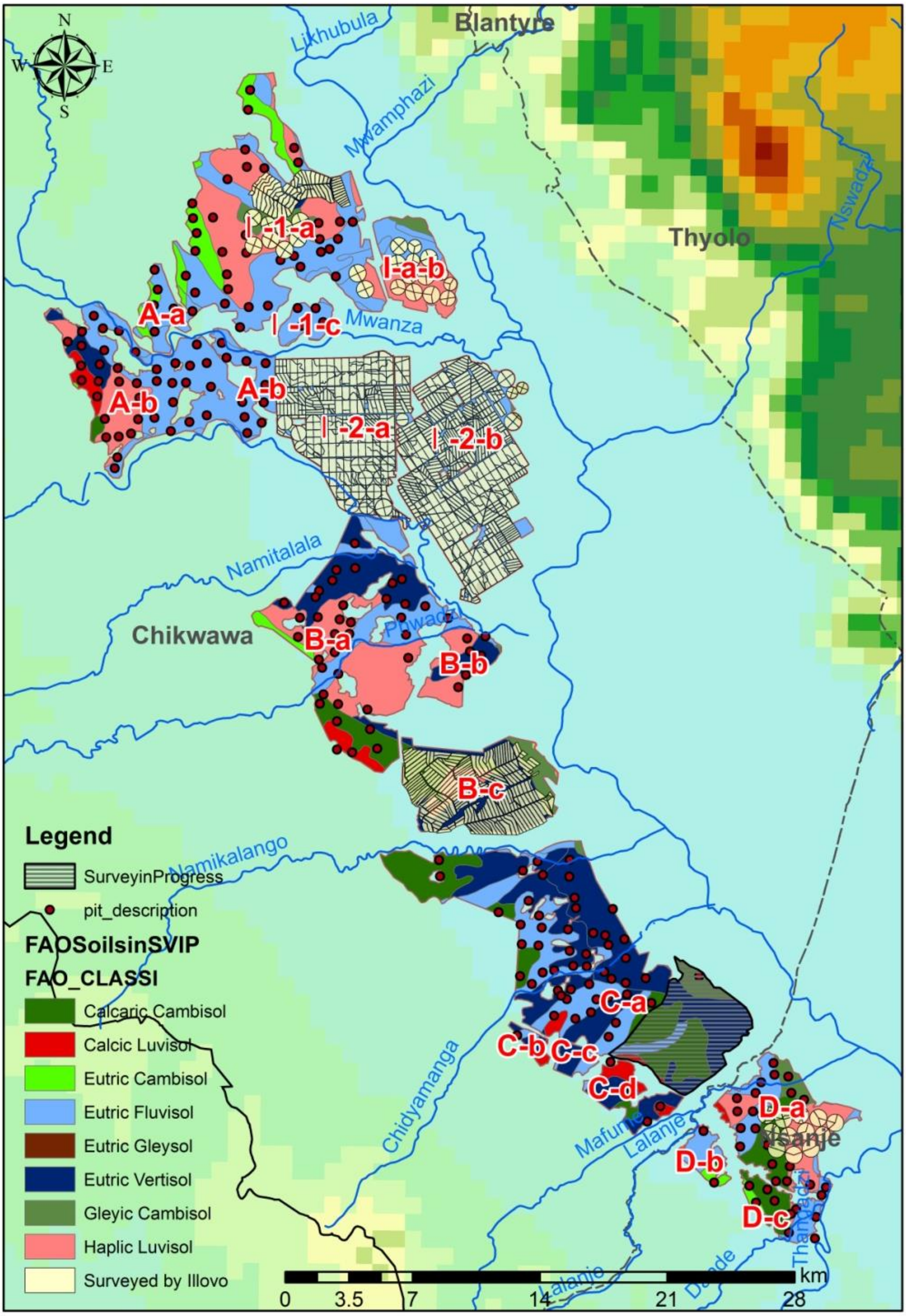
At this stage KRC should have developed a provisional soil legend based on own field observations. BRLi received copies of unpublished soil maps from KRC (Figure 24 and 25), which appear to be older existing soil maps of fairly small scale (in the order of 1:100.000) based on older FAO classification.

Figure 24 Soil map used by KRC (unpublished, based on FAO classification)



The map below shows an already existing soil pattern with notes on areas still under survey or completed by Illovo. This map (without source reference) is also used by KRC to plot their pit and other observations.

Figure 25 Soil map used by KRC (Unpublished, 2016)

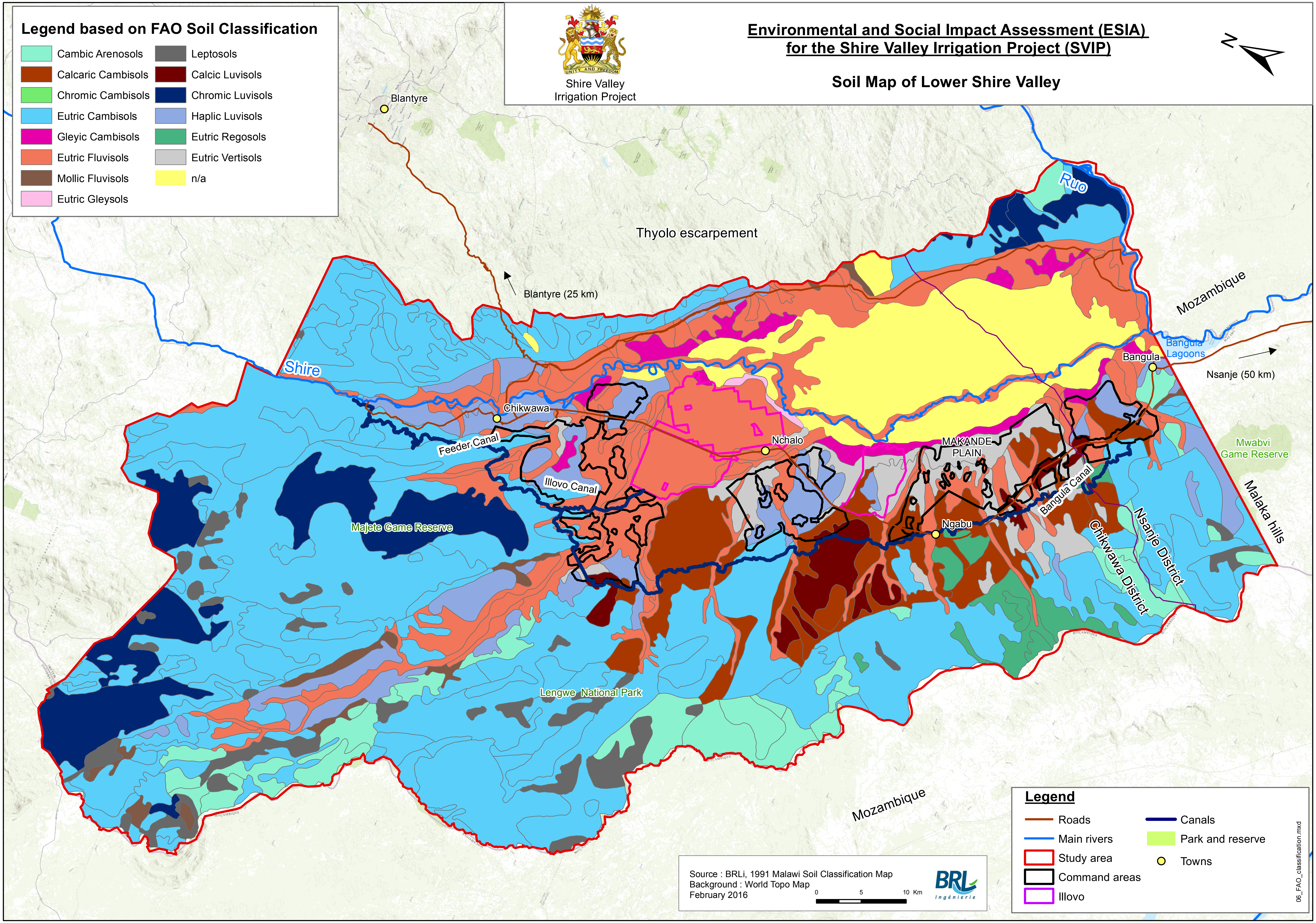


If the soil mapping for the Technical Feasibility Study had been completed, the logical choice for a representative soil map for the Study Area should be the soil map prepared by the Korea Rural Corporation (KRC).

4.7.3.5 Conclusion on Soil Map and Limitations

CONCLUSION

Since the KRC soil survey is still in progress, the most representative map is the Soil Map of Lower Shire Valley using FAO Soil Classification system from the Government of Malawi "Malawi Soil Classification Map" (Land Resources Department, 1991) as presented in the next map.


Environmental and Social Impact Assessment (ESIA)
for the Shire Valley Irrigation Project (SVIP)
Soil Map of Lower Shire Valley
Shire Valley
Irrigation Project
UNITY AND FREEDOM
Legend based on FAO Soil Classification
Cambic Arenosols
Calcaric Cambisols
Chromic Cambisols
Eutric Cambisols
Gleyic Cambisols
Eutric Fluvisols
Mollic Fluvisols
Eutric Gleysols
Leptosols
Calcic Luvisols
Chromic Luvisols
Haplic Luvisols
Eutric Regosols
Eutric Vertisols
n/a
Blantyre
Thyolo escarpement
Blantyre (25 km)
Ruo
Mozambique
Bangula Lagoons
Bangula
Nsanje (50 km)
Shire
Chikwawa
Nchalo
MAKANDE PLAIN
Feeder Canal
Illovo Canal
Majete Game Reserve
Mwabvi Game Reserve
Malaka hills
Bangula Canal
Ngabu
Chikwawa District
Nsanje District
Lengwe National Park
Mozambique
Legend
Roads
Main rivers
Study area
Command areas
Illovo
Canals
Park and reserve
Towns
Source : BRLi, 1991 Malawi Soil Classification Map
Background : World Topo Map
February 2016
0 5 10 Km
BRL Ingénierie
06_FAO_classification.mxd

LIMITATIONS

The Soil map using FAO classification is good to provide a general idea of the soils in the Study Area. However, it has several limits to its accuracy:

- From what the Soil Specialist has seen in the field and literature there are most likely some errors in the mapping. For example, the large unit of Eutric Fluvisols around Nchalo and Zone A contains more soil variation than illustrated, and certainly includes Cambisols. In addition, the Vertisols seem underestimated in Zone B-c and Zone C around Ngabu; in other areas there is not much logic in the mapping pattern of Luvisols with associated Cambisols and Fluvisols.
- From a classification point of view: the map is kept as simple as possible: most soil units show very little variation in second level subdivisions; most are Eutric and little else; one would expect more use of other second level terms as pellic, chromic, gleyic, calcic etc (which do occur in the area).
- From a reference point of view: The FAO soil classification system is the preferred system in Malawi, but FAO Soil Classification system has been replaced by the World Reference Base (WRB) for Soil Resources (IUSS Working Group WRB, 2006; published by FAO, Rome). The 2006 edition has already been updated by the 2015 edition.

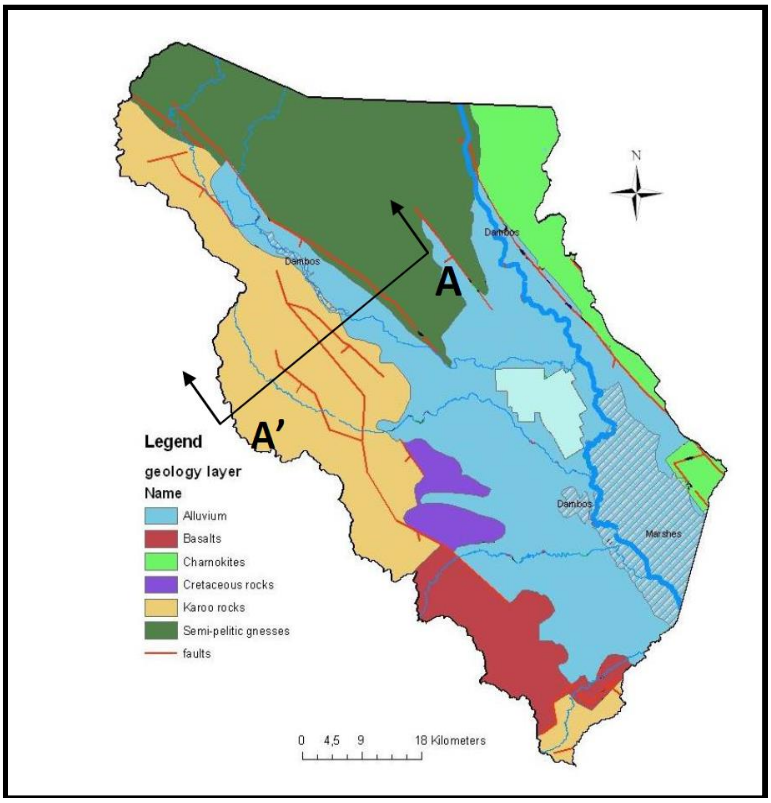
A review of the current soil expertise undertaken by KRC is annexed to this report.

4.7.4 Analysis on Soil Environment

4.7.4.1 Local geology

The soils in the Lower Shire Valley show a strong relationship with the geology of the area and the dominant sedimentary processes. Hills and uplands to the North and North East belong to the Basement Complex (Precambrian) consisting of gneiss and other rock from which detritus is removed by the Shire river. The hills South West of the valley are formed by a variety of sedimentary rocks belonging to the Karroo system (sandstone, shale, limestone, marl, etc.), mostly from the upper part of the Karroo (Mesozoic). The Karroo sequence in the Western hills is concluded by basic magma outflows, mainly basalts (see Geological Map, Figure 26).

Figure 26 Geological map of Chikwawa District (around Illovo, Phase I-2)



The Lower Shire Valley forms a part of the Great African Rift Valley and is bounded by escarpments associated with major faults which run in South West – North West direction. The escarpments are distinct in Northern and Eastern directions, but not to the West. Because of relatively flat slopes the Lower Shire Valley (at 50-200 masl) is predominantly a depositional environment and filled with an estimated 50-150m thick sequence of Quaternary unconsolidated sediments. Groundwater is mostly found at 3-15m depth, with slight to moderate salinity.

On the Eastern side of the Lower Shire valley, a series of alluvial fans with coarse debris and sandy soils is found at the abrupt transition to the steep escarpment, the fans alternating with small low lying areas with poorly drained clayey soils. On the Western side, the transition from the western hills to the Shire Valley is gradual and smooth from the foot slopes of the hills via a flat pediment with gentle slopes to the lower alluvial slopes and finally the Elephant Marsh.

4.7.4.2 Sedimentation and Soil Formation

The occurrence of Shire River terraces is mentioned in several reports. In the SOGREAH (1982) and in CODA (2008) soil mapping distinguishes around Kasinthula three different Shire river terraces (upper, middle and lower). Illovo (2015) reports that there are at least two alluvial terraces of the Shire flood plain:

- the lower marshland on either side of the river; and
- more elevated sequences of clays, silts, sands and occasional gravels (intercalated with colluvium).

It is also observed in the same reports that, because of the very gentle slope, the Lower Shire Valley is characterised as an area of deposition and valley infilling.

From a landscape genetic point of view, an aggradation environment is in general not compatible with the formation of river terraces. Terraces may be formed when a river incises but not when the river drops excess material it can no longer carry, hence terraces and aggradation do not coexist. The described terraces are most likely not proper terraces but irregular pediment deposits in a somewhat higher position. The lower Elephant marsh is not a terrace anyway but rather part of the floodplain.

From a soil genetic point of view, it is important to understand the principal sedimentary environment and physiographic processes in the valley. Aggradation or deposition is caused by all rivers and smaller streams, often accompanied by extensive sheet floods after heavy rainfall. When deposition is taking place at a regular basis in an area, the soils in the area are relatively young as they are regularly covered with new sediment and rejuvenated. Soils which require a long period of formation are not likely to be found.

Most of the transported materials from the Shire River are deposited in the central part of the valley, around the main channel. The phenomenon of sediment deposition in the Kapichira reservoir is also a concern. The provenance of the great majority of the sediments in the Western part of the Lower Shire valley is from the West and North West hills which form the catchment area of the series of small rivers and streams tributary to the Shire River.

The combination of a decreasing and degrading vegetation cover (through human activities) of the hills and foot slopes together with dominance of hard setting soils with compact structures and surface sealing on the foot slopes of the hills and subsequent pediment slopes is very conducive to accelerated runoff and erosion, increasing the quantity of flood water to the lower plains. Much of the eroded material is in transit across the pediment surface which is the middle part of the plain in between hills and lower alluvial plain. Transport over the pediment takes place in an irregular pattern of shifting small streams and sheetfloods, which is erosive and depositional at the same time.

Increased runoff is the reason of the increasing floods and erosion/deposition in Lower Shire valley, and in particular onto the Makande plain (on the western part of Elephant marsh). The lower very gently sloping parts and depressions are frequently flooded during the rainy season and receive the finer parts of the sediment. The result of flooding is also that large areas of the predominant clay soils (Vertisols) become inaccessible.

4.7.4.3 Physiographic Zones and Soil Patterns

The various rock types, notably their detritus and weathering products, strongly influence the composition of resulting sediments and soil parent material and related soil texture (particle size).

Dominant parent material in the uplands (Basement Complex) is gneiss, which weathers into a course loamy and often gravelly soil. The Shire River is able to carry large quantities of this predominantly coarse material downstream until it is deposited in the level lower valley where the river loses stream velocity.

Also the rivers from the North West carry relatively coarse material derived from Karroo sedimentary rock; however they also contain a fair amount of finer material from the variable Karroo rock. The resulting deposits from river like Mwanza are a mix of coarser (gravel, sand), medium (silt) and finer (clay) materials which are deposited in distinct sedimentary zones. Floodwaters are relatively high in Ca and Mg which may lead to formation of montmorillonite clay in suitable depositional environments, in particular depressions.

The rivers and streams which come from the western Karroo basalt hills transport in suspension a relatively large proportion of clay as well as a surplus of Ca and Mg in solution not only derived from the weathered basalt, but also from other calcareous sedimentary rocks. As a result the water that floods the lower plains has high concentrations of soluble Ca and Mg. The distance and slope are ideal to deposit large amounts of fine particles on the lower Makande plain.

The relationship between physiography and soils form the basis for a practical subdivision of the Study area into three subareas - Northern, Central and Southern - with distinct sediment and soil characteristics.

NORTHERN AREA FROM CHIKWAWA TO NAMITALALA RIVER

Northern Area encompasses Phase 1, including Zone A. The Northern Area is characterised by deposition of coarse grained sediments from the Shire River and mixed sediment influx from other rivers from the North and North West. Clayey sediments are only found locally.

In the most Northern section the Shire River floodplain is only one to two kilometres wide but south of the Mwanza confluence the floodplain spreads out extensively to form the Elephant Marsh. The deposits in the floodplain area consist of stratified sandy and silty alluvium. In the central part of the valley deep poorly drained sandy soils are found without much soil development. More to the West soils are still deep, but have a more variable texture and generally better drainage and show incipient soil formation. It is reported that some salinity and alkalinity may occur in depressions with clayey soils and at the edge of marshes (see section on groundwater).

To summarise the soil classification as reported in the various surveys reports, Fluvisols are mapped in the central part of the Shire floodplain, but opinions differ in the next zone to the west (South of Mwanza River, including Nchalo). Some maps still show Fluvisols but others (Illovo, 2015) classify predominantly Cambisols (and very few Fluvisols). Further west of Nchalo and north of Mwanza the soil pattern is more complex. On most maps Luvisols and Fluvisols are the most dominant soils, whereas proportions of Cambisols and Calcisols vary. Occurrence of Vertisols is minor.

A general conclusion on FAO/WRB classification applied in this zone is that there are large differences in classification and not many full and comprehensive soil profiles descriptions following international standards to enable in-depth check and verification of WRB classification labels.

CENTRAL AREA FROM NAMITALALA RIVER TO MAFUME/LALANJE RIVER

Central Area encompasses Phase 2 Zones B and C. The Central Area is characterised by a drainage pattern from the West and South West basalt hills producing clayey weathering material which is transported via the pediment slopes to the lower Makande plain. The sediment is transported by rivers and smaller streams but also by sheet floods. The depositional pattern is related to widespread flooding of the lower Makande plain, with silty and clayey deposits, and more sandy deposits near the stream beds and gullies that frequently shift over the pediment and lower plain.

Figure 27 Incipient Gully and Sheetflood Erosion Concurrent with Deposition in Lower Makande Plain (Zone B-b)

Source: BRLi (2016)

Figure 28 Sheetflood Erosion visible from Google Earth

The composition of the flood water with high concentration of Ca and Mg in solution and clay in suspension is responsible for the formation and dominant occurrence of strongly developed Vertisols with their characteristic swell shrink properties. Vertisols are chemically fertile (apart from P and N deficiencies) and although having poor physical properties (workability, accessibility), the Makande plain is intensively cultivated.

To summarize soil classification labels for the Makande plain, Vertisols are by far dominant in the part East of the main road, which is not surprising because Makande means “clay-soil”. Illovo has mapped 76% Vertisols in Alumenda estate (lower Zone B) and percentages are not expected to be much different in the corresponding lower part of Zone C. The consultant has observed at Ngabu town and other places in the plain very strongly developed Vertisols with strong gilgai (mounds and depressions pattern) and cracks 10cm wide at the surface.

Some maps show a transitional zone of Gleyic Cambisols in between the broad Vertisol zone and the Elephant Marsh. Vertisols are also extensive on the western side of the main road, especially towards the South. Fluvisols are mapped in the lower Eastern part of the plain along channels, but their extent is in reality probably restricted. The small areas included in Project Zone B and C that lie west of the main road show also Luvisols and Cambisols in a pattern that needs to be checked.

SOUTHERN AREA FROM MAFUME/LALANJE RIVER

Southern Area encompasses Phase 2 Zone D. The smaller southern area has a shorter distance to the Mulaka hills which has a mixed geology (with basalt no longer dominant as to the North) and therefore has a more mixed influx with a much larger proportion of coarser materials and less finer materials, which is reflected in the more sandy composition of the sediments and soils in this part of the lower plain. The Southern area also shows much more erosion compared to the Central area.

In the Southern area only few documented results of soil investigations were available. The little information available (FAO soil map; Illovo, 2015) show a complex pattern of Luvisols, Cambisol and Fluvisols, but no Vertisols.

4.7.4.4 Vertisols and Land Suitability

The Soil Specialist has raised some concerns about suitability of part of the land which may have an impact on operation of the scheme and for which mitigation measures may be needed. This concern relates to suitability of strongly developed, frequently flooded and (very) poorly drained Vertisols. Following standard FAO Land Evaluation these soils are not suitable for irrigation (apart from rice) unless optimal management levels are implemented. Vertisols are problematic because of their physical properties, which make them inaccessible and very difficult to work when wet.

Early conservative estimates of the consultant of the percentage Vertisols are:

- Zone A and D: 0-10%,
- Zone B: 30-50% (40 % would represents 2500 ha) and
- Zone C: 50-70% (60 % would represents about 5500 ha),

These estimates are based on field visit observations and discussion with various stakeholders as well as review of the soil data presented in the previous sections.

This is a substantial proportion of Vertisols, especially for Zone B and C (about 8000 ha). However, not all Vertisols are (very) strongly developed; perhaps about half has quite moderate features and may possibly be sustainably irrigated also under a less than optimal management level. This may reduce the net amount of land available for up to 4000 ha for Zone B and C (about half of 8000 ha); however this will strongly depend on the choice of crop, as different irrigated crops e.g. maize, sugarcane or rice will often have different suitability for the same soil. When provisions for optimal management are anticipated and actually implemented (as in Alumenda) such heavy Vertisols might still be cultivated with some success. Without optimal commercial management level, the consultant raises serious doubt about the suitability of these heavy Vertisols for most irrigated crops (apart from rice).

ASSESSMENT LIMITATION

The soil expert has estimated the surface of heavy Verstisol (4000 ha) based on information available and a reconnaissance survey. It is the consultant's opinion that the occurrence of Vertisols in Areas B and C was underestimated in earlier surveys.

In area C, the occurrence of heavy Vertisols was shown by the Shire Valley ADD Chief Land Resources Conservation Officer in the currently abandoned research area at Ngabu. In Area B, at least two locations of strongly developed Vertisols were shown by Korea Rural Corporation Soils Specialist. The Consultant soil specialist strongly encourage KRC to map identified Vertisols.

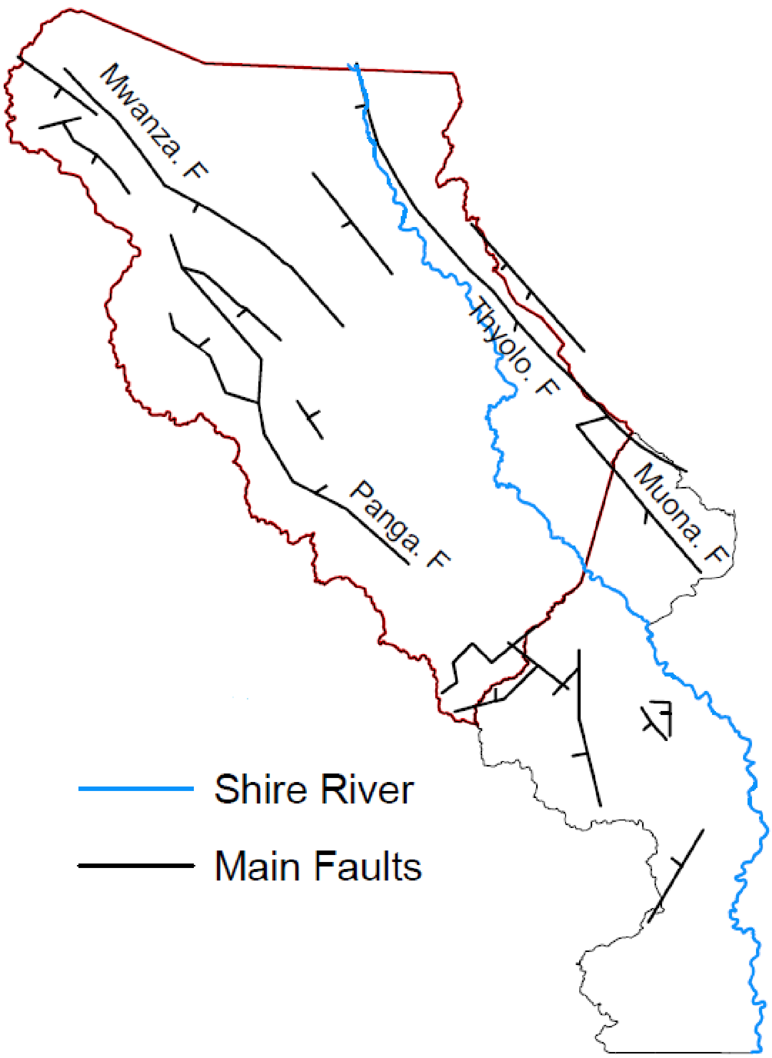
4.8 AQUIFER AND GROUNDWATER

The main aquifer units in the Study area in order of increasing importance as groundwater resources, are:

- the weathered and/or fractured basement rocks;
- Karoo and Cretaceous sedimentary rocks;
- weathered and/or fractured basalts faults; and
- the unconsolidated alluvial deposits.

In the Study area geological structures such as faults, folds and fractures provide flow-paths for migration of underlying or adjacent under pressure saline groundwater within the aquifer system which causes groundwater to be brackish or saline in most areas (Monjerezi et al., 2011, 2012 and 2012a). The following figure shows the main faults of the Study area.

Figure 29 Main faults in the Study area



Source: Adapted from Monjerezi, 2012

Monjerezi et al. (2011) have sampled groundwater in 247 boreholes in Chikwawa district. The results of chemical analyses and field measurements have revealed that Electric Conductivity (EC) varied considerably from 35 to 36,000 µS cm-1, and correspondingly Total Dissolved Solids ranged from 16 to 26,539 mg L-1. These two measurements are used to detect salinity in water. Based on these data, the vast majority (91%) of groundwater sampled is classified as brackish and 5% as saline. WHO guidelines for Na, Cl-, $SO^{2-}{}_4$ and Mg in drinking water (WHO, 2004) were respectively exceeded in 42%, 29%, 15% and 35% of all groundwater samples (Monjerezi et al., 2011). In addition, Barium, Boron, Chromium and Lead had concentrations exceeding WHO drinking water guidelines in 6.5%, 9.7%, 16.1% and 64.5% of all samples respectively; these toxic metals were influenced by saline content of water (Monjerezi et al., 2012a). These sampled groundwater are used by local communities as drinking water supply (there are about 305 boreholes in the district of Chikwawa and many temporary hand dug wells).

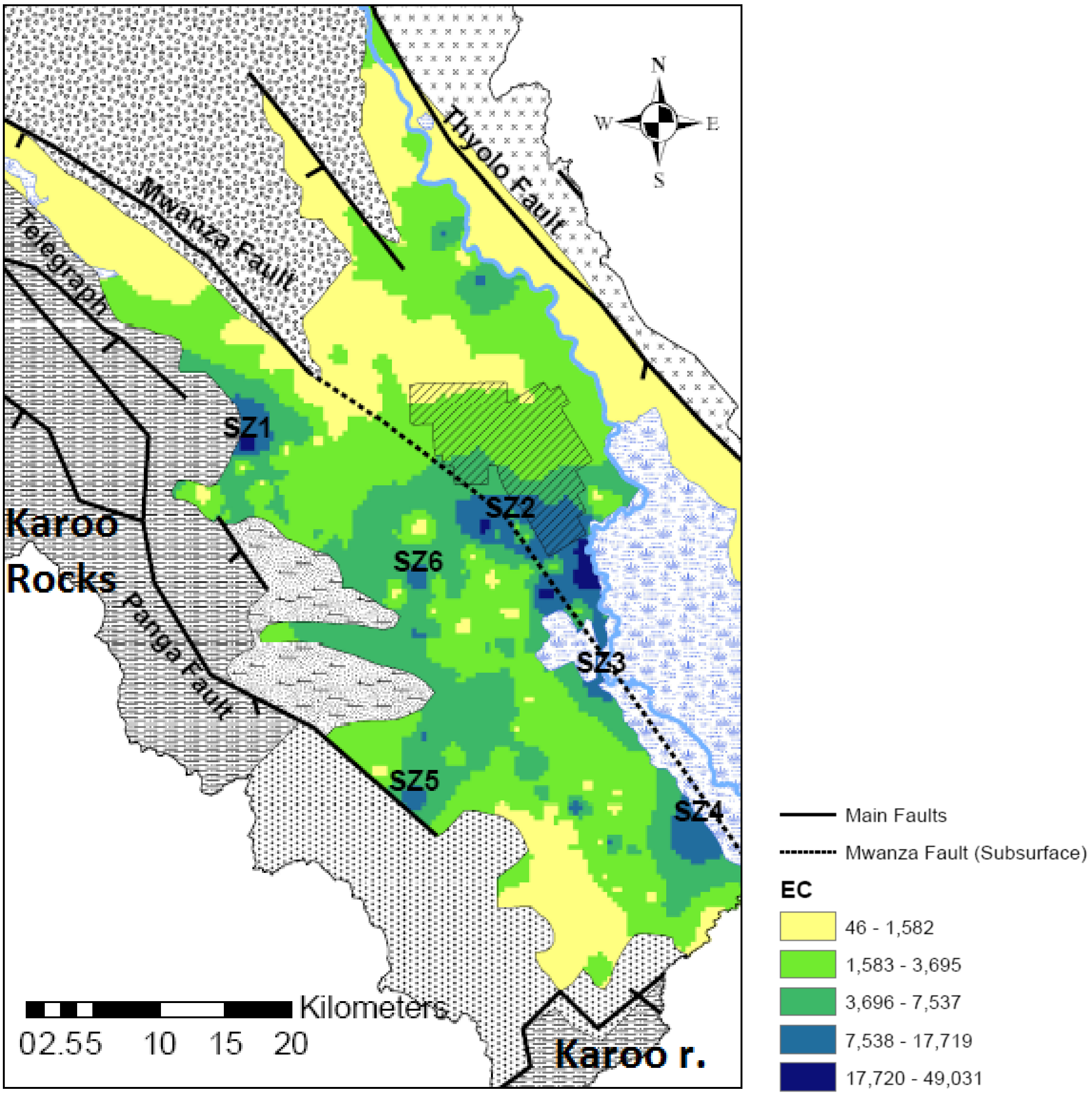
In general, the salinity in groundwater increases gradually as it flows towards Shire River. In the region, there is a spatial variation in groundwater salinity with extreme gradients in chemical composition over short distances; however there is not a significant variation with depth of groundwater (Monjerezi et al., 2011).

The high salinity close to the Shire River indicates that the river is not significantly influent to the underlying water table, suggesting a negligible or very slow movement of water from the river into the aquifer. Saline soils are found in some zones along the Elephant marsh on the Western bank (Monjerezi et al., 2011) which is caused by evaporation of brackish and saline shallow groundwater along the Mwanza Fault. The Karoo rocks are dissected by faults which are also responsible for intrusion of mineralized groundwater and soil salinization (Monjerezi et al., 2012).

The following figure shows spatial distribution of water salinity (EC in µs/cm) in relation with geological faults (Shire River is shown in the center as well as Illovo estate).

Irrigation using water brackish or saline water results in a fertility decrease of the irrigated soil.

Figure 30 Electrical Conductivity (EC) of groundwater



Source: Adapted from Monjerezi et al. (2012)

5. SOCIOECONOMIC BASELINE

5.1 INTRODUCTION

This chapter includes baseline assessment of the current socioeconomic features of the Stud area.

The proposed project targets close to 100,000 small holder farming households who will benefit from gravity irrigation. The Project extends between 25-40 kilometres wide from Kapichira Falls to Bangula. The crops to be grown include maize, sorghum, cotton, rice and high value crops such as tomatoes, onions, beans and sweet potatoes.

5.2 METHODOLOGY

The social baseline study has been developed in line with tasks outlined in the Terms of Reference for the assignment elaborated further in the ESIA Inception Report for the assignment (BRLi, 2015).

The baseline study incorporates both primary and secondary research. Primary research activities included community observations, selected focus groups meetings with community members, traditional leadership, and women's group combined with key informant interviews with district council officials, members of the civil society groups particularly non-government organizations. Information on household characteristics was obtained from surveys conducted by COWI (2016), a consultant working on communication, community participation, land tenure and resettlement policy framework who have conducted a detailed household survey within the Project area.

Focus Discussion Groups (FDGs) aimed at identifying community characteristics, opportunities, needs, priorities, issues, challenges specifically related to food security, employment, land tenure, economic activities, education, health, water and sanitation. Participants were also be asked to identify groups that may be considered vulnerable, disadvantaged and marginalized. Key issues raised by people consulted are provided in section 5.3. Community observations focused on describing physical infrastructures such as health facilities, schools, transport, land use, markets, and water supply facilities. A checklist has been prepared to assist in obtaining information during community observations.

Secondary data for key socioeconomic issues with the project area was obtained through preliminary desktop research. A number of reports as described in reference section were reviewed. Data gaps identified during desktop research included the following:

- Some available data and information are too outdated for a social baseline study (6-15 years old). Normally, social data should not be older than five years considering the various socio-economic changes that could happen within a 5-year period.
- There was lack of information on traditional authorities located within the project area. Most of the data contained general information for the district and no specific data were provided

Key secondary sources used include:

- Government of Malawi – various reports from ministries, development plans, policies, legislation, census
- Non-governmental organization and other civil society organizations publications and articles
- Academic papers and journal articles

Community observations focused on identifying physical infrastructures such as health facilities, schools, transport, land use, markets, water supply schemes, cultural sites, religious sites, and recreational sites. A checklist was prepared to assist in obtaining information during community observations.

Primary and secondary data gathered was analyzed by the rural sociologist. Quantitative and qualitative data was populated into Excel spreadsheets and organized in tables and graphs. Averages and percentages were calculated while patterns and trends were noted. Surveys responses provide valuable information on perceptions and opinions on socioeconomic conditions in the study area.

The purpose of consultations was to solicit views and opinions of different people on the proposed project; to determine how the project will affect them and how best the project will be implemented to minimize adverse social impacts on the communities within the area. The consultative meetings involved key NGOs working in the traditional area and Traditional Authorities (TAs).

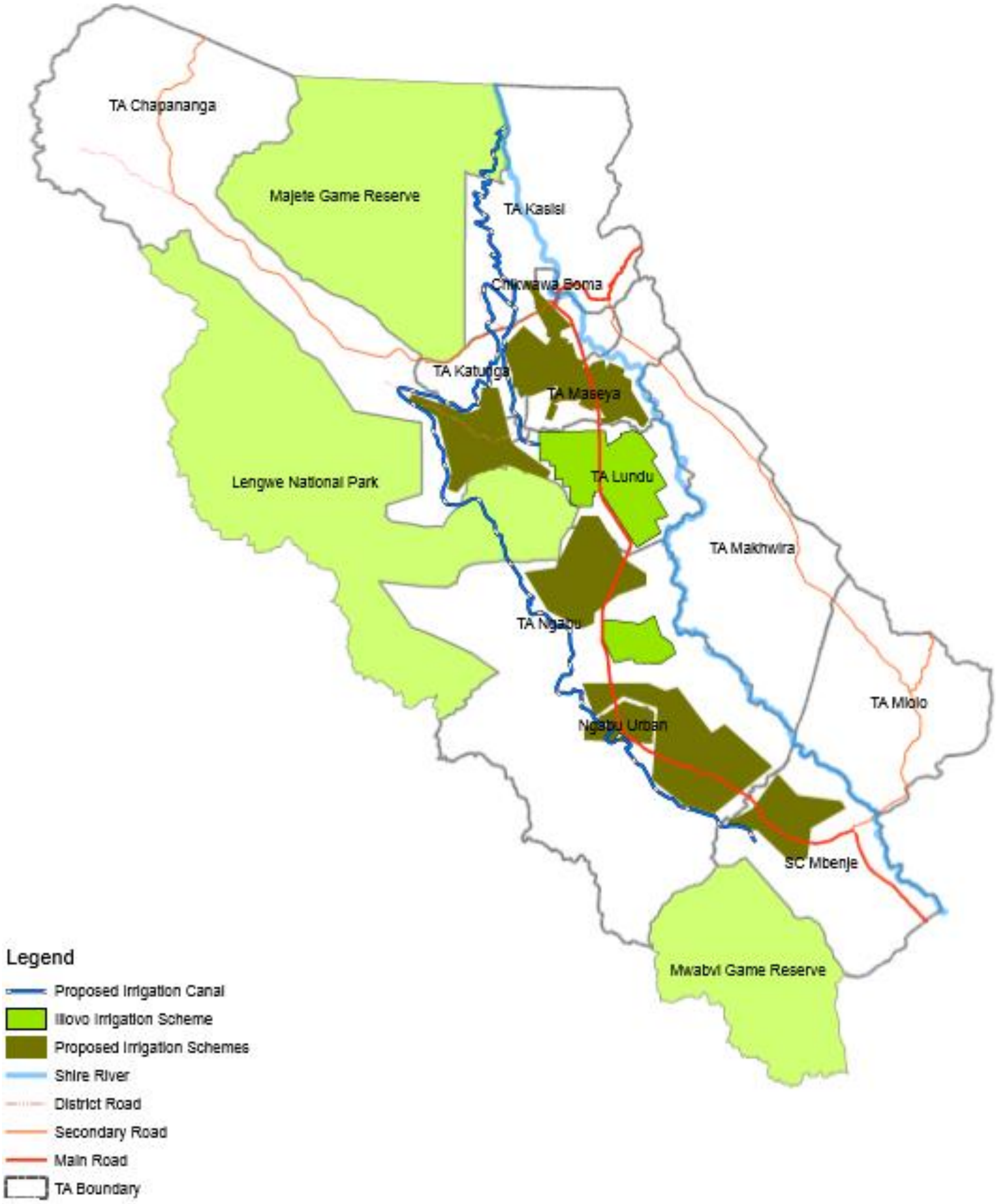
Traditional leaders concern by the Project are as follow:

- TA Kasisi in Chikwawa
- TA Chapananga in Chikwawa
- TA Katunga in Chikwawa
- TA Maseya in Chikwawa
- Paramount Chief Lundu in Chikwawa
- TA Ngabu in Chikwawa
- TA Mbenje in Nsanje

TA Makhwira and TA Mlolo, on the eastern side of Elephant marsh, are outside the Project. However, some baseline information were collected for the biophysical environment.

Minutes of consultation are included in annex, the full ESIA will study the concerns raised by some of the stakeholders during surveys.

Figure 31 Traditional Authorities



5.3 CONSULTATION RESULTS

The general perception of the stakeholders about the project was positive and traditional leaders stated that the project dates back to the 60s. However, after Traditional leaders and communities were sensitized the project did not materialize. Consultations restarted in 2008 but did not continue. Since 2015 TAs have been invited to a number of meetings where they were informed that there was now commitment by both the Malawi Government and donors to implement this project. However, there is still concern among Traditional leaders and communities in the project area that these consultations may not be different from the previous ones which ended without the project being implemented. The key issues and questions raised by stakeholders consulted in the project area are as follow:

- Drowning of livestock in the main canal; the canal will obstruct access of livestock to communal grazing land and water.
- The canal is a drowning hazards for wildlife in Lengwe National Park attempting to cross it or falling in it.
- Splitting of villages by the main canal is a concern.
- Local leadership should be consulted before implementation of any resettlement. The project should prioritize water distribution to smallholder farmers than private companies. Relocation of graveyards will not be accepted unless in extreme cases
- The Project should provide equal employment opportunities for men and women during construction of the canal and ancillary facilities and women shall be included in Water Users Association during operation phase.
- There were interests in knowing if farm inputs shall be provided to smallholder farmers and if the use of water from the irrigation canal shall involve any fees.
- Has the project considered flood issues in the design?
- How will the people whose houses and properties affected by main canal be compensated?
- Fear of having crocodiles occupying canals and drains. Crocodiles were actually observed by the consultant in one of the drain of Illovo during the January 2016 mission.
- How will the project benefit disabled people and youth in the area?

5.4 SOCIAL INDICATORS

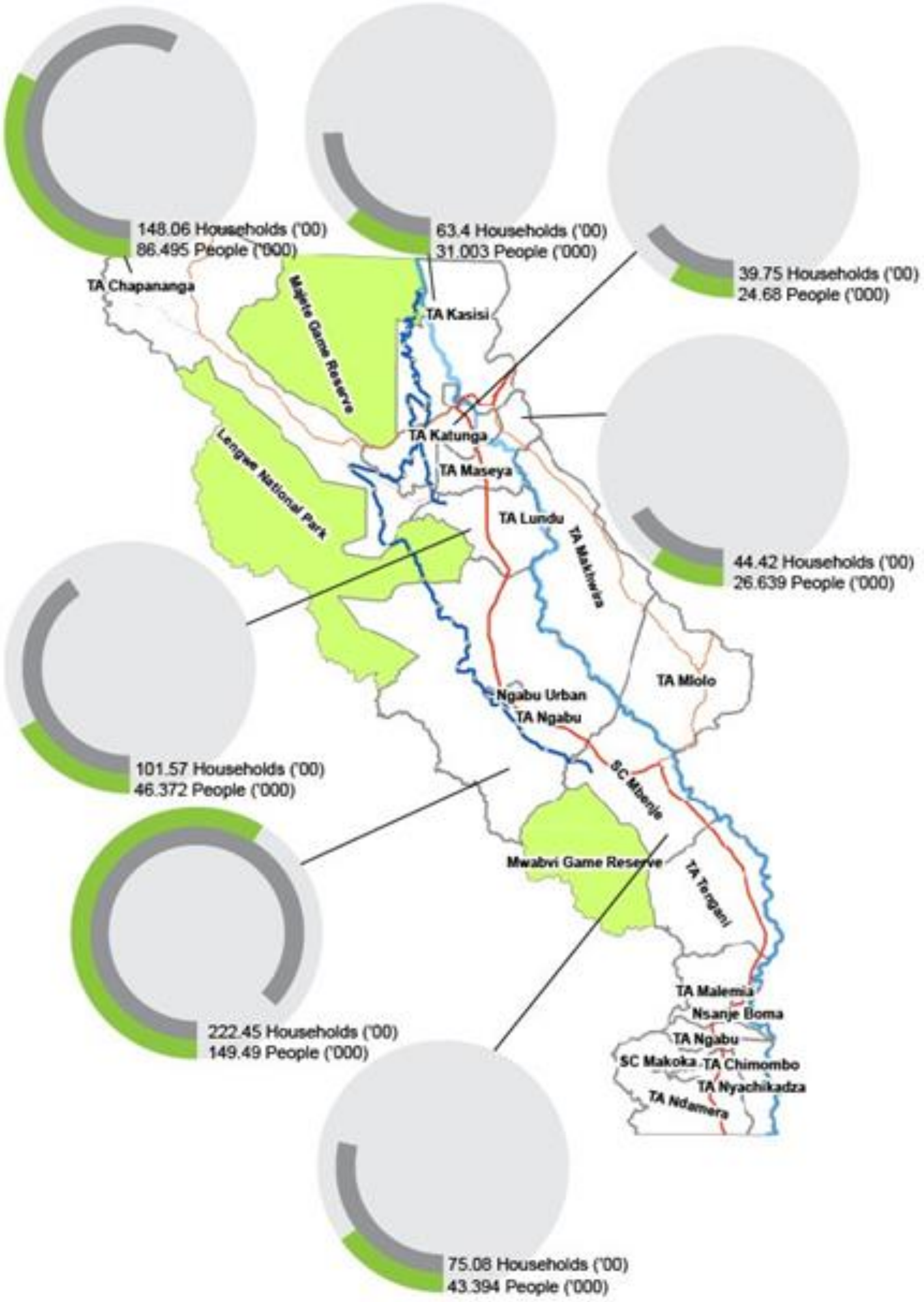
5.4.1 Population and demographics

The two districts in which the SVIP is earmarked are similar in many respects including population densities, level of development, education and health facilities and other socio-economic factors.

With regard to demography, according to Population Census carried out in 2008, the district population of Chikwawa is estimated at 434,648 consisting of 226,017 females and 208,631 males. Much of the population is said to reside in the area of TA Ngabu. It is estimated that the population growth rate for Chikwawa District is 2.7 percent per annum which is lower than that of Malawi. By 2015, the density of population of the district was calculated at 93 persons per square kilometer and females comprise 52 percent of the population while males take up the remaining 48 per cent.

Elsewhere in Nsanje, the combined population of those that live in the urban area and its conurbations and those that are rural-based is estimated at 238,103 (Population and Housing Census, 2008). At Traditional authority level, TAs Mlolo and Mbenje have higher population. Figure 32 presents population and number of households in the study area.

Figure 32 Population



*Households per hundreds ('00) and people per thousand ('000)

5.4.2 Household size

Although each of the districts will have its own average household size, it is known that the average household size for the southern region districts of Malawi is 4.4 persons compared to 4.7 for the central and 5.2 persons for the northern districts (Population and Housing Census, 2008). According to the results of the survey conducted in the area, average household size for the sampled population is 4.9 in Phase 1 and 5.1 in Phase 2 (COWI, 2016). Apparently, the difference in household size between the Study area and the Southern Region was attributed by the difference in population sample size (COWI collected sample only in the study area).

COWI survey showed that there are more men than women in the study area, which is also a difference with the 2008 census.

5.4.3 Gender aspect

The COWI household survey conducted in the project sites revealed gender inequalities in agriculture undertakings. It was observed that women spent more time on farming activities yet decisions on sale of farm produce were largely made by men. Discussions with women groups such Chambuluka, Namatchuchu, Joliji, and Misili Womens Club under Development Aid from People to People (DAPP) revealed that women carried more farming activities and household chores whilst men were engaged in casual labour in Illovo estates. Consultations with Illovo and Zikomo Cane Cutting Company, a contractor for Illovo indicated that 70 percent of casual labourers are men. It was evident that farming activities on small scale are predominantly carried out by women. On sale of farm produce and livestock, women indicated that the decision is solely made by men. Proceeds from the sales are not shared equally and rarely do men disclose to their wives the total amount realised from the sale. One major challenged raised by women was food insecurity during floods and prolonged dry periods.

An investigation was also conducted on level of engagement of women government and NGOs sponsored projects implemented in the project area. It was observed that government sponsored projects under Local Development Fund (LDF), Malawi Social Action Fund (MASAF) promote gender equality on labour force working on such projects. The District Community Development Officer for Chikwawa indicated that in some projects the number of women working on government sponsored projects is more than that of men. Projects such as Farm Income Diversification Program (FIDP) and Ubale Project being implemented by NGOs in the project area number of women beneficiaries is surpasses that of men. One reason is that most men are largely engaged in casual labour in Illovo Estates which pays more money than projects compared to government sponsored projects. For instance, under LDF projects the payment is MK7,200 for 12 days which is three times less what one could get from Illovo. Further, some projects do not pay cash but rather farm inputs and food and this is less attractive to men in the area who prefer getting cash.

However on decision regarding the use of land at household level, it was discovered that largely adult male (40 percent) made decisions in both phase areas of the project area. Adult male and female jointly were also predominantly involved in decisions concerning use of land.

5.4.4 Vulnerable people

Vulnerable, disadvantaged and marginalized groups which include the poor, disabled, orphans, the elderly youth, women, and children are many in the project area and these groups are impacted heavily by poverty and economic shocks. During focus group discussions conducted in traditional authorities Kasisi, Chapananga, Katunga, Maseya, Lundu, Ngabu and Mbenje, participants reported orphans and elderly as most vulnerable groups. Youth from 15 to 35 years of age are considered marginalized since they have higher levels of unemployment. Female headed households were also considered as marginalized groups as most of them do not have property and land rights due to cultural norms.

5.4.5 Education Attainment and quality

The COWI household survey conducted in the project areas established that 67.6 percent of the sampled population have attended primary education, while 12.6 percent have attained secondary education. Of the total sampled population there were no major disparities in attending of primary education between males and females. 68.4 percent of females have attended primary school while 66.8 percent of males have attended primary education. There were disparities in terms of secondary education attainment as 10.67 percent of females have attended secondary education as compared to 14.5 percent for males. Only 3 persons out of 1062 people of the sampled population have attended tertiary education. The main reason as to why few people attended secondary and tertiary education is high tuition fees for secondary education.

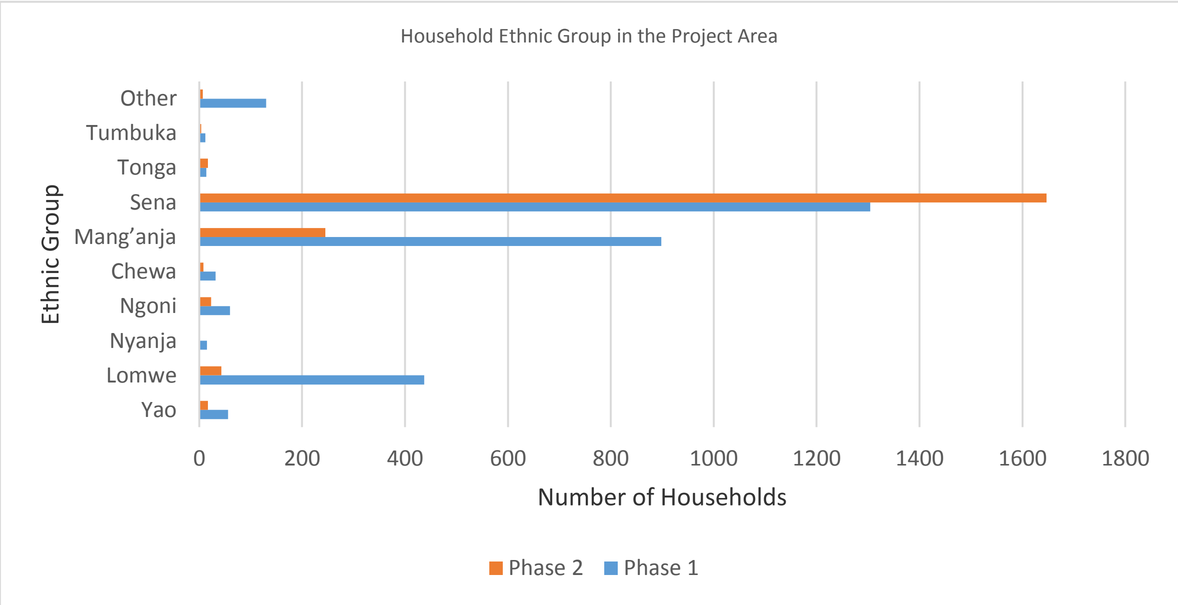
The number of dropouts in primary school was higher for girls than boys except in T/A Chapananga and Katunga.

Most schools both primary schools and secondary schools in the study area do not have enough infrastructure. The surveys unveiled that there was insufficient classrooms, desks, toilets and drinking water in the schools that, to some extent, attributes to school dropout. However, the most striking reason that attributed to dropout was early marriages. In most schools pupils sit on the dirty floor even outside under the tree due to insufficient desks, chairs and classrooms.

5.4.6 Settlements and Community Organization

Settlement in the study area are largely nucleated around social infrastructures such as markets, schools and water supplies. Communities are organized according to families and relations in the area with common cultural beliefs and language. The ethnic group in the project area is predominantly the Sena as shown in Figure 33. The Mang'anja are second largest ethnic group followed by the Lomwe. However the rest of the proportion is shared by the Ngoni, Chewa, Tonga, Tumbuka, Nyanja, Yao and other ethnic groups. Needless to say, the area has an eclectic structure of culture and traditions.

Figure 33 Household ethic groups



The majority of the residents are Christians with a few traces of Muslims and atheists. Most adults are married and a considerable number of single adults. Polygamy is practiced by a few men in the area.

5.5 INFRASTRUCTURES

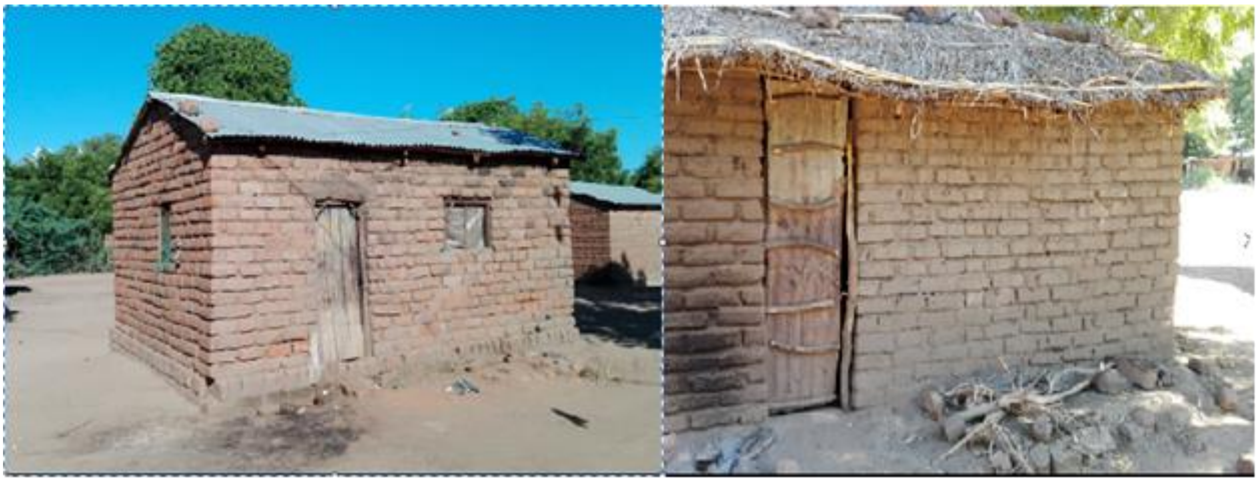
5.5.1 Housing

Most dwellings in the project area are made of materials that can be sourced locally, such as bricks, grass, poles, clay (see next figures). During the field visit, it was observed that that modern homes more often are made of burnt bricks, cement and roofed with corrugated iron sheets, whereas older homes are commonly made of sunburnt bricks or mud and are grass thatched. Table 14 provides a comparative analysis of population and housing characteristics of households in Chikwawa and Nsanje against households at national and regional revels.

Table 14 Population and housing for Chikwawa and Nsanje against regional and national conditions

	Chikwawa	Nsanje	National average	Southern region	Observations
Levels and trends in urbanisation					
Population (people) Annual growth rate (%) Population density (persons/km2)	434,648 2.0 91	238,103 2.1 123	13,077,160 2.8 139	5,858,035 2.4 184	Lower than average density and growth rate.
Urbanisation centres> 5,000 inhabitants	1.6	8.5	15.3	15.9	
Housing conditions					
Household size (people)			4.6	4.4	
Occupancy tenure (%) -owned -rented -other			 87 11 3		Owner occupancy dominant, rented dwellings is an urban phenomenon only.
Size of dwelling (%) - one room for sleeping - two rooms for sleeping	 45.6 38.2	 47.8 34.7	 41.3 38.5	 40.3 40.7	Smaller size dwelling prevalent.
State of permanency (%) -traditional dwelling -semi-permanent -permanent	 43.0 34.8 22.3	 45.1 40.8 14.0	 44.4 34.2 21.4	 34.9 41.5 23.6	Majority lives in dwellings using traditional materials and construction techniques. However, some improvements in durability since 1998.
Construction materials (%) Floor -earth, sand, dung -cement, bricks, etc. Walls -mud -unburnt bricks -burnt bricks Roof -grass thatch -corrugated iron	 85.6 14.1 19.2 35.9 38.2 74.6 24.9	 87.0 12.8 13.5 36.6 44.3 76.3 23.0	 78.5 21.2 19.9 38.3 38.5 70.6 28.4	 77.1 14.1 4.3 50.7 42.2 66.9 32.1	Majority of dwellings are susceptible to flood damage. Flood proofing of individual dwellings may not be feasible.

Figure 34 Permanent dwelling and traditional dwelling in the study area



5.5.2 Access roads

The project area has 4 classes of roads namely the Main Road (M1), Secondary Roads (S152, S136 and S151), District Roads (D379, D380, D383 and D385) and numerous unclassified roads. The major road linking the urban centers is M1 which connects the project area to the major cities of Malawi. It is a new upgraded road, and the only asphalted road in the Study area, which has eased transportation problems that were experienced in the area. There are 3 Secondary Roads, 2 Tertiary Roads and 839 Unclassified Roads that are regularly maintained and connect small trading centers to major urban centers in the project area. Driving outside the M1 during rainy season could be difficult and the roads on the eastern side of Elephant marsh become impassable due to flooded tributary rivers (flash floods).

Common modes of transport in the project area, include motorcycles, bicycles (*shapa or kabaza)*, vehicles and ox-carts. Most household in the project area own push bicycles (66%) and a small percent own motorcycles and ox-carts. The common modes of transport used to access health facilities and trading centers in the area are push bicycles and motorcycles.

5.5.3 Telecommunication

The Study area is covered by mobile network from both Airtel and Telekom Networks but communities complained that the network signal is very weak especially when moving away from the M1 road. In phase 1, around 55% of people own mobile phones while in phase approximately mobile phone owner are about 40%.

5.5.4 Water supply

Communities within the project side heavily rely on boreholes, public tap, protected wells and perennial rivers to draw for domestic purposes. However, households predominantly use borehole water as illustrated in Figure 35. According to the household survey conducted in the project areas, 78 percent of the 1062 sampled households have access to potable water from boreholes whereas 14 percent of the sampled households draw water from public tap or kiosk while 3 percent draw water from unprotected wells. From field visit, it was observed that households in the project area travel less than 30 minutes to nearest water collection point. However, during field investigation in Joliji, Nyamphota, Malemi and Pangilesi Villages in Paramount Lundu, it was observed that the water from boreholes are very salty as such communities have resorted to drawing water from unprotected wells dug on rivers beds as shown in Figure 36.

Figure 35 Main sources of drinking water

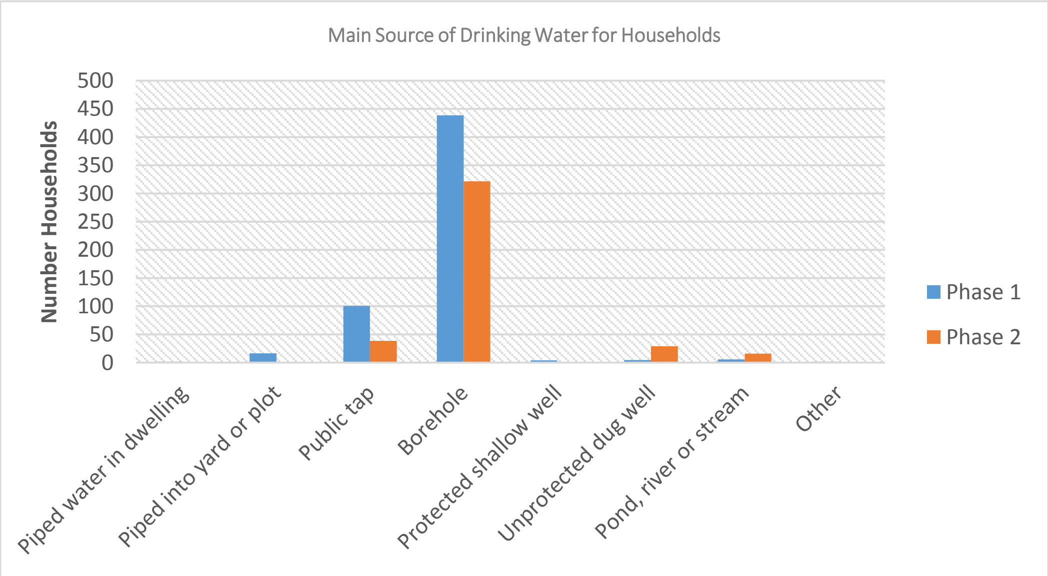


Figure 36 Unprotected well from river bed

5.5.5 Sanitation and hygiene

Across the Study area, households go to great efforts making water safe. It was learned in the survey that households employ a number of sanitary methods, both traditional and modern in keeping the water free from germs. The methods include: boiling, chlorination/waterguard, filtering and covering the water containers. However the most common methods employed in both phase areas was covering the container. In phase 1 42% of the people cover their container while 24% chlorinate their water with waterguard and 26% employ other methods. The proportions were virtually similar in phase 2 (COWI, 2016). Covering water only allows to protect water from dust and insects.

Across the project areas, 81 percent of the households have toilet facility. This means that a household either has a VIP latrine or a traditional latrine with roof. During field investigations, 96 percent of the sampled households indicated to have traditional pit latrines (COWI, 2016).

5.5.6 Health facilities

There are a number of health facilities within the project areas. Main referral health facilities within reach of the communities include Chikwawa District Hospital and Nsanje District Hospital. A number of dispensaries and clinics are located in the project area and these include Mankhokwe, Tengani, Phokera, Mitole, Nchalo and Kasinthula. Key informant interviews with health personnel at nearest health centres indicated that malaria, diarrhea, bilharzia and STIs are the most frequent diseases. According to results of the key informant interviews with health officials from nearest health centres conducted in the project area, malaria is a significant problem and the leading cause of deaths in the project area.

The results of the COWI survey (2016) also revealed that diarrhea is the second common disease in the area. The disease is most common during the rainy season when water sources are contaminated. This is attributed to poor sanitation and hygiene practices. More information on diseases are provided in section 5.7.

During focus group discussions held in TAs Kasisi, Katunga, Lundu, Mbenje, Maseya, Chapananga and Ngabu, participants identified several health issues : lack of medicine and drugs in hospital for common diseases, lack of malaria test kits, inadequate staff, lack of bed spacing, lack of equipment for sting other diseases are common major problems experienced in all six health centres.

5.5.7 Electricity supply

In the project area, urban areas and trading centres such as Chikwawa Boma, Nsanje Boma, Nchalo, Bereu, Phokera, Ngabu and Bangula are powered by Electricity Supply Commission of Malawi (ESCOM) from Kapichira powerstation. Households in most rural areas use solar lanterns, candles and kerosene lamps for lighting in their households. The connection to national electricity grid is still low in the project area and the households indicated that electricity is still not affordable. Households in most rural areas use solar lanterns, candles and kerosene lamps for lighting in their households.

The most source of energy for cooking is firewood both widely used in the urban and rural areas in the project area. Charcoal is used in the urban area because it is relatively expensive. Extensive dependence on firewood significantly contributes to deforestation subsequently effecting water retention processes and cause soil erosion and sedimentation.

5.6 LAND

5.6.1 Land tenure

In Malawi, land is divided into four major categories: customary, government, public and private. The Land Act of 1965 and the National Land Policy of 2002 recognizes these categories of land.

About two thirds of Shire Valley Agricultural Development Division (SVADD) is customary land, controlled by the Chiefs (Traditionnal authorities). Customary land are recognized at Traditional Authority level but not at the Department of Lands level. Land for cultivation is allocated by the chief and a farmer can claim traditional rights to land he has once farmed but no legal rights. Land not used for cultivation can freely be used by anybody for grazing. Customary land includes grazing lands, markets, grounds, graveyards.

Private land is held either under free hold title or leasehold title. Private land or estates cover only a small percentage of the ADD.

Public land is held in trust by the Government and includes Lengwe National Park, Majete and Mwabvi Wildlife Reserves, various Forest reserves, railways, roads, and towns.

Leased land includes private farm and settlements which are on private leasehold agreement within the district. The proposed project will be implemented on both customary and public land. However, land is a contentious issue in the project area and in many areas it has resulted in tensions between communities and private companies accused of grabbing land from locals. Most of the people in the project area are without recognized land tenure rights and very few have been able to secure recognized title deeds for themselves.

Securing land rights in the project area largely depends on inheritance in the project area. The Sena who follows patrilineal system kinship, land belongs to men and is transferred from fathers to sons while Mang'anja who follows matrilineal system kinship, land is transferred along matrilineal lines. In patrilineal system, women do not own land while in matrilineal kinship they have access to own land. However, from an interview that was conducted with the District Social Coordinator (DSC) and the community members, both in Chikwawa and Nsanje, 95% of the households are virilocal (household located in the village of the man) and only 5% are uxorilocal (household located in the woman's village) therefore giving much land ownership powers to men than women.

Inequalities in land distribution, access and ownership is a common problem in the area.

5.6.2 Land size

Land holding size for majority of communities in the project area ranges from 0.1 ha to 1 ha. About 43.2% of the smallholder farmers interviewed in the project area have 0.1ha or less of land for both settlement and cultivation. About 29 % of the farmers have 0.1 to 0.5 ha whilst 17.8 % of the farmers have land sizes more than 0.5 ha (COWI, 2016).

5.6.3 Land use

Most of land use fall in four categories: rainfed agriculture; irrigated agriculture; livestock and grazing and fishing.

5.6.3.1 Agricultural Rainfed Production

Agriculture is the single most important sector of the economy as it employs about 80% of the workforce. Chikwawa district has a total of 126,201 farm families comprised of 65 % and 35% male headed and female headed households. The Makande plain is the major area of agricultural production in the Agricultural Development Division (ADD). Mean annual rainfall is 700-800mm. Mean monthly temperature is 25-30 degrees in the growing period. Agriculture provides the major source of livelihood for the district. Food crops grown in the district include maize, rice, sorghum, various horticultural crops, and sweet potatoes.

MAIN CHALLENGES TO RAINFED PRODUCTION

Rainfall is erratic in the Study area more especially in the western bank of the Shire River. This has a big impact on food security.

MAIN PESTS AND PEST MANAGEMENT

In the Study area, the main pests of rainfed production and pest management are the following:

- Cotton:
    - Pest: aphids and African borer are the main pests of cotton, however none of these diseases are problematic in the Study area.
    - Pest control: is made by manual spraying of chemicals, no protective clothing is used by workers.
- Cereal:
    - Pest: armyworm, stalk borer and termites are the main pests of maize and sorghum. No control is done.
    - Pest control: chemical spraying is only used in case of massive attack.
- Cereal storage:
    - Pest: the large grain borer and weevils are major pests of cereals during the storage of the grains.
    - Pest management: chemicals are widely used to control storage pests.

The Pest Management Plan (PMP), which is a separate report, will further study pests and pesticides and propose management measures for the Project.

5.6.3.2 Irrigated Agriculture

Irrigated sugarcane and other crops are grown on both sides of the Shire River. The largest and most developed of these schemes are Nchalo Sugar Estate (in total 13,805ha including Nchalo, Alumenda and several smaller estates) and Kasinthula Smallholder Irrigation Scheme (755ha) on the western bank and government schemes such as Nkhate (253ha) and Muona Irrigation Scheme (60ha) on the eastern bank. There are also a number of small-scale farmer self-help irrigation schemes using treadle pumps. Average rice yields under controlled irrigation is 3000 kg/ha for one crop. Locally two crops are achieved of either rice alone (summer + winter) or rice (summer) and maize or beans (winter).

MAIN PESTS AND PEST MANAGEMENT

In the Study area, the main pests of irrigated agriculture and pest management are the following:

- Sugar cane

  - Pest: aphids are a major problem in the area. Thrips are present and rodents are widely spread.
  - Pest control: the control of pests is done by chemical aerial spraying. Protective clothing is used in Illovo estate but not in outgrower schemes.
- Sugar diseases:
  - Diseases: smut is a major problem in the area.
  - Disease control: control is done by manual eradication of the infected plants. Hot water treatment is used for seedcane to prevent the spreading of diseases at the plantation stage.

The Pest Management Plan (PMP) will further study pests and pesticides and propose management measures for the Project.

PROSOPIS JULIFLORA

In addition, in the Study area a non-native shrub is invading several areas of arable and grazing lands. It also widely grows in ditches along the M1 road.

The shrub originates from South America and has been introduced to Malawi for life fencing for maize garden (Shackleton, 2014). Although it is invasive, it is considered a valuable shrub for several reasons : it is a source of fuelwood, a source of pole, timber and fencing for maize garden. However, it is considered as a nuisance by communities since disadvantages are more significant than their advantages (Chikuni, 2005). According to Chikuni (2005), the issues with this shrub are the following: because of its spines and rapid colonization, it blocks footpath and limits grazing areas, it also takes up land set for agriculture. In Kenya, it is also known to wound gums of goats affecting their health (Shackleton, 2014).

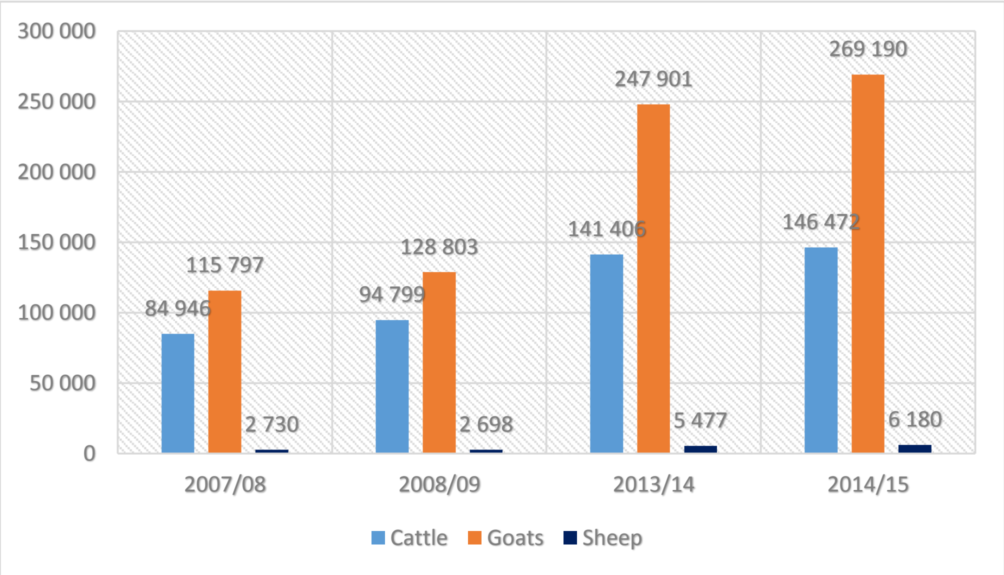
5.6.3.3 Livestock and Grazing

Patches of mixed low altitude savanna and severely degraded grassland are used for grazing of mainly cattle, goats, sheep and pigs. Approximately 12 percent of the farm families own livestock. The area carries one of the highest livestock populations in Malawi. With the exceptions of few ranches, livestock are kept on communal land under free range conditions. There is little productive relationship between livestock production and crop production. Occasionally crop residues and stubble are used for feeding livestock. Animal manure is rarely used to improve soil fertility for crop production.

Traditionally, livestock particularly cattle are kept for social status and only sold if cash is needed. The quantity of animals is more important than their condition and optimum exploitation for produce and cash. For this reason output from traditional animals farming is limited, despite large numbers of livestock. Meat, milk and eggs are used for home consumption and sold locally to a limited extent.

Results from COWI household surveys conducted in the area indicated that most of livestock owners graze their livestock in communal lands and this was very evident during field visit in the project area. There are a number of conflicts in the study area over livestock grazing land especially during the growing season from December to May. For the most part, cattle and goats feed on other people’s crops. Otherwise, frequency of conflicts plummet after harvesting crops. Interviews with the District Livestock Officer both in Chikwawa and Nsanje as well as community members, revealed that there are no special corridors for livestock in the study area. Livestock, pass anywhere according to the discretion of the headman and that is one of the reasons contributing to conflicts with livestock farmers and crop farmers.

Figure 37 Livestock Population in Chikwawa District



5.6.3.4 Gender aspect

In both Phase 1 and Phase 2 of the project area gender and decision making on land-use is dominated by adult male. Adult male make most decisions regarding land-use as presented in figures 38 and 39.

Figure 38 Gender and Decision Making on landuse at Household Level: Phase 1

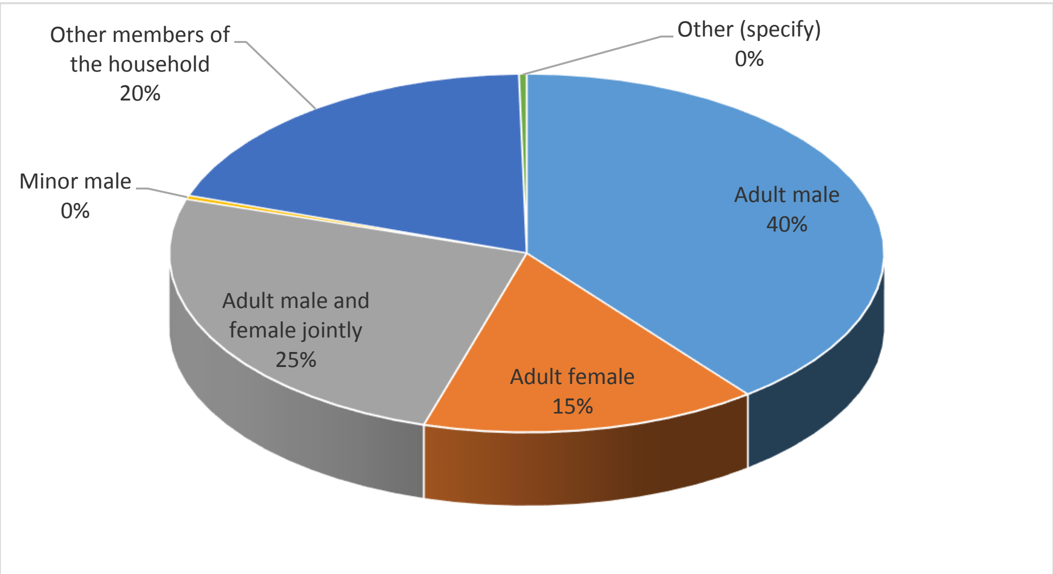
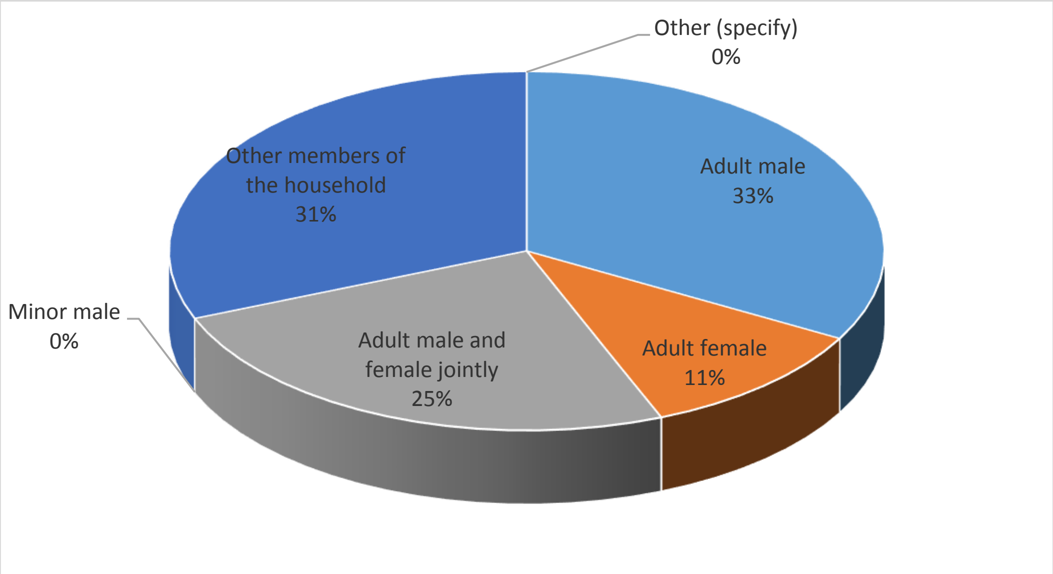


Figure 39 Gender and Decision Making on landuse at Household Level: Phase 2



5.6.3.5 Settlement Pattern

Like most of the settlement patterns, there is a propensity of dense settlements at trading centres, and business centres; the settlement pattern in the study area takes a similar setting with much of the population concentrated at Chikwawa Boma, Nchalo, Ngabu, Bangula and Nsanje Boma. Such places offer business opportunities and have medical and facilities that foster better living standards. Nchalo is the most densely populated area in the entire study area beacause of Illovo Sugar Company that offers a lot of job opportunities and a wide spectrum of business streams. On the other hand, Shire River banks are relatively populated due to farming and fishing activities. The river bank is fertile and idea for farming as well as grazing livestock. Areas further from Shire River and urban area are sparsely populated.

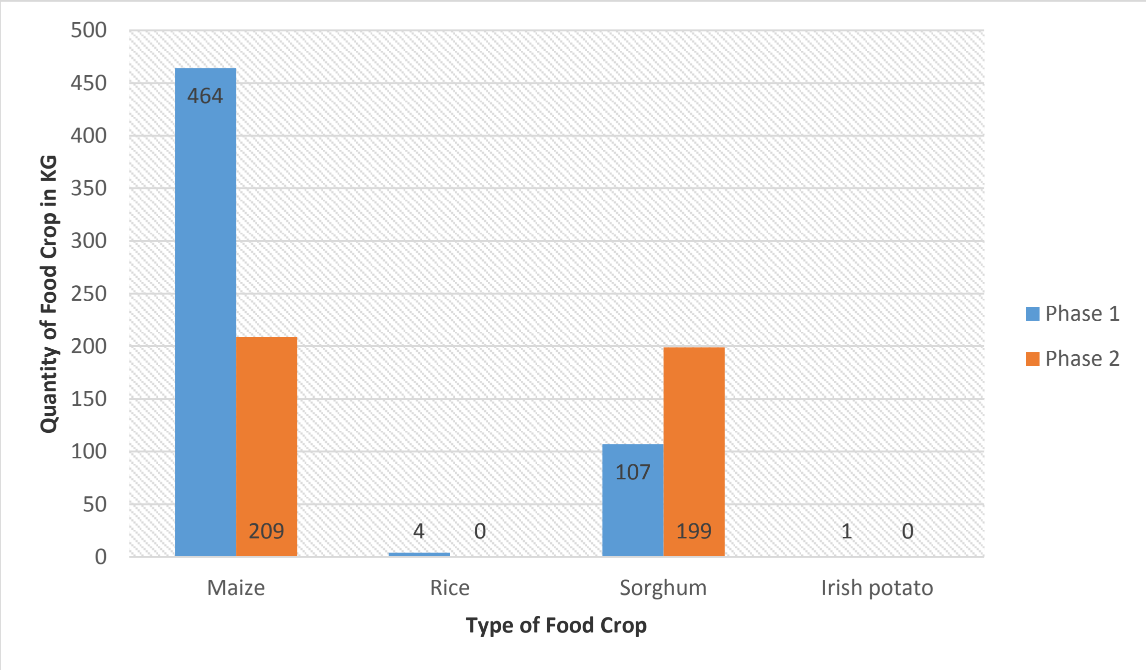
5.6.4 Economics

The economy of the study area is largely agro-based with households engaged in crop production. Maize is the main food crop grown in the project area while cotton is the main cash crop grown by smallholder farmers in the area though sugarcane cultivated in Illovo sugar estates could be regarded as the main cash earner in the study area. Livestock production and fish farming is also a key economic activity in the area for local masses. Areas of tourist attraction in the study area includes Lengwe National Park and Majete Wildlife Reserve have allowed the developement of economic activities for communities such as the Majete community campsite and community based organisation which are engaged in various income generating activities. Sections below provide a discussion of main economic activities undertaken in the study area.

5.6.4.1 Crop Production

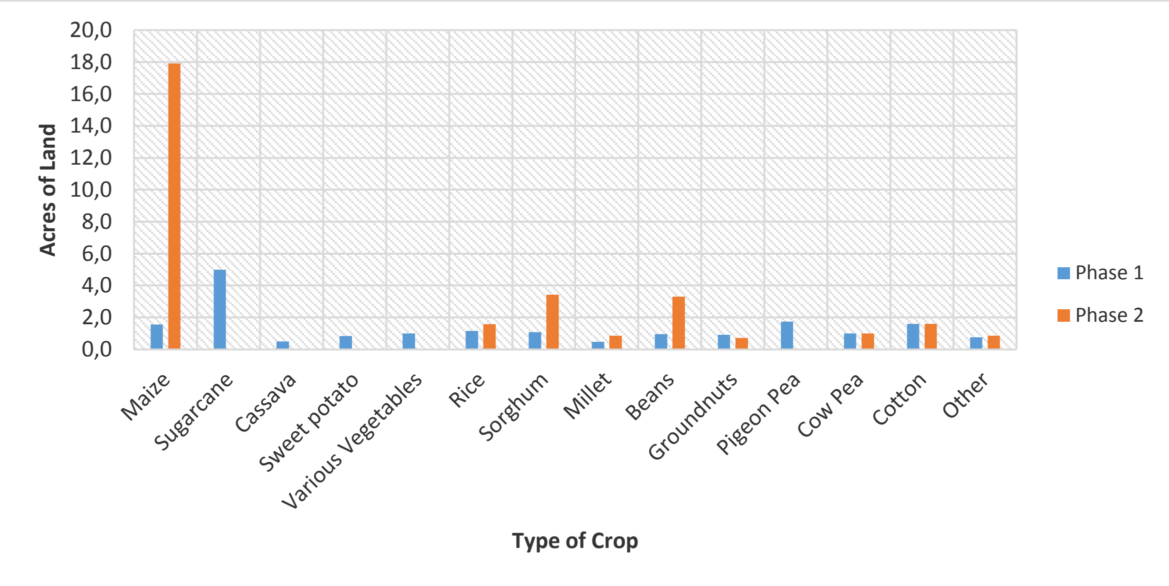
The project area is largely an agro-based economy relying heavily on rainfed agriculture except for large commercial farming being undertaken by Illovo and medium scale irrigation schemes such as Phata and Kasinthula. The main income generation source in the project area is rainfed crop production sales as displayed in Figure 40, indicating 46% and 52% in phase 1 and phase 2 of the study area respectively. A majority of smallholder farmers are vulnerable to adverse weather such as prolonged drought and flooding which negatively affect productivity for a population with very limited economic opportunities to cushion the impacts from adverse weather. Major crops grown in the project area include maize sorghum , millet, cotton, vegetables such as tomatoes, cabbage and beans. During site visit and discussions with community leadership, it was observed that smallholder farmers in the upper reaches of Mwanza, Mkombezi, Mnthumba are more vulnerable to prolonged drought exacerbated by lack of residual moisture to promote winter cropping. Communities living in the floodplains have alternatives especially fishing from Shire River and winter cropping along Mwanza and Shire rivers (in Elephant marsh, also called dimba agriculture). Availability of fertile soils deposited by Mwanza and Shire promotes productivity in their floodplains.

Figure 40 Main food crops



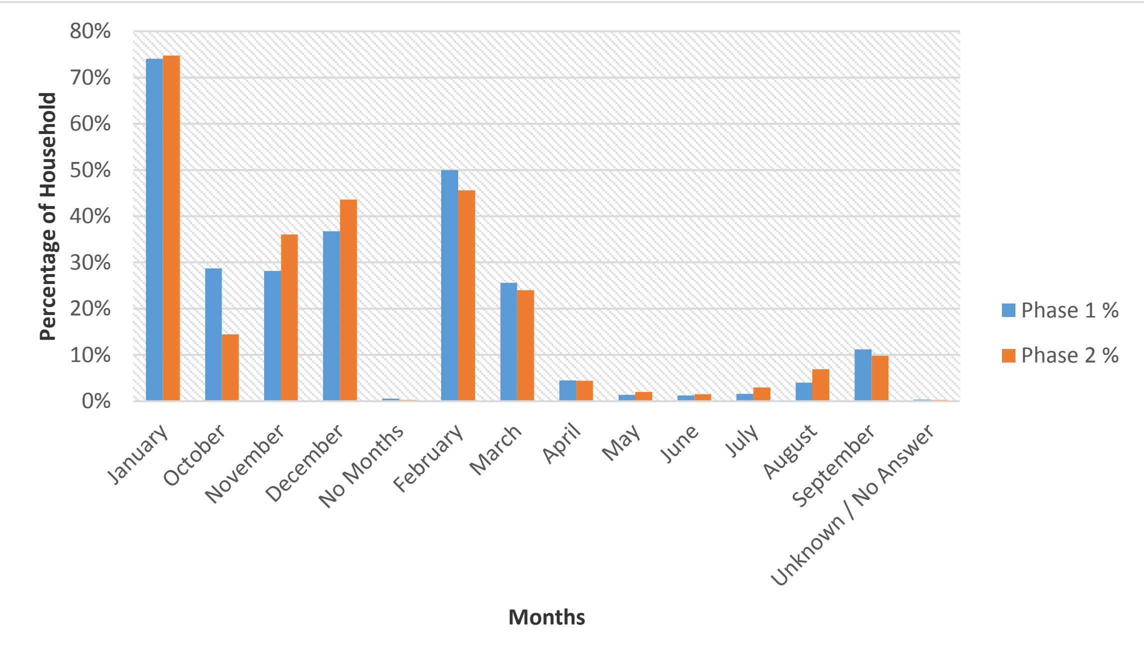
In terms of land use, the most common grown crop in the area is maize followed by sugarcane as shown in Figure 41. Maize is a staple food in the area and that explains why it is mostly grown. However, the area is also ideal for sugarcane which is one of the most lucrative cash crop in the area.

Figure 41 Household crop production



Over reliance on agriculture for income generation strikingly renders most of the households struggle to get food and generate income in November through February as shown in Figure 42 because the food reserves are either run out or the crops are not yet ready for harvest. Climate change has exacerbate this food security problem in this area and Malawi at large.

Figure 42 Household generating months



Apart from sugarcane grown in Illovo Estates, Kasinthula and Phata schemes, cotton has previously been cash earner for most of the smallholder farmers in the project area especially those located above the flood line. However, prolonged dry years coupled with low prices fetched on the markets have resulted in many farmers losing their crops and abandoning cotton farming. Presence of ginnery companies at Miseu Folo and Bangula Trading Centres indicate the role cotton has been playing in economy activity of the project area.

There are number of smallholder irrigation schemes in the project area which largely depend on residual moisture along Shire, Mwanza, Mkombezi, Mnthumba and Thangadzi rivers. The predominant crop in these schemes is maize and primary for food. One major challenge experienced by farmers is unreliable water from nearby wells and lack of pumping equipment to draw water from nearby rivers. At Mkombezi Irrigation Scheme, farmers divert water from Illovo canal to irrigate their crops.

5.6.4.2 Livestock production

Livestock farming is also a key economic activity in the project areas especially rearing of cattle, goats, pigs and poultry. Most of the agricultural produce sold are at the nearest trading centres. Traders from nearest townships and urban centres also flock to the project areas to purchase farm produce. Results from COWI household surveys conducted in the area indicated that most of livestock owners graze their livestock in communal lands and this was very evident during field visit in the project area.

5.6.4.3 Fishing

Fishing in the study area is largely undertaken in Shire River and in a few fish farming ponds. Fishing forms a key economic activity for households located along the Shire River especially during periods when crop production is very low due to flooding and prolonged dry spells. Common fish found in the Shire include Clarias gariepinus (Mlamba), Clarias ngamensis and Oreochromis mossambicus. Discussions with fisheries officials in Chikwawa district indicated that the current is supply of fish is low in the region as such dried fish is imported from Mozambique to meet the demand. It was estimated that the average price of fish was MK523.53 per kilogram translating into a total value of MK128,578,968 in 2014/15. Currently, there are 231 fish farmers in the study area with 51 fish ponds covering an estimated area of 25 hectares. In terms of fishery, about 1,830 people are involved in this activity benefiting an insignificant percentage of households.

More information on fish species and their value as food source is in section 8.7.

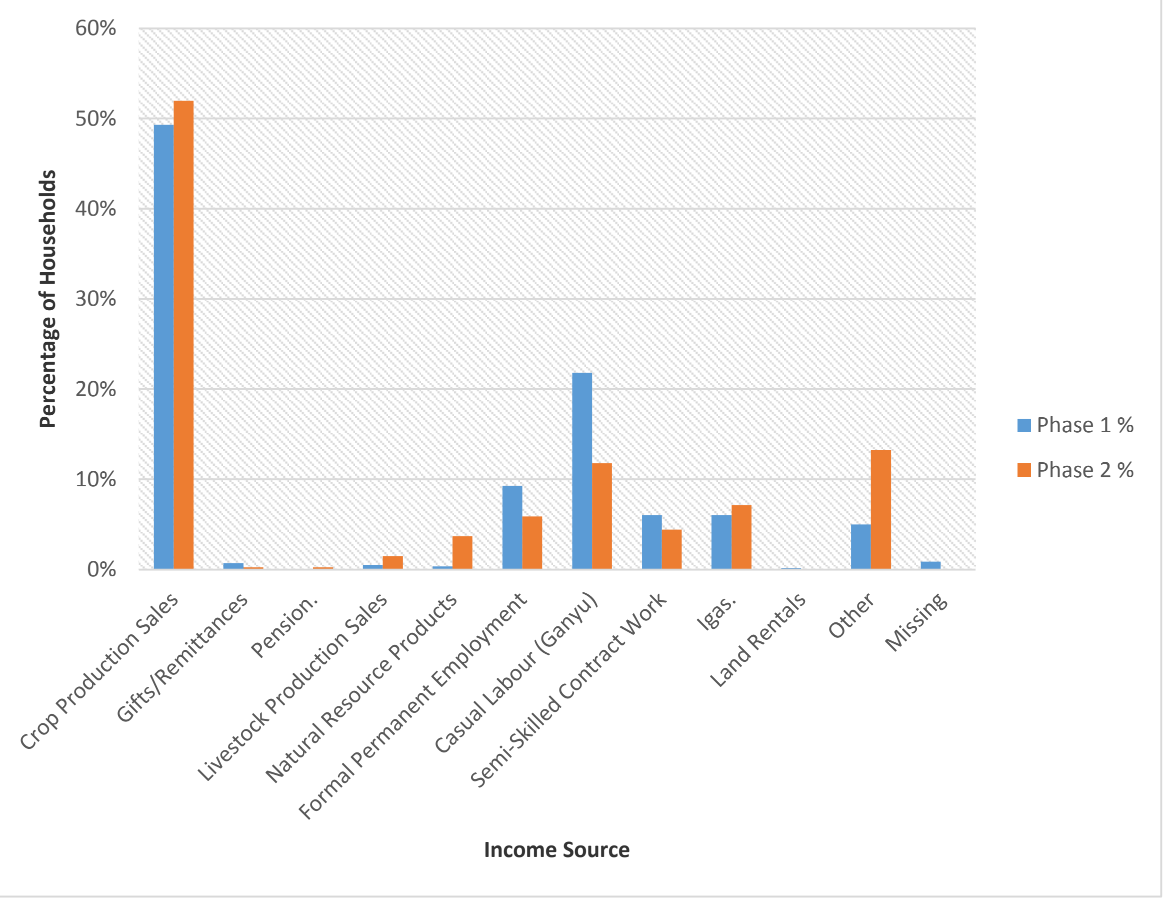
5.6.4.4 Employment

A large section of population in the study area especially those in TAs Lundu, Maseya and Katunga are employed directly by Illovo or indirectly through contractors as permanent and seasonal casual laborers. Illovo's contribution to the local economy is enormous. The company directly and indirectly employs as many as 10,000 people in Lower Shire and also supports close to 2,500 workers throughout outgrowers. The indirect labour force is outsourced during weeding harvesting and pest control. Traditional leaders and communities indicated that income earned from employment in Illovo Estates provides significant revenues for families to complement crop production in the area which at times is adversely impacted by weather shocks. Casual labour is the second largest and vital source of income for most households in the study area with 22% in phase 1 and 12% in phase 2 as shown in Figure 43.

5.6.4.5 Income

On annual incomes, about 53 percent of the respondents indicated that they make about less than MK100,000 (+/-150 $US) while 43 percent of the respondents generate about MK100,000-500,000 (150-715 $US) annually. Only 4% of the respondents indicated to generate more than MK500,000. From the survey, it was clear that about 84.3 percent of the respondents in the project area live below one dollar per day.

Figure 43 Main income sources



5.6.4.6 Benefits from Parks

Majete Wildlife Reserve has proved economically beneficial to surrounding communities since a number of people have been employed in the Park and earns incomes.

At the community level there is collaborative management of the Park to enhance community ownership and commitment to conserve the Park. Community members are allowed to harvest some of the products in the park such as grass and herbs. They are also allowed to place bee hives to harvest honey as an income generating activity.

Community Based Organizations (CBOs) have also been established in villages around the Park undertaking environmental and income generating activities. Profits from such activities are shared by committee members to improve their livelihoods and excess funds assist needy communities and projects. For example, Park Management have donated four maize mills to four CBOs as part of income generating activity.

In terms of corporate responsibility Majete Wildlife Reserve have managed to construct a number of school blocks and teachers houses in the area and have been paying school fees for some needy students.

Lengwe National Park has proved economically beneficial to surrounding communities as well. At the community level joint management structures were established to ensure co-management of the Park and foster community commitment to conserve the Park. Community Based Organizations (CBOs) were established in all villages which surround the Park through which Park Management support various community level development projects.

5.7 HEALTH ISSUES

5.7.1 Introduction

Malawi has a high density of population. This population is young (under 15 years represent 47% of the population) with an annually growth rate of 3.3% (Malawi National Statistical Office and ICF Macro, 2011). The greatest part of the population lives in rural areas where the country suffers from the burden of major tropical transmitted diseases like malaria and schistosomiasis. In addition, a severe food crisis affected the country in 2001-2003. This famine has had a part of responsibility in the high level of HIV infection rate through transactional sex for food or gifts (Loevinsohn, 2015).

The rapid decrease of the under-five mortality rate from 145 per 1,000 live births in 2000 to 110 in 2010 and 85 in 2014 shows a clear improvement in the health preventive and curative activities. However, with a ratio of 0.03 physicians for 1000 inhabitants, the access to high level care is difficult especially for the rural population.

In this context, the ESIA ToRs has requested to provide with a baseline characterization of health issues in the Study area. In addition, there is a common concern about the development of large scale irrigation schemes and the increase of waterborne diseases.

5.7.2 Water-Related Diseases

Some infectious diseases are related to water by their way of transmission:

- Malaria and its Anopheles mosquitoes vectors breeding in still water;
- Schistosomiasis and aquatic snails used as obligate intermediate hosts;
- Soil transmitted worms using muddy places;
- Cholera or leptospirosis germs possibly present in freshwater.

The expansion of irrigation areas can increase the intensity of transmission of these diseases. However, there is never a direct and proportional link between the quantity of surface water and the quantity of related diseases. Conversely, the scarcity of water can also increase their transmission due to population influx near the water places and associated difficulties in hygiene. The scarcity of food or money have negative effects on human behaviour. On the contrary, irrigation can have positive effects on health through increase of money income, of food production and its regularity and through some changes in human behaviour. The vulnerability of communities to changes depends on their adaptive capacity, which requires both appropriate technology and responsive public health systems. The availability of resources depends on social stability, economic wealth, and priority allocation of resources to public health (Sutherst, 2004).

5.7.2.1 Malaria

Malaria is caused by the parasite Plasmodium falciparum. It continues to be one of the leading causes of morbidity and mortality in Malawi. It is estimated that the country experiences between 4 and 6 million episodes of malaria annually. The transmission by Anopheles gambiae s.l. and An. funestus s.l. mosquitoes is perennial with a seasonal increase during the rainy season (Mathanga et al., 2015). In Chikwawa district, the estimated entomological inoculation rate for Plasmodium falciparum is of 172 infective bites per human/year which is a high transmission rate (Boudowa et al., 2015).

As in others African countries, children under the age of five years bear the highest burden of malaria with annual incidence rates as high as 1,160 episodes per 1,000 children. Surveys carried out in primary schools show a rate of 40% to 60% of the pupils infected by Plasmodium falciparum (asymptomatic carriers) (Mathanga et al., 2012). At the same time, 20% of pregnant women are also asymptomatic carriers.

The Malawian Ministry of Health has developed a National Malaria Strategic Plan 2011-2016 to reduce its burden through improved diagnosis, appropriate treatment, and integrated vector management. It recognises the use of Long-Lasting Insecticide-treated Nets (LLIN) as an important intervention for the control of malaria. The plan includes free distribution of LLINs to children born in health facilities, to children attending their first visit under the Expanded Program on Immunization and to pregnant women at their first visit to an antenatal care clinic (Ministry of Health, 2014). The policy supports national distribution campaigns every two to three years and targets pregnant women and children under five, considered the most vulnerable populations. According to surveys, approximately 50% of children and pregnant women sleep under a treated net.

The intermittent preventive treatment strategy during pregnancy has been recommended since 1993: all pregnant women have to take at least two treatment doses of sulfadoxine-pyrimethamine during routine antenatal care visits. The last two years have seen alternative distribution channels, including community-based mechanisms. National surveys have shown that the proportion of women who took at least 2 doses of preventive treatment during pregnancy is less than 60%.

As in other Sub-Saharan countries, the clinical diagnosis of malaria has to be confirmed at all levels of health structures, using malaria rapid diagnostic tests or light microscopy. The recommended treatment regimen of uncomplicated malaria is an artemisinin-based combination therapy. The first line drug is artemether-lumefantrine. Parenteral artesunate replaces quinine as the recommended medication for the treatment of severe malaria. Theoretically, these drugs are available without cost in health facilities. However, between 2004 and 2010, the proportion of under-five children with fever who used an anti-malarial drug the day of or day after diagnosis remained low at approximately 25%.

Illovo Estate distributes insecticide impregnated nets to its workers and their relatives. Of course, this distribution does not ensure a real use of the bed nets. When the weather is very hot, it is not comfortable to sleep under a net, especially in little houses with a corrugated iron roof. Out of Illovo, the free distribution of bed nets is only to pregnant women and children through the public health structures. Some surveys show that about half of the under-five sleep under a bed net but the surveys do not provide any detail on the sort of net used. An old net without impregnation by insecticide, with holes or not well tucked under mattress is ineffective against malaria transmission.

Illovo workers and relatives have an access to prompt diagnosis and treatment of a malaria attack in one of the seven clinics of the estate. The workers of the other sugar estates (outgrowers) do not have a similar access to care. As the rest of the population, they have to go to one of the health facilities. Some of these facilities have biological tests for the diagnosis and free malaria treatments. However, other facilities are without any drugs and may only refer the patients to other health centres, sometimes as far as 15 km away. Therefore, outside of Illovo Estate, malaria is not well managed in the Study area.

IS THERE A STRONG LINK BETWEEN IRRIGATION AND MALARIA?

In fact, this link is weak because the vector mosquitoes do not breed in the channels with running water. Their larvae grow in small and shallow pools of still water, often temporary pools. It is more forest clearing to make farmland that causes an increased production of Anopheles than irrigation. These mosquitoes can however benefit from terminal channels left in non-running water or from poorly maintained drainage channels. The development of irrigation in the Phase II A area does not deeply upset the situation: these lands are already widely used for rain-fed crop production and are therefore a strong support for the production of Anopheles. With a transmission rate greater than 100 infected bites per person per year leading to an overload of infections, the increased in water will maybe increase the Anopheles production in some places but will not induce a genuine change in malaria pattern.

5.7.2.2 Schistosomiasis

Schistosomiasis, also known as bilharzia, is a chronic disease caused by parasitic flat worms of Schistosoma genus. Two major forms exist in Malawi, the urogenital and the intestinal schistosomiasis caused by different Schistosoma species, *Schistosoma haematobium* and *S. mansoni*, respectively.

In order to complete their lifecycles, schistosomes worms require obligate aquatic snail hosts. Human beings are the reservoir of the parasites and the source of infection of the snails. The distribution of the susceptible populations of Bulinus and Biomphalaria snails broadly outlines the endemic areas where urogenital and intestinal schistosomiasis can occur. There is a close association between the species of parasites and the species of snails. Snail can only proliferate within narrow ranges of temperature, pH and of salinity. However, these conditions are often observed in tropical areas especially in irrigated schemes. The infection of human beings occurs trough healthy skin in contact with water where infective forms of the parasites move after leaving the snails. Schistosomiasis is the group of infectious diseases the most closely linked with the use of water for agricultural production or fishing in tropical areas.

The prevalence of the infection by Schistosoma is often described as the highest in adolescents and young adults (Makaula et al., 2014). However, infection occurs as early as childhood, when children follow their mothers in activities in fresh water such as washing clothes or irrigating rice or gardening. A survey in Chikwawa district in 2012 showed that 45% of the mothers and 18% of the children were infected with urinary schistosomiasis, with a range from 5% to 60% depending on the villages. The intestinal schistosomiasis was rare in children but present in 21% of the mothers. A co-infection with both S. haematobium and S. mansoni was estimated to be 8% in mothers (Poole et al., 2014). It is a surprising observation because it was previously assumed that this area was only endemic for urogenital schistosomiasis (Chipeta et al., 2013).

The workers of Illovo estate benefit from protective clothes and boots and from sensitization. In case of symptoms of schistosomiasis, they are treated in one of the clinics. Their relatives have also access to free treatment. The workers of outgrowers and also the neighbouring population may be free treated in Kasinthula bilharzias health post. A microscope examination of urine is done there but not an examination of faeces because of the lack of knowledge on intestinal schistosomiasis in the area. Seven hundred outpatients were tested in this health post in 2015 and 400 treated.

5.7.2.3 Soil-transmitted helminthiasis

Among the infections by soil-transmitted helminths, the most common are ankylostomiasis (hookworm infection) and ascariasis (ascaris worm infection).

Hookworm infection affects over half a billion people globally. These worms live in the small intestine. The most significant risk is anaemia secondary to the loss of iron and proteins in the gut. The infection is done through the skin and commonly caused by walking barefoot through wet areas contaminated with human fecal matter.

Ascariasis has no or few symptoms, especially if the number of worms is small. Symptoms increase with the number of worms present in the gut (abdominal swelling or pain, diarrhea). The infection occurs by eating food or drink contaminated with Ascaris eggs coming from human feces. About one billion people globally have ascariasis.

Various surveys in Malawi, especially in the south of the country, show evidence of low levels of prevalence for both ankylostomiasis and ascariasis, below 10% of the children are infected (Bowie et al., 2004, Phiri, 2000, and Msyamboza et al., 2010). It is slightly surprising but the results of the various surveys are similar. They are consistent with the observation of lower intestinal schistosomiasis prevalence in comparison with the urinary one. It can be partially explained by a certain use of pit latrines for defecation.

The expansion of irrigated land can foster an increase of these infections, especially by hookworms.

5.7.2.4 Onchocerciasis

Onchocerciasis – or “river blindness” – is an eye and skin disease caused by the filarial worm Onchocerca volvulus transmitted by repeated bites of infected blackflies (genus Simulium). These flies breed in fast-flowing streams. Adults flies bite mammals present near the rivers and streams. In the human body, the worms produce larvae that migrate to the skin and eyes. Infected people show symptoms such as severe itching and various skin lesions. Some infected develop eye lesions which can lead to permanent blindness.

Onchocerciasis is present in southern Malawi in the highlands area of Thyolo, Mwanza and Mulanje (Courtright et al., 1995 and Mustapha et al, 2005). Because the blackflies live near the fast-flowing streams, the flat areas are free of this disease as is the case for the existing irrigation schemes. SVIP is therefore not at risk of onchocerciasis. The feeder, the secondary and the tertiary canals will not be places for Simulium breeding because of their slow current speed. The only case where the Simulium could occur is if a weir is installed to stop tiger fish invasion of the upper Shire River (if the weir creates riffles downstream).

5.7.2.5 Cholera

Cholera is an acute infectious diarrhea caused by the ingestion of food or water contaminated with a pathogenic strain of the bacterium Vibrio cholera. It affects both children and adults and can kill within hours. About 80% of people infected do not develop any symptoms, although the bacteria are present in their feces and are shed back into the environment, potentially infecting other people. The cholera transmission uses the fecal-oral route and is closely linked to inadequate environmental management where minimum requirements of clean water and sanitation are not met. Its transmission is caused by human to human contacts (dirty hands in contact with food or water). In Africa, human beings are the only reservoir of the infectious agent.

Cholera outbreaks in Malawi occurred every year since 1998 with a maximum of 33,500 cases in 2001-2002. A decrease of the annual number of cases has been observed since this period. Cholera outbreaks in the Southern region of Malawi occur during the rainy season (sometimes throughout the year), including the 2015-16 rainy season. Nsanje, Chikwawa and Blantyre districts are major hotspots. Unsafe water sources, lack of maintenance of broken boreholes, frequent breakdown of piped water supply, low coverage of pit latrines, lack of hand washing facilities, salty borehole water, cross-border spread of the disease from Mozambique, and socio-cultural issues ("Chlorine-treated water smells and tastes bad", perception of the disease as witchcraft) are some of the causes of the persistent cholera outbreaks (Msyamboza, 2014).

Biological analysis show that the quality of drinking water from wells in southern Malawi is very poor, frequently polluted with fecal matter. Approximately 80% of the shallow wells tested in the dry season and 100% of the wells in the wet season do not meet the drinking water standard guidelines for total coliforms bacteria set by the Ministry of Water Development (Pritchard, 2007). Heavy rains are a risk factor for cholera outbreaks because they bring excreta in wells and in water collections. Cholera outbreaks can however occur independently of rain.

The irrigation is not by itself a risk factor for the spread of cholera. However, a bad use of the canals with open defecation inside the water or on the banks could increase its transmission.

5.7.2.6 Leptospirosis

Leptospirosis is caused by various bacteria of the genus Leptospira that affects humans and animals. Without treatment, leptospirosis can lead to kidney damage, meningitis, liver failure, respiratory distress, and even death. The bacteria are spread through the urine of infected animals, especially rodents, which can get into water or soil and can survive there for weeks or months. Humans may be infected through contact with water, soil, or food contaminated with the urine of animals. The bacteria enter the body through skin or mucous membranes. Leptospirosis is an occupational hazard for farmers, especially in tropical areas with wetlands. It is known to be present in some sugar cane plantations. However, data on this disease are scarce in Malawi. Bacteria have been observed in livestock but there are no data for human beings (Myburgh et al., 1989).

The use of boots and protective clothes by the farm workers reduces the risk of infection but swimming or wading in fresh water remain a risk factor.

The expansion of irrigated lands may result in cases of leptospirosis in the communities, the use of protective clothes being rare and wading being a too pleasant activity for young people. Before any excess of concern for this disease, it would be of interest to carry on serological surveys in samples of the population and also to inform the health workers. Leptospirosis attacks may be easily confused with others febrile attacks like malaria and consequently poorly treated.

5.7.3 HIV infection and AIDS

The burden of the HIV infection is high in Malawi. After a peak at probably 22.8% in 1999 among the 15-49 adults, the estimated prevalence was 10.6% in 2010 in the same population (Zulu et al., 2014). In 2012, the whole population living with HIV infection in Malawi was estimated at 1.13 million. The Southern part of the country seems be slightly more affected than the two others regions. In Chikwawa district, the prevalence rate in 2010 among pregnant women was 11.4%. Poverty and high population density appear to be associated with a higher HIV prevalence.

The medical personnel interviewed during key informant interviews indicated that HIV/AIDS prevalence rates have been decreasing in the two districts though cases are frequently registered in dispensaries located close to urban centres. Deaths related to HIV/AIDS have significantly dropped in the areas because of antiretroviral therapy available in dispensaries and increased patients accessing the therapy. However, it was indicated during the FDGs that provision of voluntary counselling and testing programmes should be scaled up in the project area.

6. CULTURAL HERITAGE

6.1 INTRODUCTION

This section deals with cultural heritage in Project's study area.

The principal objectives of this section are to:

- Present existing information on cultural heritage ;
- Describe findings from field surveys ;
- Identify and describe cultural resources and their values.

This report is based on three main sources of cultural heritage surveys in the Study area:

- Cultural heritage surveys by the Malawi Department of Antiquities (MDoA) carried out from November 23 to December 13 2015.
- Cultural heritage surveys by the consultant cultural heritage specialist carried out from January 24 to February 6 2016.
- Previous cultural heritage surveys in the Chikwawa and Nsanje Districts (done at different periods for example by Robison in 1973).

The following section details the methodology of the consultant cultural heritage specialist to undertake cultural heritage assessment in the Study area.

6.2 METHODOLOGY AND APPROACH OF THE STUDY

The methodology of this study consisted of three distinctive components:

- Desktop assessment
- Fieldwork assessment
- Meeting with relevant stakeholders

6.2.1 Desktop Assessment

Several types of published data were available, which includes articles and books. The consultant used the Section of Archaeology's bibliographic database at the Royal Museum of Central Africa (RMCA) in Tervuren, Belgium as well as the library of the Malawian Historical Society in Blantyre. In addition, graveyard localization for the Study area were provided by COWI consultant and the MDoA provided the consultant with their cultural heritage survey report. Even though unpublished data also exists for the Project's immediate impact area, the consultant was unable to use it as it comprises data for a doctoral research project by a postgraduate student from the University of Leiden in The Netherlands.

6.2.2 Fieldwork Assessment

For this study, fieldwork was carried out from January 24 until February 6, 2016. One expert and one guide/translator made up the team.

- Dr. Noemie Arazi (Cultural Heritage Specialist for the consultant and Research Associate at the University of Brussels, Belgium)
- Mr. Charles Chikwana (Junior Clerk at the District Commissioner's Office of Chikwawa)

Mr. Oris Malijani a representative from the MDoA accompanied the team during their last three days of fieldwork.

Fieldwork consisted essentially of interviews and pedestrian surveys. Interviews were conducted with Paramount Chief Lundu and Traditional Authorities as well as with elderly people and cultivators, which allowed the team to introduce themselves to the communities and access essential information on their territory. The team's work was presented as an opportunity to voice the inhabitant's concerns over cultural heritage issues such as the preservation of sacred sites. The team also explained the search for archaeological sites (stone tools, potsherds, slag, concentrations of charcoal, etc.), and their importance for reconstructing the country's prehistory and history. All the cultural heritage sites mentioned during the interviews were visited and their geographical positions registered with a hand-held GPS.

Further to the identification of sites that have a cultural, spiritual or religious significance for local communities, a common role of field survey is also the assessment of the potential archaeological significance of places where development is proposed. This is usually connected to construction work, which in this case concerns the canal, associated infrastructure work and the clearance and leveling of land for the areas earmarked for irrigation. The assessment determines whether the area of impact is likely to contain significant archaeological resources and makes recommendations as to whether the archaeological remains can be avoided or rescues excavations are necessary before development work can commence.

Considering the vast terrain of the Study area, it was decided to cover as much ground as possible of the Canal RoW and the areas earmarked for irrigation that have not yet been visited by the MDoA.

The methodology chosen was field walking in grids or along lines called transects, which has formed the backbone of archaeological survey fieldwork, at least where visibility is fairly good. A team walks slowly through the target area looking for artifacts or other archaeological indicators on the surface. The method works best on either ploughed ground or surfaces with little vegetation. On ploughed surfaces, as the soil is turned regularly artifacts will move to the top. Each site or find spot was recorded with a handheld GPS to produce the map of cultural heritage sites (see Map of Cultural heritage sites).

6.3 RESULTS

The results, especially on the archaeological data, should be viewed as preliminary in nature as all interpretations are based on surface finds (no trial excavations were carried out neither any C-14 dating). Considerable numbers of sites were identified, indicating the area's wealth in cultural resources.

6.3.1 Desktop Assessment

Even though the Lower Shire Valley is known for boasting considerable numbers of cultural sites, only a limited amount of published data is available on its archaeology and any other types of heritage resources.

The Cultural heritage surveys by the Malawi Department of Antiquities (MDoA) carried in 2015 has identified several sites numbered CK1 to CK45 most of which are pottery sherds and stone tools likely from the Iron Age. Some findings were collected for further analysis. The cultural heritage map shows their location.

One of the most important publications on the area remains the work by Keith Robinson, who conducted extensive archaeological surveys in southern Malawi and made small-scale excavations along the Lower Shire Valley (Robinson, 1973). The main area investigated by Robinson was along the western bank of the Shire River from the Kapichira Falls in the north to Chiromo in the south, mainly focusing on the western tributaries of the Shire, which overlay the Study area.

Robinson noted in 1973 a number of surface occurrences of stone artefacts in the nature of camp sites mainly on raised ground near streams and rivers. The usual material included white quartz, rock crystal and dolerite, which he attributed to the Late Stone Age as they contained microlithic elements. He also found cores and flakes on the Chombwa stream, which he described as Middle Stone Age, but no thorough analysis of this material nor any C-14 dating was undertaken.

Robinson's surveys mainly included the identification of Iron Age sites. The following sites are shown on the cultural heritage map and located in the Study area, some archeological sites have already been salvaged. In Chikwawa District Robinson's surveys comprise surface scatters at Miwawa Water Hole at the southern boundary of Majete (CK2a), at Phwadzi Stream I (CK4a) and II (CK4b), at the north and south bank of the Nkhombedzi wa Fodya stream (CK5a and CK5b), at the Madziabango stream (CK5c), at Changalumbe Bridge (CK7a), at the north bank of the Lalanje stream (CK9a). In Nsanje District Robinson found Iron Age material on the south bank of the Lulanje (NS1), at the river bank by the Thangadzi Bridge (NS2) and around Chisomba Village (NS4). He identified one shrine known as Nyangu, the ceremonial queen mother to the Kalonga of the Chewa (Maravi) peoples, situated in a grove of trees near the headquarters of Chief Chapananga (Cole-King 1973). These sites are localized on the Cultural heritage map.

Robinson's excavations were carried out at two Iron Age sites at the Phwadzi Stream (I and II), which yielded one charcoal sample that has been dated to AD 500. This date falls within the Early Iron Age period of Malawi, which extends up to the end of the first millennium AD. In southern Malawi the Early Iron Age is mostly represented by a pottery style that is known as Nkope ware. The basic vessel form of Nkope ware are globular pots with everted rims and bowls with flattened and thickened or inturned rims, mainly showing broad line incisions and comb stamped patterns (for an example of Nkope ware see next figure). The latter was made using an implement with relatively large and square teeth. At the end of the Early Iron Age appears a distinct pottery style called Kapeni ware, which is also present in the Lower Shire Valley. Kapeni pottery exhibits thin walled ceramics with everted rims, decorated with a combination of bold oblique, vertical and horizontal channeled incisions (see next figure). The Late Iron Age covers more or less the second millennium BC and includes wares known as Mawudzu (see next figure) - dated to around the 14th to 18th centuries - and Nkhudzi (see next figure) – dated to around the 18th century up to the present, which are equally present within the Project's impact area. The former exhibits straight rimmed pots, decorated with incised, impressed and stamped motifs of herring bone patterns and oblique lines, while the latter often exhibits fine, bichrome red and black pottery.

Figure 44 Examples of Nkope Pottery, Early Iron Age

Source: Rachel Warren, unknown date

Figure 45 Examples of Kapeni Pottery, Terminal Early Iron Age

Source: Rachel Warren, unknown date

Figure 46 Examples of Mawudzu (or Maudzu) Pottery, Late Iron Age

Source: Rachel Warren, unknown date

Figure 47 Examples of Nkhudzi Pottery, Late Iron Age

Source: Rachel Warren, unknown date

An important element of the Lower Shire Valley is that it was home to the Lundu Kingdom. The power of the Lundus was founded on the strategic position they occupied in relation to trade between the Portuguese and the interior and on the agricultural production of the Shire Valley that was critical to the survival of the Portuguese settlements in times of drought. Cotton was also provided for trade (Schoffeleers, 1987). According to oral traditions, a legendary figure with super human powers, known as Mbona, lived in the Lower Shire Valley during the rise of the Lundu Kingdom. Mbona is said to have had magic powers of bringing rain, creating wells of water on sandy lands, creating forests where they did not exist and hiding from enemies by turning into other creatures such as a guinea fowl. When he died his head was cut and placed at Khulubvi sacred groove, located in the Nsanje District. This place has become an important sacred site to the Mang'anja people, who inhabit the area and worship the spirit of Mbona. From this site other sacred sites developed in the Lower Shire Valley where Mang'anja people gathered to worship the spirit of Mbona. In addition to the Khulubvi sacred grove, they include the following group of sites:

- Nyandzikwi sacred site on the junction of Bangula and Maraka road in group village headman Lundu in Nsanje District
- Mwala Umodzi shrine, located near Mgwiriza Village within the course of the Thangadzi River
- Kaloga sacred cave site, located within the area near Kanyimbi village in the Mwabvi Wildlife Reserve
- Chifunda Lundu, located close to the present day headquarters of Paramount Chief Lundu
- Nkhadzi sacred site, located in the area of group village head man Ngabu in Nsanje district
- Mtsakana rain shrine, in the vicinity of group village headman Zimara, T.A. Maseya in Chikhwawa District
- Konde Dzimbiri rain shrine is located in the area of sub T.A. Mphuka in Chikhwawa District

In spite of Malawi's decline in traditional ceremonies, those sites keep their sacred character and still attract people for various traditional practices and expressions. Because of their historical importance, the Khulubvi sacred grove as well as the aforementioned associated shrines have been submitted in 2010 on the tentative list to acquire the UNESCO status of World Heritage Site, unfortunately, the application form does not provide with exact coordinates of these sacred sites and shrines.

Another site of cultural importance within the Project's study area is a Baobab tree within the Majete Wildlife Reserve where David Livingstone, the famous Scottish missionary, put up a camp when he visited the area. The grave of Thornton, one of the members of Livingstone's expedition, is located at Maganga village, few kilometres from Majete. The grave, also situated under a baobab tree, is a gazetted monument (Chikwawa 301: Vol. VI.No.3) but is situated outside of the Project's study area. Livingstone's Baobab tree in the Majete Wildlife Reserve, in contrast, might become part of another tentative list submission, which runs under the title of Malawi Slave Routes and Dr. David Livingstone Trail. Indeed, from the submission list it is not clear whether this specific area of Livingstone's journey falls within the trail that has been submitted for World Heritage status. It should also be mentioned that the MDoA covered this area during the first phase of their cultural heritage impact assessment but no particular mention is made on that tree. However, Park management showed the consultant the tree and the grinding stones underneath it as shown in the following picture. The Livingstone Baobab is called CKL on the cultural heritage map.

Figure 48 Grinding stone and "Livingston" Baobab

Source: BRLi (2015)

6.3.2 Fieldwork Assessment

The consultant cultural heritage specialist spent eight days on active fieldwork during which four sacred sites and thirty archaeological sites were identified. Four graveyards were also recorded as well as three find spots of isolated objects that are of scientific interest. The latter include two percussive stones and one enormous piece of slag. The full list of identified sites can be found in the report's annex and are shown on the cultural site map. It was decided to use the same site numbers for the consultant discoveries as the one used by the MDoA survey report in order to stay consistent (starting with CK for Chikwawa district and NS for Nsanje district).

6.3.2.1 Sacred Sites

In order to access and record sacred sites, the team needed to meet with Paramount Chief Lundu. In spite of two official meetings, at which Traditional Authorities (TAs) were also present, only four sacred sites were shown to the consultant Cultural Heritage Specialist.

They include a sacred forest behind Paramount Chief Lundu's Residency (also known as Mbewe ya Mitengo), Chifunda Lundu (the Lundu's former enthronement site), the site of Mawira and the sacred hill known as Mangalangala.

- Mbewe ya Mitengo (CK50) is located behind Chief Lundu's Residency (in Zone A of the Study area). According to oral traditions this is the place where the ancient Lundus resided. It was also used for sacrifices and initiations. Welling carried out archaeological excavations at Mbewe ya Mitengo. The material is exposed at the Tisunge Cultural Center, which is located just behind the site. According to Paramount Chief Lundu, Mbewe ya Mitengo is a protected site and cannot be impacted by any development. Even though we did not enter the site, we passed around it when visiting the Tisunge Cultural Center.

- Chifunda Lundu (CK51) is associated with the worship of Mbona (see previous section). It is said that Mbona rested there as he was coming from Kaphirintiwa to establish his own capital at Mbewe ya Mitengo (the present day headquarters of Paramount Chief Lundu). In the past, whenever the enthronisation of a new chief was taking place, he was supposed to be anointed at Chifunda Lundu before going to Mbewe ya Mitengo. The site displays heavy boulders underneath dense vegetation and covers around $20m^2$. No associated material culture was visible on the day of visit. The site does not seem to be in use any longer. However, according to Paramount Chief Lundu no negative impacts such as land transformation activities can be made on this site. But it does not seem in danger of any impacts as it is located outside of Zone A.
- Mawira (CK52) can be described as a water source that is of cultural significance to the area's local community. It is located in Zone A of the Study area next to the Mwanza river. Its importance is linked to the water's hot temperature, which contrasts with the cool temperatures of the Mwanza River. According to the inhabitants of Azyuda there is always water to be found at that spot even during a dry spell. The site is located in the territory which falls under the authority of Paramount Chief Lundu, who did not mention anything on that particular site. Hence, additional information is required on possible mitigation measures in case that site should be negatively impacted. On a scientific perspective, hot springs along the Mwanza are common and originate from upwelling from the Mwanza Fault, representing the most recent stages of the Cretaceous hydrothermal activity (Per Aagaard, 2011).
- Mangalangala (CK53) is a sacred hill, located close to the site of Mawira. The site was pointed out to us by the people who live in Azyuda. Even though we have not visited the hill we were able to take its coordinates as it is visible on Google Earth. The hill is considered sacred as it is visited by women who have difficulties conceiving as well as in times of drought. Again, Paramount Chief Lundu did not mention anything on this particular site during our meeting. However, given its height any future irrigation activities should leave the hill untouched.

Even though graveyards also constitute cultural heritage resources, they have been assigned to COWI Consultant during their surveys. However, whenever a graveyard was identified, we noted its coordinates and took pictures. They tend to be protected by dense vegetation in small patches of forest as access by strangers is not permitted. The map of cultural heritage shows the graveyards identified by COWI. According to the consultant surveys, relocation of graveyards will not be accepted unless in extreme cases.

6.3.2.2 Archaeological sites

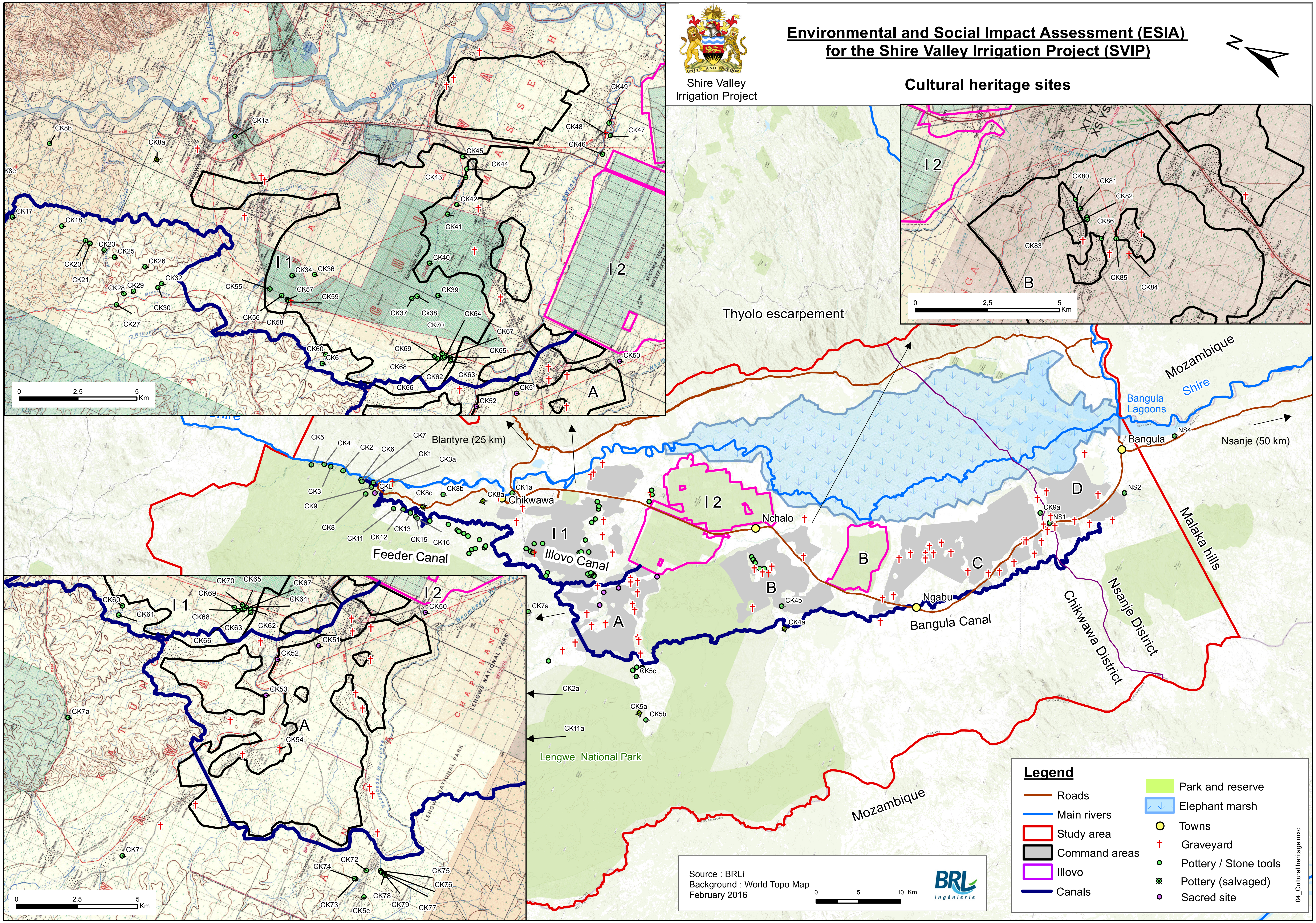
Thirty archaeological sites were identified, which mainly consist of open air sites showing surface scatters of materials such as pottery, metal objects, slag, charcoal and earth (*daga*) house remains. They were mostly found in cultivated fields, either showing a flat or slightly elevated surface. The latter are often associated with termite mounds. As neither excavations were carried nor any C-14 dating, their age remains mostly unknown. Some sherds however appear to be relatively freshly broken at some sites and might therefore constitute modern material. Others in contrast are well embedded in the soil and might therefore be older in age. Only a handful of sites showed stylistic similarities with pottery known from dated sites. It is therefore problematic at this stage to attribute any preliminary statements on age ranges. However, we know from Robinson's excavations that the Lower Shire Valley has been occupied since at least the Early Iron Age and even since the Middle Stone Age (as evidenced by the Tomali gravel pits at the Chomwa stream, which contain deposits of 20,000-100,000 year-old stone tools).

As regards to iron production, 'indigenous' smelting might have occurred in the study area as two occurrences of iron slag were noted (see next figure). However, none of the elderly people interviewed remembers any smelting event in the area and none knew of any of their parents who had produced iron.

Figure 49 Iron Slag found close to Chafudzika (CK71)

Source: BRLi (2016)

Stone artefacts were limited to grinding and percussive stones. Even though these tools tend to be associated to the Stone Age, their use can still be observed in present-day households. We were able to see the use of a percussive stone in the manufacturing of a straw mat.


Environmental and Social Impact Assessment (ESIA)
for the Shire Valley Irrigation Project (SVIP)
Cultural heritage sites
Shire Valley
Irrigation Project
UNITY AND FREEDOM
Thyolo escarpement
Mozambique
Shire
Bangula
Lagoons
Bangula
Nsanje (50 km)
Blantyre (25 km)
Chikwawa
Nchalo
Ngabu
Feeder Canal
Illovo Canal
Bangula Canal
Malaka hills
Nsanje District
Chikwawa District
Lengwe National Park
I 1
I 2
A
B
C
D
Legend
Roads
Main rivers
Study area
Command areas
Illovo
Canals
Park and reserve
Elephant marsh
Towns
Graveyard
Pottery / Stone tools
Pottery (salvaged)
Sacred site
Source : BRLi
Background : World Topo Map
February 2016
0 5 10 Km
BRL Ingénierie
04_Cultural heritage.mxd

6.3.3 Determination of Site Significance and Values

In order to define the mitigation measures of the sites located within and/or in proximity of future development zones, sites need to be classified according to their importance and the required appropriate intervention. The following categories have been defined for the cultural resources identified in this study. Each category implies specific mitigation measures that will be defined in the ESIA:

- Low Priority Site: no special measure is necessary;
- Medium Priority Site: further monitoring during construction to ascertain final priority/importance is necessary;
- High Priority Site: protection measures shall be implanted.

The prioritization of a site is not a definite measure of its scientific importance but rather a temporary classification regarding potential and further mitigation requirements. In this regard, some high priority sites may well be re-evaluated as non-important after further study.

The criteria used to define the value of a site are multiple and complex. However, regarding the area's archaeological sites the aim is to understand both the history of the people in the region (chronology) and the way of life of past populations (palaeo-ethnography). In this context these criteria can be summarized as follows:

- Age of the finds;
- Density and/or variety of the finds;
- Context of the finds;
- Social significance of the finds.

In addition, precursory archaeological knowledge of the area can also influence the value of a site.

Age is a self-explanatory criterion: the older a site is, the more important it is. This is because old sites are rare and finding one is an opportunity to understand the distant past of an area. Most often, sites more than 15,000 years old (Early or Middle Stone Age) are found during major construction works (roads, mines, and pipelines) because they are buried deep underground.

To be considered important, a site must also present a **high density** and/or **variety of artifacts**. Isolated finds are very difficult to interpret since a representative sample of the material is needed in order to be able to understand the activities carried out at the site by prehistoric peoples.

Artifacts must also be in **primary context** (i.e. as the prehistoric people left them) in order to be exploitable from a scientific standpoint. If natural (erosion, digging animals) or anthropological phenomena have disturbed a site too heavily, the association and position of artifacts cannot be interpreted. Most of the time, a site is discovered because part of it is unearthed by erosion or digging; archaeological interventions will therefore focus on the part of the site that is still undisturbed.

Recent sites (tombs, monuments, shrines) can be of high **social significance** (i.e., be "sacred") to local populations and, in that case, should not be damaged either by archaeologists or by construction activities unless proper compensation is negotiated. In this regard, burial sites or any other sites considered as sacred by local communities are always classified as 'High priority sites that shall not be lost at all costs'.

When taken together, a preliminary site prioritization classification can be illustrated in the following table.

Table 15 Site priorization

Old Age	Primary context	High Artefact Density or Variety	High social significance	Priority
Yes	Yes	Yes	Yes	High
Yes	Yes	Yes	No	High
No	Yes	Yes	Yes	High
Yes	Yes	No	No	Medium
No	No	No	Yes	Medium
No	Yes	No	Yes	Medium
No	No	Yes	No	Low

Prior archaeological knowledge of the area where a site is found is also an important criterion. Medium Priority sites could eventually be re-classified as High Priority sites if no High Priority sites are discovered in a region that was previously unexplored.

As no excavations were carried out neither any C-14 dating, it has been difficult to make any preliminary interpretations on age ranges of the identified sites. Furthermore, pottery found on the surface has shown considerable signs of wear and erosion. This has made it difficult to identify characteristic decoration types, representative of distinct periods. The criteria of “Age of Finds” is therefore difficult to apply in this preliminary stage of the study. However, the other two criteria such as “Primary Context” and “High Artefact Density or Variety” have been useful to determine whether an archaeological site can be classified as High, Medium or Low Priority. All sacred sites have been categorized as High Priority (see above explanation). For an assessment of site significance, see the annex report.

The IFC in its Performance Standard 8 mentions sites of critical value. This definition applies to “(i) the internationally recognized heritage of communities who use, or have used within living memory the cultural heritage for long-standing cultural purposes; or (ii) legally protected cultural heritage areas, including those proposed by host governments for such designation (examples include World Heritage Sites and Nationally Protected Areas)”.

In the case of this Project, the former type (i) may apply to the sacred sites identified in this study, which include Mbewe ya Mitengo, Chifunda Lundu, Mawira and Mangalangala, while the latter type (ii) applies to the sites that have been submitted on the tentative list for inscription on the World Heritage List. They include the associated shrines of the Khulubvi Sacred Grove (see previous section) and Livingstone’s Baobab tree in the Majete Wildlife Reserve that might be part of the Dr. Livingstone’s Trail submitted on the tentative list to acquire the UNESCO status of World Heritage Site.

6.4 CONCLUSION AND LIMITATIONS

CONCLUSION

The findings of the cultural heritage study have revealed that the Project’s impact area is endowed with cultural resources from past and present. Indeed, the archaeological material indicates that its occupational history might go as far back as the Early Iron Age.

LIMITATIONS

The vast size of the study area, and the rainy season during which the consultant Cultural heritage specialist field work was carried out have posed challenges to cover large samples of the study area. Moreover, site formation processes seem to work in such a way that many sites are eroded by weathering and sheetflood erosion, down washed and displaced along the Shire tributaries. Therefore, some sites that were identified by either the MDoA or the consultant Cultural heritage specialist (especially pottery and shreds) could be washed away before construction starts. This is the reason why the full ESIA will develop chance find procedures for construction monitoring.

There have also been recent investigations carried out in the area, namely by Menno Welling from the University of Leiden in The Netherlands. He conducted several excavations for his doctoral degree between 2001-2005, researching the area's Lundu Kingdom. The latter was present from at least 1500 AD to 1860 AD. Welling's data however remains unpublished and as a consequence inaccessible for other researchers and/or heritage professionals. When his research work will be published they shall be taken into account by Project management.

7. NATURAL HERITAGE

This section presents various natural sites of particular landscape value and with unique natural features in the Study area.

In the Study area, three parks are gazetted, they are legally protected areas:

- Lengwe National Park;
- Majete Wildlife Reserve (formally called Majete Game Reserve);
- Mwabvi Wildlife Reserve.

In addition to their role as biodiversity reserve, these parks are important landscape features since they represent the last vast forested areas that are noticeable from a distance. Although Elephant marsh is not gazetted nor protected nor under any form of management, it is also considered a natural heritage site, especially due to its important size and its location in the center of the valley. In fact, Elephant marsh was gazetted as a game reserve in 1897 and degazzetted in 1922 (Dudley, 1997). There is no touristic activity in the marsh.

7.1 MAJETE WILDLIFE RESERVE

7.1.1 Status of the Reserve

Majete was established as a game reserve in 1955.

Majete is a reserve under the National Parks and Wildlife Act (1992) and its boundary are gazetted under the Government Notice No. 146 of 1976. It covers an area of 689 km^2.

The Park has been managed by African Parks since 2003. Since then, the number of tourists has significantly increased to 6000 (in 2012) to around 8000 (in 2015) (Park management, personal communication). Majete is the main touristic attraction in the Lower Shire Valley.

7.1.2 Main Landscape Features

Kapichira Falls are interesting features of the Reserve, prior to its management transfer to African Parks, it was its main touristic attraction (ULG Northampton-Price Waterhouse consultants, 2000).

There are actually three zones in the Reserve as shown in the following map (MWR, 2015).

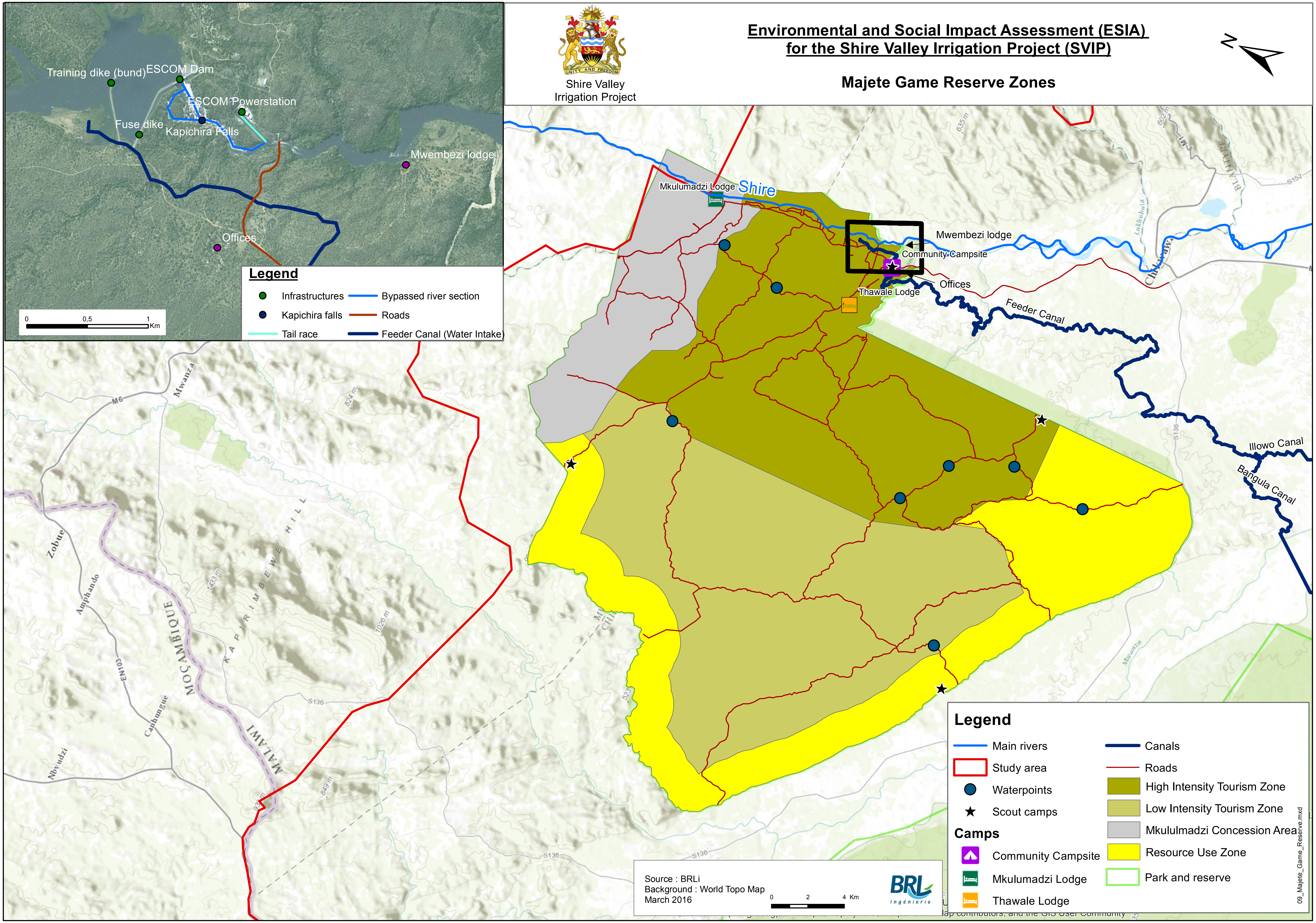
- Mkulumadzi Concession Zone: this zone is an exclusive tourism area with a high-end lodge in the Mkulumadzi catchment;
- High Intensity Tourism Zone: Thawale lodge and a camp site are located in this zone, a road network is in place that allows access from Thawale and the camp site to game viewing activities. Most trails are located in this zone. The topography is flat and gently going downhill toward the River. Kapichira falls are located in this area, it is the only place of this zone with small rocky cliffs.
- Low Intensity Tourism Zone: is zoned for low impact and low density tourism activities, water distribution and vegetation types result in low densities of animals it is therefore less suited for game viewing. This zone is to be kept free of permanent structures. It has a more pronounced topography. The rest of the Shire shoreline in the Park is flat and sandy.

- Resource Use Zone: the Resource Use Zone is zoned for multiple consumptive resource use which includes collection of natural resources on an organised basis by registered community members such as thatching grass, reeds and bamboo.
- Utility Zone: is where the headquarter and offices are located (Mathithi headquarters).

The park is almost entirely fenced, only a small portion close to the future water intake is not fenced.

Figure 50 Kapichira falls and Shire River from Majete

Source: BRLi (2015)



Environmental and Social Impact Assessment (ESIA)
for the Shire Valley Irrigation Project (SVIP)
Majete Game Reserve Zones
Shire Valley
Irrigation Project
UNITY AND FREEDOM
N
Training dike (bund)
ESCOM Dam
ESCOM Powerstation
Fuse dike
Kapichira Falls
Mwembezi lodge
Offices
Legend
Infrastructures
Kapichira falls
Tail race
Bypassed river section
Roads
Feeder Canal (Water Intake)
0 0,5 1 Km
Mkulumadzi Lodge
Shire
Mwembezi lodge
Community Campsite
Offices
Thawale Lodge
Feeder Canal
Illowo Canal
Bangula Canal
Zobue
Amphando
MOÇAMBIQUE
MALAWI
KAPIRIMBEWE HILL
Mwanza
M6
S136
EN103
Canhungue
Nhvudzi
BLANTYRE
S152
M1
Legend
Main rivers
Study area
Waterpoints
Scout camps
Camps
Community Campsite
Mkulumadzi Lodge
Thawale Lodge
Canals
Roads
High Intensity Tourism Zone
Low Intensity Tourism Zone
Mkululmadzi Concession Area
Resource Use Zone
Park and reserve
Source : BRLi
Background : World Topo Map
March 2016
0 2 4 Km
BRL ingénierie
09_Majete_Game_Reserve.mxd

7.1.3 Management Document

The document called “Majete Wildlife Reserve, 5 years Business Plan 2015-2019” is intended to guide the management of MWR and to implement strategies. It defines the reserve’s objectives and goals. This document is a draft, and a final version will be produced. At time of this report, writing no final version was available to the consultant.

How will the SVIP influence or affect the objectives and strategies of the Business Plan will be detailed in the impact assessment section (in the full ESIA). One of the strategies of the MWR is to improve the viewing facility at Kapichira falls. Due to the location of the future water intake, in the “High Intensity Tourism Zone” close to the Kapichira fall, strategies of the Business Plan that related to the fall viewing facilities may be affected.

7.2 LENGWE NATIONAL PARK

7.2.1 Status of the Park

The park was established as a game reserve in 1928 and declared a national park in 1970. It was recognized as one of the two only places in British Colonial Africa were Nyala antelope occurred. In 1928 its size was 520 km^2. In 1975, it was extended to its actual size (UICN/UNEP Directory of Afrotropical Protected Areas, 1987) and re-declared a National Park by Establishment (Amendment) Order 1975, dated 26 August 1975, and published as Government Notice No.149 of 1975 (LNP Park Plan, 2005). The original park covered the area called the “Old Lengwe” also called the Eastern Salient while the extension called the “Uplands Unit” covers the border with Mozambique and reach North as far as the Mwanza River.

The actual size of the LNP is 887 km^2. The park is managed by the government. In 2000, the number of paying visitors in the park was only 584 (LNP Park Plan, 2005). In 2015, the number of paying visitors had remained steady at 556 (LNP, General Management Plan 2016-2020, 2015).

7.2.2 Main Landscape Features

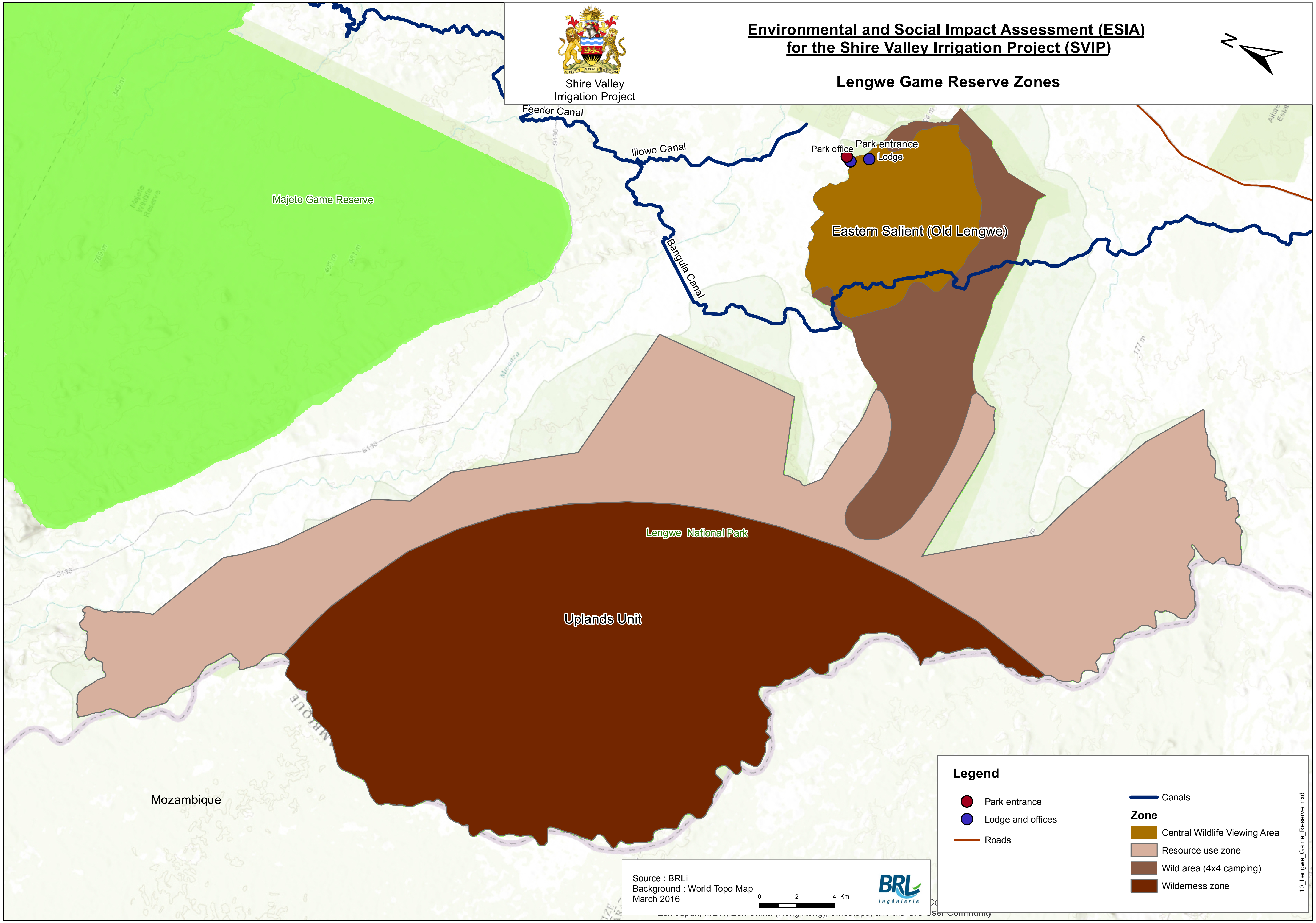
Old Lengwe, where the canal will pass, is the best preserved area of the Park and is dominated by tree savanna and thickets of high ecological value because it is one of the last remaining habitat of the Nyala. The topography is rather flat varying from 60 to 150 masl. The Wester part of the LNP, called the Uplands Unit, is gently undulating to about 300 masl with a few hills close to 400 masl.

Touristic and management infrastructures are located in the Eastern end of the park close to the park entrance gate (in the Old Lengwe). Nyala lodge has accommodation for tourists. Most trails are located in the Old Lengwe.

The LNP Park Plan (2005) has defined several zones as shown in the following map, these zones are still recommendations from the Park Plan and whether they are implemented or not is unknown:

- The Uplands Unit should be designated as “Wilderness Areas” with the development of base camps the only permitted infrastructures.
- “Semi-Wilderness Areas” with two sub zones:
    - The “Central Wild Area”, which is the main part of the Old Lengwe with the actual road network and the Nyala Lodge, used for wildlife viewing from vehicles and hides. It includes the thicket forest vegetation.

  - The “Outer Wild Area”, which consists of the area surrounding the Central Wild Area designated for self-catering exclusive camps.
- The “Resource Use Zones”: are areas where controlled use of natural resources by the surrounding communities are permitted. These areas will be divided based on the original landholding of traditional authorities.
- “Utility Areas”: are sites for management offices and visitors infrastructures. Also, the 2005 LNP Park Plan had foreseen an area further inland of Old Lengwe and a new lodge as well as new scout camps in the Uplands Unit (Center camp, Ngande, Chilangbangombe, Makungwa).



Environmental and Social Impact Assessment (ESIA)
for the Shire Valley Irrigation Project (SVIP)
Lengwe Game Reserve Zones
Shire Valley
Irrigation Project
Feeder Canal
Illowo Canal
Bangula Canal
Majete Game Reserve
Park office
Park entrance
Lodge
Eastern Salient (Old Lengwe)
Lengwe National Park
Uplands Unit
Mozambique
Legend
Park entrance
Lodge and offices
Roads
Canals
Zone
Central Wildlife Viewing Area
Resource use zone
Wild area (4x4 camping)
Wilderness zone
Source : BRLi
Background : World Topo Map
March 2016
0 2 4 Km
BRL Ingénierie
10_Lengwe_Game_Reserve.mxd

7.2.3 Management Document

In 1983, the Park Master Plan divided the Park into two management compartments; these are still part of the actual park zonation: the West Uplands Unit and the Eastern Salient (also called the “Old Lengwe” since it was the original Park before the extension).

From the 1983 Master Plan, each compartment had different management objectives. Uplands Unit objectives were to conserve the woodlands and remove illegal settlements, while Eastern Salient objectives were to conserve the thicket communities and to reduce the Nyala population (at that time overpopulated). Unfortunately, Nyala population were reduced below the desire objectives (LNP Park Plan, 2005).

One management document that was provided to the consultant by park management dates from 2005 it is a draft version of the report called “Lengwe National Park, Park Plan”. According to LNP Park Plan (2005), restoring the Nyala population is one of the main objective of the Old Lengwe while protecting the Nkombedzi wa Fodya river catchment and soil protection is one of the new objective of the Upland Unit.

An updated to the park management plan was produced under the Shire River Basin Management Program (SRBMP) Component B, Sub component B4. This document is called “Lengwe National Park, General Management Plan 2016-2020 work document”. It has defined new objectives. The overall objective is to “rehabilitate LNP to a standard that allow for the efficient and effective management of its natural resources to the benefit of wildlife, communities, and tourism” (LNP, General Management Plan 2016-2020, 2015), sub objectives include :

- the conservation and increase of existing wildlife population,
- the ongoing collaboration with surrounding communities through incone generating activities and community investments,
- the increase in infrastructures and accomodation for visitors, and
- the development of sustainable finance mechanisms involving revenue sharing with the surrounding communities.

How will the SVIP influence or affect the objectives and strategies of the Park Plan will be detailed in the impact assessment section (in the full ESIA) but will be dependent on the availability of a validated document.

7.3 MWABVI WILDLIFE RESERVE

This reserve will not be affected by the Project. Therefore, it is only briefly presented in this section.

7.3.1 Status of the Reserve

Originally called the Tangadzi Stream Reserve in 1928, Mwabvi Wildlife reserve was gazetted in 1951, in 1982 it was reduced (de-gazetted) of about 60% (UICN/UNEP Directory of Afrotropical Protected Areas, 1987).

The park covers an area of 104 km^2 and is managed by the same staff as Lengwe National Park.

7.3.2 Main Landscape Features

The Reserve is drained by the Thangadzi River which is a wide seasonal river and is crossed by several small hills that stand out with their thick tree coverage in a flat agricultural landscape.

7.3.3 Management Document

A Park Plan was produced in 2000 by ULG Northampton-Price Waterhouse consultants. However, this document has not been found and no information was collected regarding updates to this plan. Therefore, management objectives are unknown.

7.4 ELEPHANT MARSH

Although Elephant Marsh has no official status, it is going through a process of putting it under community-based management. A study undertaken under the Shire River Basin Management Program (SRBMP) called “Climate resilient livelihoods and sustainable natural resources management in the Elephant Marshes, Malawi” by MRAG Ltd (2015-2016) aims at designating the marshes as a community-managed protected area and as a wetland of international importance under the Ramsar convention. The management plan will identify strategies and actions that will contribute to increasing the resilience of local communities dependent on the marshes to various forms of change (MRAG, 2015).

At time of Baseline finalization, this study was still in its inception phase (an Inception report and Mid Term report have been produced). Updates from this study will be integrated in the full ESIA report.

8. ECOLOGY

This section deals with terrestrial, wetland and aquatic habitats. As an introduction to the various "habitats", a Land Cover presentation is included.

8.1 LAND COVER

Relevant information about land cover and condition of the land in Chikwawa, including recent changes, is presented in the Atlas of Malawi Land Cover and Land Cover Change 1990-2010 (FAO, 2013). Based on this Atlas, the following table shows the main land cover per district using the FAO Land cover classification and codes. In addition the map, next page shows main land cover types.

Table 16 Land cover using FAO Land Cover Classification

Percentage of land cover in Chikwawa District (%)		Percentage in land cover in Nsanje District (%)	
Open Woodland with Herbaceous Layer (TREO)	40.1	Open Woodland with Herbaceous Layer (TREO)	34.0
Rainfed Herbaceous Crop(s) With Small Sized Field(s) (AGHS)	22.6	Rainfed Herbaceous Crop(s) With Small Sized Field(s) (AGHS)	29.9
Closed Herbaceous Vegetation with Sparse Trees - Trees and shrubs savannha (HBCL)	8.1	Closed Herbaceous Vegetation with Sparse Trees - Trees and shrubs savannha (HBCL)	1.5
Post Flooding Cultivation Of Small Sized Field(s) Of Herbaceous Crop(s) Cultivated Dambo (AGFL)	6.4	Post Flooding Cultivation Of Small Sized Field(s) Of Herbaceous Crop(s) Cultivated Dambo (AGFL)	3.2
Rainfed Herbaceous Crop(s) With Small Sized Field(s) + Sparse Trees (AGTR)	6.4	Rainfed Herbaceous Crop(s) With Small Sized Field(s) + Sparse Trees (AGTR)	3.9
Built Up Area(s) (URBA)	3.6	Built Up Area(s) (URBA)	4.7
Closed Herbaceous Vegetation On Permanently Flooded Land Permanent marsh (HBFP)	3.4	Closed Herbaceous Vegetation On Permanently Flooded Land Permanent marsh (HBFP)	11.1
Irrigated Herbaceous Crop(s) With Large to Medium Sized Field(s) Sugar Cane (ASUG)	3.4	Irrigated Herbaceous Crop(s) With Large to Medium Sized Field(s) Sugar Cane (ASUG)	0.4
Closed Broadleaved Deciduous Trees (TREC)	2.2	Closed Broadleaved Deciduous Trees (TREC)	5.6
Closed to Open Shrubland (Thicket) (SRCO)	1.4	Closed to Open Shrubland (Thicket) (SRCO)	1.9
Other	2.4	Other	3.8

Source: Adapted from FAO (2013)

NATURAL OR SEMI-NATURAL TERRESTRIAL VEGETATION

Semi-natural vegetation is defined as vegetation not planted by humans but influenced by human actions such as grazing, selective logging, remnant forests. (FAO, 2013). Natural habitats are habitats were human activities do not intervene with ecological processes.

- Open Woodland with Herbaceous Layer (TREO): this class includes habitats that are mainly covered by trees, with open canopy and herbaceous layer. Most of the Lengwe and Majete parks and hilly area fall under this category.

- Closed Broadleaved Deciduous Trees (TREC): this class includes dense forested areas.
- Closed Herbaceous Vegetation with Sparse Trees - Trees and shrubs savannah (HBCL): this class includes dense grassland with sparse trees and shrub.
- Closed to Open Shrubland (Thicket) (SRCO) : this class includes thickets without trees. The last large remaining thicket forest is located in Old Lengwe. It has to be considered a highly important habitat.

NATURAL OR SEMI-NATURAL AQUATIC VEGETATION

This class includes transitional areas between purely aquatic ecosystem and terrestrial ecosystem with hydrophytic vegetation (vegetation dependent on damp condition), also called wetland:

- Closed Herbaceous Vegetation on Permanently Flooded Land Permanent marsh (HBFP): this class refers to wetlands such as Bangula lagoon and the Elephant marsh.

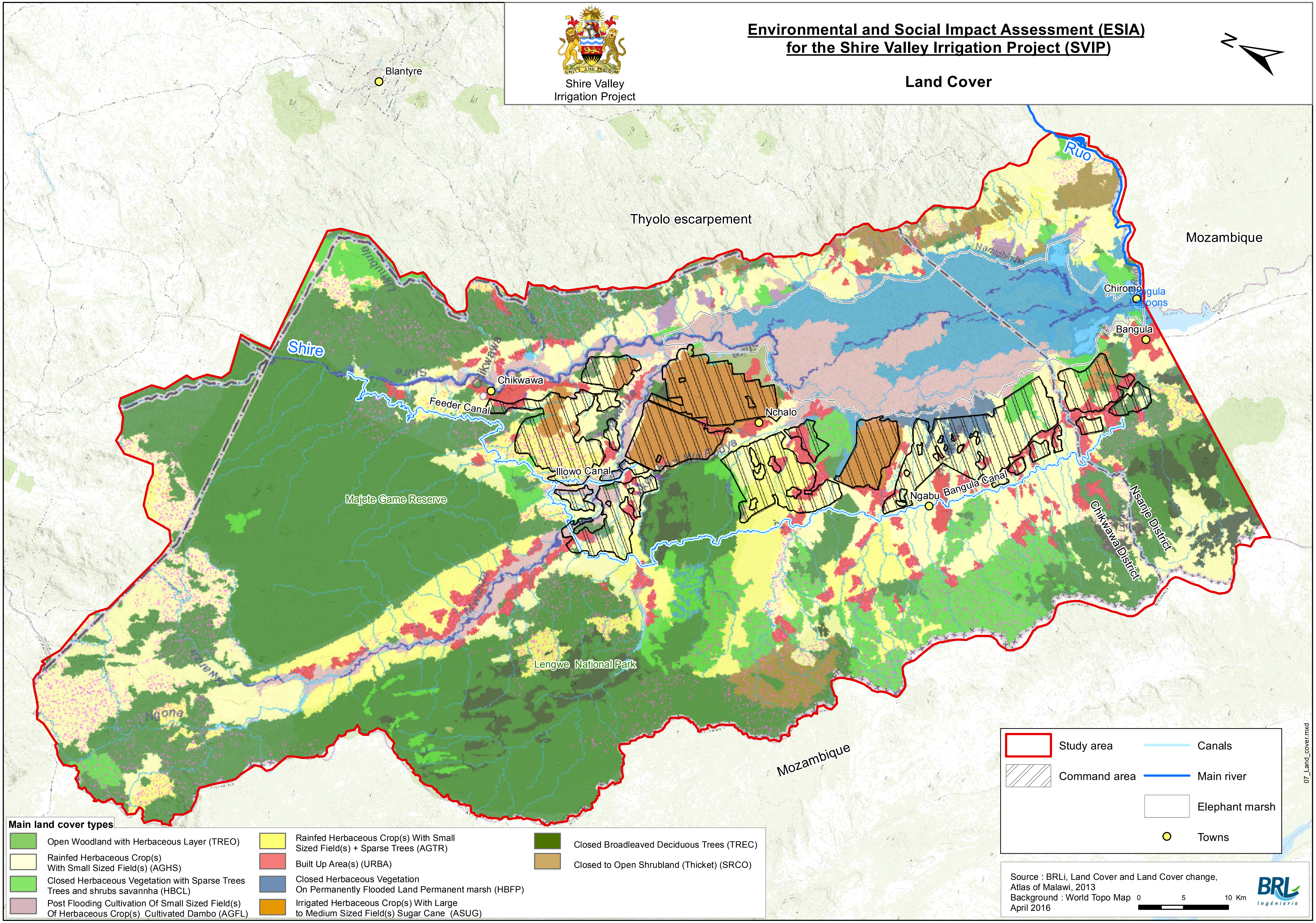
CULTIVATED AND MANAGED TERRESTRIAL AREAS

This class refers to areas where the natural vegetation has been removed and replaced by other types of vegetation of anthropogenic origin mainly for agricultural activities (FAO, 2013).

- Rainfed Herbaceous Crop(s) With Small Sized Field(s) (AGHS)
- Rainfed Herbaceous Crop(s) With Small Sized Field(s) + Sparse Trees (AGTR)
- Irrigated Herbaceous Crop(s) With Large to Medium Sized Field(s) Sugar Cane (ASUG), refers to Illovo and outgrowers
- Post Flooding Cultivation Of Small Sized Field(s) Of Herbaceous Crop(s) Cultivated Dambo (AGFL): refers to “dimba agriculture” carry out in dambo and in Elephant marsh.

URBAN AREAS

This class refers to areas that have an artificial cover such as construction and towns, extraction activities (mines and quarries) (FAO, 2013). The main urban areas are Chikwawa, Nchalo, Ngabu and Bangula.


Environmental and Social Impact Assessment (ESIA)
for the Shire Valley Irrigation Project (SVIP)
Land Cover
Shire Valley
Irrigation Project
Blantyre
Thyolo escarpement
Mozambique
Ruo
Chiromo
Bangula Lagoons
Bangula
Shire
Chikwawa
Feeder Canal
Nchalo
Illowo Canal
Majete Game Reserve
Ngabu
Bangula Canal
Chikwawa District
Nsanje District
Lengwe National Park
Mozambique
Study area
Canals
Command area
Main river
Elephant marsh
Towns
Main land cover types
Open Woodland with Herbaceous Layer (TREO)
Rainfed Herbaceous Crop(s) With Small Sized Field(s) (AGHS)
Closed Herbaceous Vegetation with Sparse Trees Trees and shrubs savannha (HBCL)
Post Flooding Cultivation Of Small Sized Field(s) Of Herbaceous Crop(s) Cultivated Dambo (AGFL)
Rainfed Herbaceous Crop(s) With Small Sized Field(s) + Sparse Trees (AGTR)
Built Up Area(s) (URBA)
Closed Herbaceous Vegetation On Permanently Flooded Land Permanent marsh (HBFP)
Irrigated Herbaceous Crop(s) With Large to Medium Sized Field(s) Sugar Cane (ASUG)
Closed Broadleaved Deciduous Trees (TREC)
Closed to Open Shrubland (Thicket) (SRCO)
Source : BRLi, Land Cover and Land Cover change, Atlas of Malawi, 2013
Background : World Topo Map
April 2016
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BRL Ingénierie
07_Land_cover.mxd

Land cover changes

According to the FAO (2013), land cover changes were more significant in the past, but since the 2000s land cover has not changed much within Chikwawa district. In Nsanje district, land cover has slightly changed where 5-10 % of natural vegetation has been changed to agricultural activities in the Bangula area.

Difference between other data and the Atlas

As presented in the section on wetland (see section 8.4), field surveys and Landsat imagery has allowed the consultant to delineate Elephant marsh. The marsh delineation slightly differs from the Atlas of Malawi Land Cover and Land Cover Change 1990-2010. In addition, a detailed habitat map was available for part of Lengwe National Park, in the Eastern most part of the Park. Therefore the main observations from the Atlas have to be replaced in two area:

- Elephant marsh: according to the Atlas, part of the Elephant marsh is classified as “Post flooding Cultivation of Small Sized Field(s) of Herbaceous Crop(s), Cultivated dambo”. While this area is indeed cultivated, on a biological point of view it is not a terrestrial habitat but rather an area of wetland that has been reclaimed for agricultural purposes. In addition, the area under cultivation is wider according to the consultant. This difference in area under cultivation size is explained by the fact that FAO used 2011 Landsat imageries while the consultant used 2015 imageries (see map on wetlands section 8).
- Lengwe National Park in “Old Lengwe”: the detailed habitat map of “Old Lengwe” does not contradict the FAO Atlas but it gives more precision on the type of habitat (see map on Old Lengwe section 8.3.2).

8.2 Anthropogenic modifications to habitats

The Study area is extensively used for agricultural activities and, as presented in other sections of this report, has been densely inhabited for a long time leading to chances in land cover. This population density has created pressure on ecological functions and habitats. In fact, the catchment is largely modified which means that a large loss of natural habitat, biota and basic ecosystem functions has occurred. The main past and current threats and pressures on habitats are:

- Logging and land transformation: land transformation to claim forested areas and thickets for agriculture (or cutting wood for charcoal) has started to take place a long time ago. According to the FAO Land Cover Atlas (FAO, 2013) in Chikwawa no land cover change was observed since 2000 while in Nsanje 5 to 10 % of natural vegetation have been cleared for agricultural activities since 2000.
- Unsustainable fishing practice: the use of inappropriate fish gears such as small meshed seine nets and mosquito nets destroy the breeding grounds and catch both the juveniles and the adult fish. During upstream migration in tributaries, some fishermen install nets across rivers, catching all fishes.
- Encroachment in Parks: in many reports, encroachment is mentioned in all three parks, in Majete this situation has stopped, unfortunately it is not the case with Lengwe as presented in sections hereunder.
- Incursion in wetland by subsistence farmers: according to nineteenth century reports there was already at that time a very large population in the area occupying the Shire’s banks (Young, 1868 quoted by Dudley, 2005).

As far as today, solid domestic waste is not a major issue in the Shire River system and wetland.

8.3 TERRESTRIAL HABITATS

Natural habitats in the Study area are confined to parks and reserves and semi-natural habitats are still present in hilly area of Thyolo escarpment and Mulaka Hills where intense deforestation is taking place mainly for charcoal production. In the vast plain, where the command areas will be developed, most forests have been cleared to give way for agricultural activities. Patches of remnant forests and thickets are still present around cemeteries but have no potential to shelter any of the large mammals that are observed in the surrounding parks. A small reserve called the Nyasa Wildlife sanctuary is present in the Kaombe Sugar cane estate. Another sanctuary, the Nyala Park at Nchalo is located within Illovo Estate. In this plain, natural forests would have been classified as “Broad leaved relatively dry woodlands and intergrades to savanna” characterized by the following species: *Adansonia sp*.(Baobab) *Cordyla sp*. *Combretum sp*. and *Acacia sp*. With Acacia and Combretum as dominant ligneous species. In Zone B, South of Lengwe, the density of Baobab is remarkable.

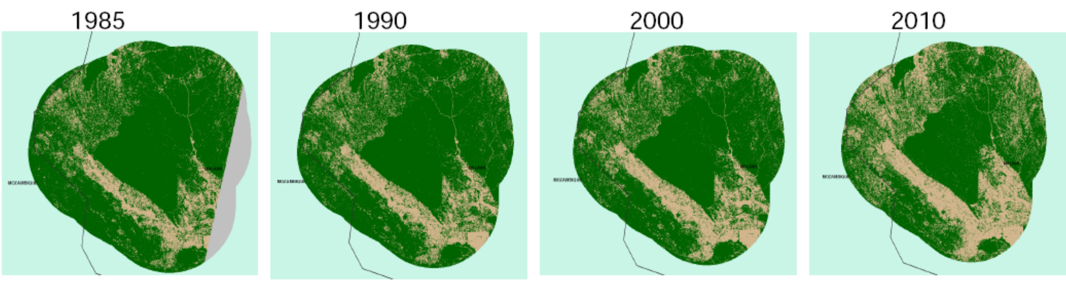
8.3.1 Majete Wildlife Reserve

8.3.1.1 Current threats and challenges

Since the park is managed by African Parks, the past threats that were related to poaching and illegal timber extraction are no longer issues. According to the Park Draft Business Plan 2015, the current challenges are coming from increasing pressure from high density population in surrounding communities. These communities have grievances in terms of benefits sharing and resources extraction that could lead to potential human wildlife conflicts and representing a poaching potential around the reserve. The park is also facing challenges that related to soil erosion (around water pond and fences) and to the constant maintenance of the 142 km of electrical fence.

Figure 51 shows the deforestation around the park in the past year. Forests are in green while deforested areas are in pink.

Figure 51 Evolution of deforestation around Majete Wildlife Reserve



Source: GeoterraImage, 2012

Other challenges come from the fact that the reserve is completely fenced, severing large animal movement, creating a closed ecological system. There is no culling to regulate population, but the some animal are translocated is carried out to limit some large animal population (sable, waterbuck, kudu, eland and zebra are translocated to other parks in Malawi). In 2017, about 200 to 250 elephant will be translocated as well (Park management, personal communication 2016).

HUMAN WILDLIFE CONFLICT

There is no human wildlife conflict since the park is fenced.

8.3.1.2 Habitats

For the sake of simplification, this section only presents the main terrestrial habitats found in MGR along the potential canal alignment route (feeder canal).

"Riverine and Alluvial Associations" and "Low Altitude Mixed Tall Deciduous Woodland" are the habitat types found that will be crossed by the feeder canal. According to Sherry (1989, quoted by ULG Northampton-Price Waterhouse consultants, 2005), these habitat are dominated by the following plant species.

- Riverine and Alluvial Associations:
  - Trees : *Acacia tortilis*, *Acacia galpinii*, *Breonadia microcephala*, *Cordyla africana*, *Kigelia africana*, *Lonchocarpus capassa*, *Sterculia appendiculata* and *Hyphaene benguellensis*
  - Shrubs: *Allophylus sp*., *Cardiogyne africana*, *Combretum mossambicensis*, *C. paniculatum*, *Dalbergia arbutifolia* and *Grewia sp*.
  - Grasses : *Cynodon*, *Digitaria*, *Leptochloa*, *Panicum*, *Phragmites* and *Urochloa*
- Low Altitude Mixed Tall Deciduous Woodland are Widespread in the river valleys of the lower-lying eastern area.
  - Trees : *Adansonia digitata*, *Acacia nigrescens*, *Combretum imberbe*, *Sclerocarya caffra*, *Sterculia quinqueloba*, *Terminalia sericea* and *Xeroderris stuhlmannii*.
  - Shrubs : *Combretum mossambicensis* and *Grewia spp*.
  - Grasses : *Digitaria*, *Heteropogon* and *Urochloa*

Both the Shire River and the Escom reservoir are valuable aquatic habitat. The reservoir fringes also have features of a wetland with patches of grassland and shallow water. Discussion on wetlands and aquatic habitats are presented in a separate section.

The following picture shows the area that will be crossed by the feeder canal (taken from the fuse dike).

Figure 52 Majete at Feeder canal location

Source: BRLi (2015)

8.3.1.3 Ecological Continuity

The reserve is fenced therefore they are no movement of large mammals outside of the reserve. Inside the Park, movement of large mammals is dictated by several factors, water availability being an important one especially in the dry season. The largest water body is the Shire River with the Escom reservoir attracting many species. In addition, Mkurumadzi River in the Northern part of the reserve is also a perennial river. There are 13 springs and pools and 8 artificial water points (AWP) as shown in the Zoning map.

8.3.2 Lengwe National Park

8.3.2.1 Current threats and challenges

Illegal wood logging (for wood in Old Lengwe and for agricultural land in the Uplands Units), illegal cattle grazing in Old Lengwe, and pressure from surrounding communities in extracting resources has affected the state of LNP. In addition, illegal hunting is also severely affecting wildlife in the park. As described in the ESIA inception report:

“Currently Lengwe suffers from illegal wood cutting activities, not only by local villagers but also from people coming from far distances either for construction logs or for charcoal. The consultant travelled on the road crossing the limit of the Old Lengwe with two rangers and in less than one hour, two persons were arrested for illegal wood clearing activities, one of which was coming from a distant villages. Both had relatively large logs. In surrounding villages, wood clearing is done at night, stashes of wood logs are not hidden and could be observed in most villages surrounding the Park. In addition, at several locations along the “earth gravel road”, illegal cattle grazing could be observed” (BRLi, 2015). This illegal logging activity was observed in the Old Lengwe (Eastern Salient) were rangers presence is concentrated. The main path for these illegal activities is the presence of the earth gravel road crossing “Old Lengwe” along which many villagers commute from one part of the park to the other.

Using different dates on Google Earth reveals that the Uplands Unit is under recent intense illegal wood clearing activities to claim land for agricultural activities as shown in the following pictures (taken at the same location at coordinates 16°4'23.16"S; 34°27'1.59"E at the border with Mozambique). No reliable data exist to quantify encroachment, however it seems to cover around one quarter of the Uplands Unit and affects most flat land of this zone. In the Old Lengwe, where rangers are more present, there is less noticeable forest clearing for agricultural activities. LNP Park Plan (2005) highlights the lack of ranger patrols in the Uplands Unit that affects the efficiency of protecting the Park in this area.

Figure 53 LNP in 2001 (Northern part of the Uplands Unit)

Figure 54 LNP in 2013 (Northern part of the Uplands Unit)

In addition, Old Lengwe is surrounded by Illovo sugar estate and a fence keeps wildlife from entering Illovo sugar estate. These pressures have fragmentized wildlife habitats.

HUMAN WILDLIFE CONFLICT

Buffalos are frequently reported to enter Illovo estate and destroying hectares of plantation looking for water and food during dry months. In 2005, a herd of 50 buffalos entered the estate, destroying 3,000 ha of plantation; the fenced had been vandalized and destroyed (IOL news, 2005).

Currently a 10 km electric fence is being installed on the northern part of Old Lengwe. A non-electric fence is located on the southern part of Old Lengwe and along the Illovo estate. No fence is present along the earth gravel road used by communities (the road that crosses the Old Lengwe on its western part).

According to the more recent park management plan (LNP General Management Plan, 2015), since 2013, approximately 30 km have been fenced, some have already been vandalized or damaged by floods, resulting in large sections removed or destroyed.

With the current SVIP scheme layout, entirely surrounding Old Lengwe, the issue of Buffalo encroachment and wildlife conflict will become a serious concern.

8.3.2.2 Habitats

For the sake of simplification, this section only presents the main terrestrial habitats found in LNP along the potential canal alignment route (Bangula canal).

Lowland tree savanna is the habitat type that will be crossed by the Bangula canal.

This habitat is dominated by Acacia and Combretum in thicket communities in the Northern part of Old Lengwe. Thickets are made of dense tall shrubs or small trees between 3 and 8 meters high. In some area, the shrub Small-leaved bloodwood (*Pterocarpus antunesii*) dominates the landscape. Small patches of deciduous forest also occurs in Old Lengwe. There is no wetland in the Park however riparian woodlands dominated by the very tall tree Sterculia appendiculata are present along the Nkombedzi Wa Fodya River. According to Dowsett and Lemaire-Dowsett, (2002), it is the best preserved riparian forest of the Park, where such communities are scares and rare.

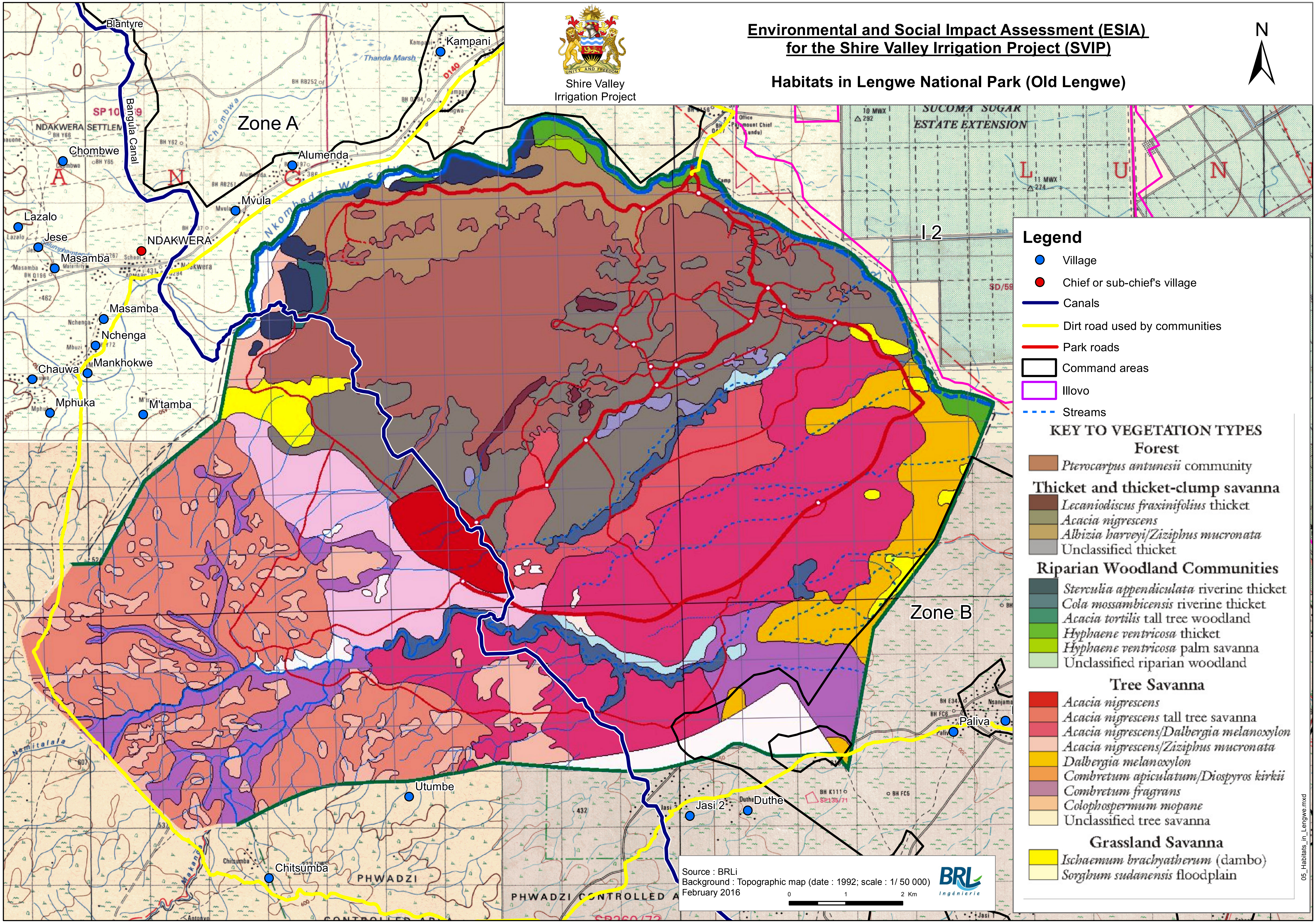
In the Southern part of Old Lengwe open wooded grassland with spares trees replaces the forest/thickets communities. Around the Namitala River, riverine thicket dominates again. According to Dowsett and Lemaire-Dowsett, (2002), *Cola mossambicensis* as presented in the habitat map of Old Lengwe (see map) is not the correct species present along Namitala River but the area is rather dominated by *Cola clavata*.

Thicket communities as found in the North-Western part of Lengwe are highly valuable habitats for many species not only mammals (such as the Nyala) but also birds who thrive in their closed canopy.

The following picture shows the area that will be cross by the Bangula canal in the southern part of the Park.

Figure 55 Area where the Bangula Canal crosses the park (tree savanna)

The following map shows habitats in Old Lengwe.



Environmental and Social Impact Assessment (ESIA)
for the Shire Valley Irrigation Project (SVIP)
Habitats in Lengwe National Park (Old Lengwe)
Shire Valley
Irrigation Project
UNITY AND FREEDOM
N
Legend
Village
Chief or sub-chief's village
Canals
Dirt road used by communities
Park roads
Command areas
Illovo
Streams
KEY TO VEGETATION TYPES
Forest
Pterocarpus antunesii community
Thicket and thicket-clump savanna
Lecaniodiscus fraxinifolius thicket
Acacia nigrescens
Albizia harveyi/Ziziphus mucronata
Unclassified thicket
Riparian Woodland Communities
Sterculia appendiculata riverine thicket
Cola mossambicensis riverine thicket
Acacia tortilis tall tree woodland
Hyphaene ventricosa thicket
Hyphaene ventricosa palm savanna
Unclassified riparian woodland
Tree Savanna
Acacia nigrescens
Acacia nigrescens tall tree savanna
Acacia nigrescens/Dalbergia melanoxylon
Acacia nigrescens/Ziziphus mucronata
Dalbergia melanoxylon
Combretum apiculatum/Diospyros kirkii
Combretum fragrans
Colophospermum mopane
Unclassified tree savanna
Grassland Savanna
Ischaemum brachyatherum (dambo)
Sorghum sudanensis floodplain
Zone A
Zone B
I 2
Blantyre
Kampani
Thanda Marsh
Bangula Canal
Chombwe
Alumenda
Mvula
Lazalo
Jese
Masamba
NDAKWERA
Masamba
Nchenga
Mankhokwe
Chauwa
Mphuka
M'tamba
Utumbe
Chitsumba
Jasi 2
Duthe
Paliva
PHWADZI
PHWADZI CONTROLLED A
SUCOMA SUGAR
ESTATE EXTENSION
Source : BRLi
Background : Topographic map (date : 1992; scale : 1/ 50 000)
February 2016
BRL Ingénierie
05_Habitats_in_Lengwe.mxd

8.3.2.3 Ecological Continuity

ECOLOGICAL CONTINUITY BETWEEN THE UPLANDS UNIT AND THE EASTERN SALIENT

LNP has two distinctive areas, the Old Lengwe which was the first National park and its western extension called the Uplands Unit that was included in the Park latter. These two areas are distinctive due to several factors:

- **Habitats**: Old Lengwe has lowland thickets – forest dominated by Pterocarpus trees and lowland tree savanna with Acacia while the western part is covered by woodland and upland woodland.
- **Water availability**: water holes are artificially providing water for wildlife in the Old Lengwe while the Uplands Unit lacks permanent water sources. After rains, there are also natural pools in Old Lengwe, in addition during the rainy season floods from Nkombedzi wa Fodya river feeds water to natural pools. Historically, the main ecological corridor for water dependent animals was between the Old Lengwe and the Shire River when most mammals were moving toward permanent water during the dry season (Dowsett and Dowsett Lemaire, 2005). The area between Lengwe and the River was covered with dense thickets allowing movement of species, now it is totally replaced by sugar plantation.
- **Park management**: Old Lengwe is more intensively scouted by rangers than the Uplands Unit (offices and rangers housing are in the Old Lengwe). The Uplands Unit is intensively encroached by communities as deforestation for agricultural land is visible on Google Earth, human settlement is usually associated with animal poaching. In addition, an earth gravel road separating the Old Lengwe from the western part is intensively used by communities and cattle.
- **Topography**: the Old Lengwe is below 150 masl while the Upland Unit reach up to 380 masl with rocky outcrops.

The Old Lengwe has some woodlands that form part of the transition zone into the Uplands unit which maintain some form of ecological continuty. However, several wildlife species such as the Buffalo and Nyala are believed not to occur in the Uplands Unit (Dowsett and Dowsett Lemaire, 2005) although the area has not been surveyed for many years.

ECOLOGICAL CONTINUITY WITHIN OLD LENGWE

Within the Old Lengwe, there is some movement of large mammals. However most of the time they are located close to ponds in the eastern end of Old Lengwe.

The canal will pass through Old Lengwe, severing it in two.

ECOLOGICAL CONTINUITY BETWEEN PARKS

Regarding large mammals, there is no ecological continuity for them between LNP and MGR due to the presence of a fence in MGR. LNP and MGR are only a 5 km appart in the northermost part of LNP. They are in fact only separated by the Mwanza river valley.

There is no ecological continuity for large mammals between LNP and Mwabvi Wildlife Reserve due to the density of population between the two parks. Due to the heavy population density, ecological continuity for large mammals outside parks and between parks was already at stake in the 50’s, in addition poaching and animal conflicts were already taking place at that time (Mitchell, 1951).

8.4 WETLAND HABITATS

This section deals with wetland habitats, it discusses about Elephant marsh and its value. A delineation of the wetland is also undertaken in this section. The Aquatic Ecology section further details topics related the value of wetlands for fishes.

8.4.1 Elephant Marsh

The main wetlands of the Study area are part of the Shire River floodplain. Downstream from Kapichira falls, the floodplain cover a narrow area of less than a few hundred meters wide. After Mwanza River junction, the floodplain expand and gradually covers a wider area called the Elephant marsh. It was named after Livingstone who, in 1859, observed in this floodplain a large group of elephants.

The name Elephant marsh does not refer to a wetland entity but rather to a cultural entity, it is not an independent system with natural boundaries. It is in fact part of the larger Lower Shire floodplain. For the sake of the ESIA and to follow the past delineation from the 1:50 000 topographic maps (1992), Elephant marsh starts at the junction of Mwanza and Shire, once the flood plain of the Shire starts to enlarge and ends at Ruo River junction with Shire (at the destroyed bridge) were the wetland is constricted by the alluvial fans of the Ruo. After the junction with Ruo, another wetland system is present: the Bangula Lagoons which is part of the Ndindi Marsh. In total, the whole Lower Shire floodplain cover about 1,100 km^2 (between Malawi and Mozambique) (Chimatiro, 2004).

During the rainy season, all seasonal tributaries of Shire River bring water to the marsh while during the dry season only Shire and Ruo feed the wetland with water. In addition, possible seepages from the Thyolo escarpment bring water to the marsh. As mentioned earlier (see hydrology section), Elephant Marsh hydrological behaviour during the dry season is almost entirely driven by the upstream basin of the Shire River and the Kamuzu Barrage water management while during the wet season, the Elephant Marsh inundation is also caused by the Ruo River. Ruo River feeds an important pool in the marsh named “Tomaninjobi Pool” where fishing activities take place. Ruo has a wide watershed and during the dry season it joins with Shire at the outflow of the Elephant marsh. During the rainy season, it floods a vast area on the western end of the study area (at the border with Mozambique).

Elephant marsh will be the focus of this chapter on wetland. Outside of parks, there are no large riparian forest nor other wetland worth mentioning in the Study area. Some rivers are still bordered with a 10-15 meters wide riverine forests to maintain banks.

It has been reported from many sources quoted by Dudley (1997) that the Elephant marsh had been dry many times in the early 20th century since it was, prior to the ESCOM powerstations, dependent on Lake Malawi level.

8.4.2 Wetland Biodiversity

Elephant marsh is dominated by grasses such as the common reed (Phragmites australis), sedges (Cyperus sp.), Hippo grass (Vossia cuspidata) and the cattail (Typha sp.). Floating plant colonies are also present such as the invasive water hyacinth (Eichhornia crassipes) and the invasive water lettuce (Pistia stratiotes). Aquatic plants aredominated by the mosquito fern (Azolla nilotica) and the invasive Kariba weed (Salvinia molesta). In the marsh, there are no riparian forest and only few ligneous plants mainly palm trees.

In areas where land has been reclaimed from the wetland, rice and maize are cultivated as recession agriculture.

The most common bird species observed by the consultant during field visits in Elephant marsh are the Kingfishers (Alcedo Atthis and A. cristata), the African Fish Eagle (Haliaeetus vocifer), Cormorant (Phalacrocorax lucidus), Cattle Egret (Bubulcus ibis), Purple Heron (Ardea purpurea), African openbill (Anastomus lamelligerus) and the Coucal (Centropus sp.).

Crocodiles are common in the marsh, they were also observed by the consultant during the rainy season mission (January 2016), sandbanks of the marsh are used as nests by female crocodiles. Hippopotamus are said to be common in the marsh but the population is declining due to past animal conflicts (see next section) (Dudley, 1997).

The Elephant marsh is also an attractive habitat for herpetofauna (reptiles and amphibians) and wetland dependent insects such as dragonflies. The ecological surveys that are taking place in the marsh in the framework of the SRBMP (Sub-study n°4: Biodiversity surveys carried out by MRAG) will provide valuable and up-to-date information on biodiversity. In addition, section 8.7 on aquatic ecology also provides a list of fish species found in the marsh.

- Butterflies. Based on biodiversity surveys done by MRAG Ltd (2016), butterfly surveys conducted in June 2015 collected 62 species one of which is a new record for Malawi and one of which is a new subspecies. Their habitats in Elephant marsh where area with high vegetation as well as village graveyards close to the marsh.
- Hepertofauna (reptile and amphibian). Based on biodiversity surveys done by MRAG Ltd (2016), limited species species were observed due to the dry season. A rainy season survey was undertaken and results will be integrated in the full ESIA report.
- Flora. Based on biodiversity surveys done by MRAG Ltd (2016), flora surveys conducted in the marsh in June 2015 identified 130 plant species.

At time of baseline writing, only the Mid Term report from MRAG (2016) was available. This report did not provide the list of identified species. The full ESIA will integrate upcoming results from the various biodiversity surveys.

One of MRAG objective in the “Climate resilient livelihoods and sustainable natural resources management in the Elephant Marshes, Malawi” is to assess whether Elephant marsh could be eligible as a Ramsar site. The full ESIA will provide updates on the process since at time of report writing the Ramsar application progress had not been finalized.

8.4.3 Wetland Delineation

Several definitions exist to designate a wetland. The most common one is the RAMSAR definition: “Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters”.

Ramsar aims at protection and management of wetland taking into account both human and ecological use of them. However, using the Ramsar definition does not allow to delineate a wetland. For the ESIA, it is important to delineate the Elephant marsh since its size varies from one report to another. Delineating a wetland provides a basis to understand the wetland behavior, and allows to determine, using a standardize method, a surface of wetland and will help to assess impacts from the SVIP.

International methods for wetland delineation (US, Canada, Europe, etc.) use one and/or two methods:

- The botanical method. The botanical method is the first one to use to delineate a wetland since plants are good indicator of soil humidity. With the botanical method, areas dominated by hydrophilic vegetation are included in the wetland while areas dominated by upland plants are excluded from the wetland. The method is integrated in several countries environmental bylaws by determining which plants are obligate wetland plants and which ones are upland plants. A wetland delineation bylaw does not exist in Malawi. However, some plants are internationally recognize as obligate or facultative wetland plant species such as the Phragmites, *Typha*, *Scirpus* and *Cyperus* genders.
- The soil method based on hydric soil identification. This method is to be used when vegetation is absent (or in the winter of Northern Hemisphere countries) and does not prevail over the botanical method. No soil sample were taken around the marsh since the botanical method was sufficient.

This section has defined the wetland in term of its spatial extent.

The level of inundation as presented in the previous Hydrology section helps to understand the hydrology of Elephant marsh and determined what factor influences the presence of water in the wetland and characterized the level of dependence of the wetland on Shire and Ruo rivers. However, hydrology and hydrolic cannot be used to delineate a wetland. <u>This is because a wetland is defined as a system where hygrophilous plants thrive rather than an inundated system</u>. Such plants do not necessitate to be submerged in water to thrive (inundated) but need, for the majority of time, to have their roots in humid soil. Using the same logic, areas that are yearly inundated are not necessarily wetlands if the presence of surface water is not long enough to allow hygrophilous plants to grow. Moreover, systems that are feed by seepages and groundwater may never receive surface water and still be considered wetlands as long as hygrophilous plants grow.

The first country to develop a delineation method was the US (US Army Corps of Engineers, Wetlands Delineation Manual, 1987) it is now widely accepted in integrated in many bylaws.

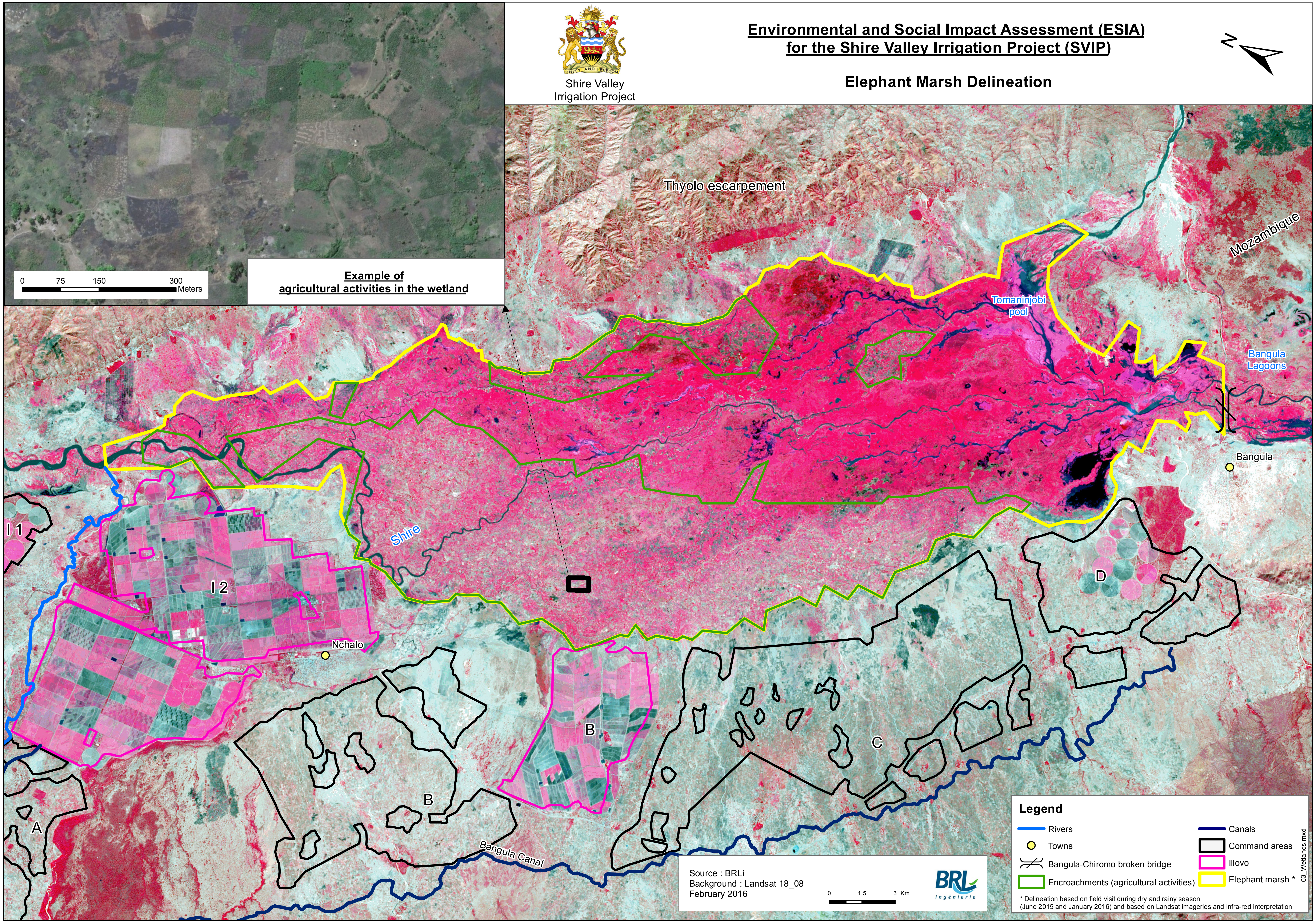
According to wetland delineation method, the presence of standing water or saturated soil is insufficient evidence of the presence of a wetland. Therefore, not all floodplain or dambos are wetlands. More importantly, <u>on an ecological point of view, wetland surface does not vary with season</u>.

The Terrestrial Ecologist has carried out a delineation of the Elephant marsh based on several elements:

- An attempt to use the botanical method to delineate the wetland by identifying on-site wetland plant species and their distribution: identification of four plant genders was used during field visits (June 2015 and January 2016) at key location to delineate the wetland: Phragmites, Typha, Scirpus and Cyperus. This method has its limit due to the vast area covered by the marsh.
- The comparison of Landsat satellite imagery for a full year (two images per month in 2015) helped to complement the field surveys. Landsat satellite imageries were treated at BRLi to highlight chlorophyll plant activity (infra-red image treatment). By analyzing a full year, areas with plant activities were compared between the dry season and the wet season to determine where plant activity was not influenced by season. Therefore, areas with plant activity during the driest months (August to November) where considered to take place in damp conditions and plants were considered to be wetland plants (thriving in damp conditions). Intense red color shows intense plant activity. The best month to produce a map was August 2015.
- For the sake of the ESIA, and to follow the past delineation from the 1:50 000 topographic maps (1992), Elephant marsh starts at the junction of Mwanza and Shire, once the flood plain of the Shire starts to enlarge and ends at Ruo River junction with Shire (at the destroyed bridge).

The following map shows the Elephant marsh delineation based on the method. The wetland, from Mwanza River to the confluence of Shire and Ruo covers an area of 49,795 ha (498 km^2), half of the total floodplain of the Lower Shire River. Some areas are reclaimed for agricultural activities (called dimba agriculture), these areas are identified on the map as "encroachment" on an ecological point of view. Encroachment of the wetland covers a total area of 21,408 ha (214.08 km^2) almost half of the wetland size.

Although wetland delineation does not vary with season, it may vary from one year to the other, as discussed in section 8.4.4.


Environmental and Social Impact Assessment (ESIA)
for the Shire Valley Irrigation Project (SVIP)
Elephant Marsh Delineation
Shire Valley
Irrigation Project
UNITY AND FREEDOM
N
Example of
agricultural activities in the wetland
0 75 150 300 Meters
Thyolo escarpement
Mozambique
Tomaninjobi
pool
Bangula
Lagoons
Bangula
Shire
I 1
I 2
Nchalo
D
C
B
B
A
Bangula Canal
Source : BRLi
Background : Landsat 18_08
February 2016
0 1.5 3 Km
BRL ingénierie
Legend
Rivers
Towns
Bangula-Chiromo broken bridge
Encroachments (agricultural activities)
Canals
Command areas
Illovo
Elephant marsh *
* Delineation based on field visit during dry and rainy season
(June 2015 and January 2016) and based on Landsat imageries and infra-red interpretation
03_Wetlands.mxd

8.4.4 Current Threats and Value of the Elephant Marsh

The Elephant Marsh is dependent on Shire River floods and its numerous meanders to feed water to hygrophilous plant communities and sustain habitats for herpetofauna and waterbirds. There are currently many threats to the wetland as presented in this section.

LACK OF ANY FORM OF STATUS

Unlike parks, the marsh has no official status and is not under any form of official management, protection or zoning (it was in fact degazzetted in 1922). This situation has allowed the marsh to be subject to many pressures. There is however a study to establish a community-managed protected area and to declare Elephant marsh a wetland of international importance under the Ramsar convention (MRAG, 2015-2016).

SUGAR CANE PUMPS

In the past, some Shire river meanders have been naturally blocked by sand bars or silt deposit or artificially by dikes. An example of meander blockage is illustrated in the following figure showing Alumenda feeder canal (all figures are taken at the same location). Based on photointerpretation, following a reduction of flow in Shire (probably by silt deposit or sand bars), a man made dike was built on a meander to increase flow in the Shire toward Alumenda pumping station canal, probably to bring sufficient water to sugar cane pumping stations. This derivation of water has made available new lands for agriculture in the vicinity of the blocked meander thanks to reduction in soil moisture (reduction of inundated area). Incursions of subsistence farmer in this area has locally reduced the quality of the wetland. The meander eventually became an oxbow used as drainage and irrigation; but lost all hydroconnection with the Shire River

Figure 56 Original situation with a meander of the Shire in the marsh (2010)

Figure 57 Manmade dyke to increase flow to the Shire

Figure 58 Ongoing encroachment of subsistence farmers following blockage of meander (2016)

SILT DEPOSITION

Erosion is taken place in the Shire catchment bringing heavy loads of silt to Elephant marsh through tributaries. Deforestation for charcoal business and agricultural activities on Thyolo escarpment is partly responsible for erosion in the Study area. As tributary rivers velocity decrease when entering the marsh, their transport capacity decreases as well leading to silt deposition. Sheetflood erosion (as presented in the soil section) also brings heavy loads of suspended material in the marsh. In the marsh, erosive river bank cultivation is also responsible for the silt load.

LAND RECLAMATION FOR AGRICULTURE (DIMBA AGRICULTURE)

Many areas in the wetland have been drained to claim land for agriculture. Cultivation in the wetland takes place on every available land, the growing population in the valley has put a lot of pressure on land as shown in the following figures (all figures are taken at the same location).

Figure 59 Original situation in the marsh (2006)

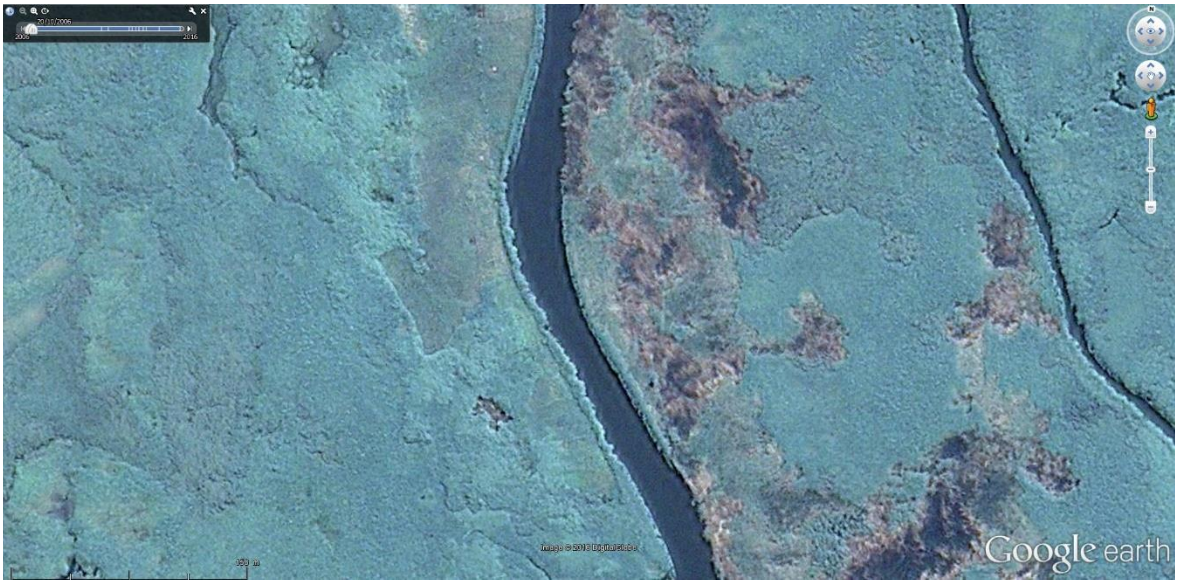


Figure 60 Beginning of encroachment (2011)

Figure 61 Ongoing encroachment (2016)

Before the existence of the Kamuzu barrage (Liwonde barrage), water in the Shire was dependent on the outflow from Lake Malawi, when the water would drop below 471.5 masl, the outflow would stop and no water was flowing in the Shire River (Norplan, 2013). According to several sources quoted by Dudley (1997), from 1908 to 1935 due to low rainfall, the outflow of Shire stopped flowing and Elephant marsh was intensively cultivated thanks to land availability during these dry years. Maize, cotton and rice were (are) the main crops in the marsh. During wet years, cultivation was very restricted due to the wetness conditions. As it is the case with many wetlands, wet conditions have a positive effect on the ecosystem but a negative effect on livelihoods. The downstream area, where pools are located is less encroached by dimba agriculture.

Invasive plants

Water hyacinth (Eichornia crassipes) and water lettuce (Pistia stratiotes) are observed in the marsh. However, they currently do not form vast colonies (consultant observations, 2015, 2016). According to various references, in past years their invasion seemed higher, in Escom reservoir there was no invasive plant colony in 2015 and 2016.

Other potential invasive plants are the water fern (Salvinia molesta), the Kariba Weed (*Salvinia molesta*), the Parrot's Feather (*Myriophyllum aquaticum*) and the Red Water Fern (*Azolla filiculoides*).

Human wildlife conflict

Around the Elephant marsh and Shire River, population are affected by crocodiles predation due to the fact that some communities rely on the permanent water for their livelihood or to wash clothes, bath or fetch water (since groundwater is of poor quality). In addition, dry season grazing by livestock coincides with the breeding season for crocodiles, a period when they are most active and aggressively protecting their nests or hatchlings. Some reports also suggest that reduction in natural preys leads crocodiles to turn to humans for food (Compass, 2000).

In 1996, an aerial survey of the marsh counted 311 hippos and 249 adult crocodiles (Bartlett and Pasteur (1996) quoted by Dudley, 1997), which is much lower than the 2601 hippo counted in 1991 by Simons et al. and the 1620 counted by Mkanda in 1994. The sudden drop is believed to be caused by a drought that has led to a decrease of Shire flow and wetland size and a reduction of grassland surface leading to increased hippo-human conflicts, crop damage and uncontrolled hippos hooting that followed (Dudley, 1997). Growth of human population and conversion of grassland to agricultural lands have also led to an increase in conflicts due to crop damage by hippos (Compass, 2000).

KAPICHIRA DAM AND HYDROPOWER

The current Kapichira dam and hydropower scheme has little effect on the Elephant marsh as the dam is a run-of-the river scheme, meaning that the retention time of the water in the reservoir is very short (what comes in goes out). The Kapachira environmental assessment written in 1991 concluded on minimal impact of the hydropower scheme on the wetland unless the Lake level drops significantly. Lower fish catches, river bank erosion, reduced crocodile breeding, increase in dimba agriculture and reduction of marsh land where the main expected impacts in case of lake level drop (Dudley, et al., 1991).

ELEPHANT MARSH VALUE

The Elephant marsh is one of the most productive ecosystems in Malawi. As presented in the Socioeconomic and Aquatic ecology sections, it provides forage for livestock, fertile soils for crop production and fish. The marshes and riverside flats provide excellent folder and watering points for livestock as well as grazing sites during the dry season when the grass is more accessible. Cultivation in wetland offers year-round moisture and fertile alluvial soils increasing yield compared to rain fed summer crop. In addition to agriculture, the marsh is a place where fisheries are taking place, especially in the southern end where pools are located. One crocodile farm is also in the marsh (Shire Crocodile limited), it exports crocodile skins. The wetland also has another important function, in times of floods it acts as a vast reservoir for overspill of flood waters from both the Shire and Ruo rivers.

On the other hand, these livelihood activities affect elephant marsh. Growing land occupation in the marsh has resulted in degradation of the wetland ecosystem. It is in fact a semi-natural environment, where water availability is dictated by Kamuzu dam upstream. As mentioned earlier, water level had been subject to important natural fluctuation in the past leading to dryness conditions and increased in agricultural activities in the marsh. Since the Kamuzu dam was built, it has allowed to sustain water in the Shire River and improve ecological health of the marsh thanks to regulated water flow.

Elephant marsh a Critical Habitat?

Under the World Bank Operational Policy 4.04 on Natural Habitat, critical habitats are area either legally protected, officially proposed for protection, identified by authoritative sources for their high conservation value, recognized as protected by traditional local communities or areas of high ecological value where rare or endagered species are highly depended of their features to complete critical phases of their life cycle.

Whether Elephant marsh or parts of it are “Critical Habitats” cannot be assess with current information. However, once the biodiversity surveys available from MRAG study (2015-2016) the full ESIA will assess the ecological value of the wetland.

8.4.5 Dambos

Dambos are broad valleys that are waterlogged for some months during the wet season, they are fed by rain water or sometimes by groundwater. Dambos geomorphology differs from rivers as they do not form bed channels. The high water table, with little lateral movement, causes anaerobic conditions in the subsoil, thus precluding most woody species. Dambos are moisture-determined habitats. However, in the Study area water does not stay long enough to allow hydrophilic plants to thrive; these are non-wetland Dambos. The biggest dambo is called Mphonza Dambo.

8.5 WILDLIFE

This section presents wildlife in the Study area. Unfortunately, Elephant marsh has been poorly studied in recent years, which explains why most sources used relate to the three parks in the Study area.

MAJETE

In terms of wildlife, the reserve that had once lost most of its large mammals was restocked with the following mammals: leopard, lion, black rhino, elephant, buffalo, zebra, sable antelope, Lichtenstein's hartebeest, eland, impala, nyala and warthog. All of these species populations are increasing.

The main wildlife animals are with 2015 number: Black rhino (confidential), Buffalo (1319), Bushbuck (400), Bushpig (400), Crocodile (50), Duiker (800), Eland (320), Elephant (389), Grysbok (50), Hippopotamus (85), Impala (2000), Klipspringer (50), Kudu (1022), Leopard (12), Lichtenstein hartebeest (80), Lion (5), Nyala (300), Porcupine (200), Reedbuck (400), Sable (1337), Warthog (800), Waterbuck (1782) and Zebra (571) (Majete aerial census results, 2015).

The reservoir along Majete and the Shire River represent highly valuable aquatic habitats since they are vast permanent water sources for many animal and the only large water body during the dry season (elephant, hippopotamus, lion and crocodile are frequent in these areas). Birds also forage in the Shire.

LENGWE

Lengwe was created to protect the rare and endemic Nyala as well as the thicket communities. Today, the park is faced with many challenges and wildlife population are threaten.

The following table shows the most common « charismatic mammals » and their status in the LNP. Wild dogs, elephant, rhinoceros, zebra, hippopotamus, sable antelope, roan antelope, waterbuck and most big cats are absent from LNP (Dowsett and Dowsett-Lemaire, 2005).

Table 17 Common mammals in LNP

Common name	Latin name	IUCN status and world population trend	Habitat
Nyala	*Tragelaphus angasi*	Least concern, population trend : stable	Thicket
Impala	*Aepyceros melampus*	Least concern, population trend : stable	Grassland, thicket
Warthog	*Phacochoerus africanus*	Least concern, population trend : stable	Woodland
Greater Kudu	*Tragelaphus strepsiceros*	Least concern, population trend : stable	Woodland

Common name	Latin name	IUCN status and world population trend	Habitat
Suni	*Neotragus moschatus livingstoni*	For N. moschatus: Least concern, population trend : stable For N. moschatus livingstoni: not studied by IUCN	Very restricted range, thickets
Buffalo	*Syncerus caffer*	Least concern, population trend : decreasing	Acacia and *Brachystegia* woodlands of Old Lengwe
Bushbuck	*Tragelaphus scriptus*	Least concern, population trend : stable	Thicket and riparian habitat
Reedbuck	*Redunca arundinum*	Least concern, population trend : stable Rare in the Park	Grassland
Nchima monkey	*Cercopithecus albogularis*	Least concern, population trend : decreasing Rare in the Park	Dambo forest, gallery forest

Source: adapted from LNP Park Plan (2005), * adapted from Dowsett and Dowsett Lemaire (2005)

Other rare species reported in the Park by Dowsett and Dowsett-Lemaire, (2005) include the Side-striped Jackal (Canis adustus), Leopard (Panthera pardus) and Tree Hyrax (Dendrohyrax arboreus).

Animal counts

The following table presents species with special conservation status and population trend. According to Dowsett and Dowsett Lemaire (2005), in LNP population counts are made by the Department of National Parks and Wildlife (DNPW) and the Wildlife Society of Malawi (WSM). There are bias in the counts for all species and the figures vary significantly between sources and from one year to the other. One of the explanation provided by Dowsett and Dowsett Lemaire (2005) comes from the census method that differs between the DNPW and the WSM. The first uses walked transect counts while the latest uses water holes counts. Both used a single method while a combination of method is more appropriate. The main bias for transect comes from the fact that some species are highly mobile and could be counted twice (leading to overestimation). The water holes count is not precise for species that drink at night (buffalo) or that rarely drink (Impala) (leading to underestimation).

Table 18 DNPW versus WSM animal census

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Warthog DNPW	927	1003		727	1332	1326			390	901	
Warthog WSM	234	275	171	67	119	117	121	140	114	29	103
Nyala DNPW	3404	4207		2746	1751	2878			2527	1084	
Nyala WSM	600	889	769	507	649	542	521	491	223	59	396
Bushbuck DNPW	261										
Bushbuck WSM	98	145	116	53	100	101	68	53	64	5	81
Kudu DNPW	381	331		307	61	139			302	461	
Kudu WSM	27	12	20	37	19	28	14	5	6	1	22

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Buffalo DNPW	1293	1889		1125	1927	2040			4144	2485	
Buffalo WSM	17	0	6	75	22	5	27	5	96	5	86
Suni DNPW	610	1371		3025	2303	1794					
Suni WSM	0	6	15	0	4	8	1	0	1	0	0
Impala DNPW	1194	1113		3699	1043	1972			4520	2823	
Impala WSM	3	91	98	90	127	164	68	33	91	1	238

Source: adapted from Dowsett and Dowsett Lemaire (2005)

From these figures, it can be concluded that Impala population is increasing and Nyala population is decreasing. LNP Park Plan (2005), concludes that Impala population are increasing at the expense of Nyala and that counts by the MWS are close to reality. In addition, Nyala have more specific niche requirement than Impala which makes the Impala a good competitor under variable habitats such as those fund in Old Lengwe (Mkanda, 1996). LNP Park Plan also considers Nyala absent in the Uplands Unit (Western part of the Park). Buffalos are also absent from the Uplands Unit (Dowsett and Dowsett Lemaire, 2005).

However, for other species the great variability makes conclusion difficult on population trend as well as on carrying capacity of the Park for these animal. Counts by the WSM show a recent drastic decrease of Impala population along with other species. According to MWS, poachers are frequently hunting in the Old Lengwe and are responsible for this significant decrease in wildlife (MWS website, 2016).

There has never been any animal re-introduction in the LNP.

Table 19 MWS recent counts

	2014	2015
Warthog	53	24
Nyala	321	200+
Bushbuck	118	28+
Kudu	11	1
Suni	11	5
Impala	335	104+

Source: adapted from MWS website (2016)

CONSOLIDATED LIST OF MAMMALS

Dowsett and Dowsett Lemaire (2002) produced a document in which they consolidate their observations on wildlife and report observations from other wildlife experts for the three parks in the Study area. The following table is adapted from their work and is adds newly re-introduced wildlife in the Majete Wildlife Reserve since it has been managed by African Parks.

Table 20 Commom mammals in the three parks

Family	Species	Lengwe	Majete	Mwabvi
Soricidae (shrews)	*Crocidura hirta*	OL		
Erinaceidae	Four-toed Hedgehog *Atelerix albiventris*			x
Pteropodidae	*Rousettus aegyptiacus*	x		
Nycteridae (slit-nosed bats)	*Nycteris macrotis*	x		
	Nycteris thebaica	x		
Rhinolophidae (nose-leafed bats)	*Rhinolophus fumigatus*			x
	Rhinolophus clivosus	X		
	Hipposideros commersoni	X		
	Hipposideros caffer	x		X
Vespertilionidae (pipistrelle bats)	*Scotophilus viridis*	X		
	Pipistrellus nanus	X		
	Nycticeius schlieffenii	X		X
	Scotoecus albofuscus	X		
Molossidae (free-tailed bats)	*Tadarida pumila*	X		
	Tadarida condylura	X		
Lorisidae (galagos)	Greater Bushbaby *Otolemur crassicaudatus*	X	X	X
	Lesser Bushbaby *Galago moholi*	X	X	X
	Zanzibar Galago *Galagoides zanzibaricus*	X	X	X
Cercopithecidae (monkeys and baboons)	Yellow Baboon *Papio cynocephalus*	X	X	X
	Vervet Monkey *Cercopithecus pygerythrus*	X	X	X
	Blue Monkey *Cercopithecus albogularis*	X	X	X
Canidae (dogs)	Side-striped Jackal *Canis adustus*	X		X
Mustelidae (mustelids)	Cape Clawless Otter *Aonyx capensis*		X	
Viverridae (civets etc.)	Two-spotted Palm Civet *Nandinia binotata*			X
	African Civet *Civettictis civetta*	X	X	X
	Rusty-spotted Genet *Genetta rubiginosa*	X	X	X
	Bushy-tailed Mongoose *Bdeogale crassicauda*	X		X
	Large Grey Mongoose *Herpestes ichneumon*	X	X	X
	Slender Mongoose *Galerella sanguinea*	X	X	X
	White-tailed Mongoose *Ichneumia albicauda*	X		
	Banded Mongoose *Mungos mungo*	X	X	X
	Dwarf Mongoose *Helogale parvula*		X	X
Hyaenidae (hyaenas)	Spotted *Hyaena Crocuta*	X	X	X
Felidae (cats)	Leopard *Panthera pardus*	X	X (recent)	X
	Lion *Panthera leo*		X (recent)	
	Serval *Felis serval*	X	X	X
	Wild Cat *Felis libyca*	X	X	X
Elephantidae (elephants)	African Elephant *Loxodonta africana*		X (recent)	

Family	Species	Lengwe	Majete	Mwabvi
Rhinocerotidae (rhinoceroses)	Black Rhino *Diceros bicornis*		X (recent)	
Equidae (horses)	Burchell's Zebra *Equus burchelli*		X (recent)	
Procaviidae (hyraxes)	Yellow-spotted Dassie *Heterohyrax brucei*	X	X	X
	Tree Hyrax *Dendrohyrax arboreus*	X	X	X
Orycteropodidae (Ant bear)	Ant bear *Orycteropus afer*	X	X	X
Suidae (pigs)	Wart Hog *Phacochoerus aethiopicus*	X	X	X
	Bush Pig *Potamochoerus porcus*	X	X	X
Hippotamidae (hippopotami)	*Hippopotamus amphibius*		X	
Bovidae (antelope etc.)	Lichtenstein's Hartebeest *Sigmoceros lichtensteinii*		X (recent)	
	Grey Duiker *Sylvicapra grimmia*	X	X	X
	Klipspringer *Oreotragus*	X	X	X
	Sharpe's Grysbok *Raphicerus sharpei*	X	X	X
	Suni *Neotragus moschatus*	X	X	X
	Impala *Aepyceros melampus*	X	X	X
	Sable Antelope *Hippotragus niger*		X	X
	Buffalo *Syncerus caffer*	X	X (recent)	X
	Greater Kudu *Tragelaphus strepsiceros*	X	X	X
	Nyala *Tragelaphus angasii*	X		X
	Bushbuck *Tragelaphus scriptus*	X	X	X
	Eland *Taurotragus oryx*		X (recent)	
	Reedbuck *Redunca arundinum*	X	X	
	Waterbuck *Kobus ellipsiprymnus*		X	
Manidae (pangolins)	Pangolin *Manis temminckii*	X	X	X
Sciuridae (squirrels)	Sun Squirrel *Heliosciurus mutabilis*	X	X	X
	Bush Squirrel *Paraxerus cepapi*	X	X	X
	Red Squirrel *Paraxerus palliatus*	X		X
Hystricidae (porcupines)	Porcupine *Hystrix africaeaustralis*	X	X	X
Thryonomyidae (cane rats)	Greater Cane Rat *Thryonomys swinderianus*		X	X
Bathyergidae (mole-rats)	Silvery Mole-rat *Heliophobius argenteocinereu*s			X
	Common Mole-rat Cryptomys hottentotus			X
Leporidae (hares)	Hare Lepus saxatilis	X	X	X
	Red Rock Hare *Pronolagus rupestris*	X		X
Macroscelididae (elephant-shrews)	Four-toed Elephant-shrew *Petrodromus tetradactylus*	X	X	X
	Peters's Short-snouted Elephant-shrew *Elephantulus fuscus*	X	X	X
	Checkered Elephant-shrew *Rhynchocyon cirnei*	X		X

Ol :Old LEngewe only, X (recent) since the change in management in Majete Wildlife Reserve

BIRDS

The number of birds occurring in the Lower Shire three reserves is very high, with between 340-350 species recorded as resident or regular migrants; another 50-60 species occur as irregular visitors or vagrants. The maintenance of important bird habitats such as well-developed deciduous forest and thicket is essential for the survival of several vulnerable bird species. Old Lengwe has the best preserved thickets in the Study area (Dowsett-Lemaire & Dowsett, 2002).

The Shire Valley is also of importance as wintering ground for a number of Palearctic migrants such as Palearctic raptors (including the IUCN endangered Steppe Eagle *Aquila nipalensis*), rollers and bee-eaters, and very large numbers of several passerine species. The very rare and IUCN endangered Basra Reed Warbler *Acrocephalus griseldis*, was observed in small numbers throughout the area (Dowsett-Lemaire & Dowsett, 2002).

8.6 IUCN AND LOCAL VULNERABILITY

IUCN STATUS

The International Union for Conservation of Nature (IUCN) holds a worldwide-recognized database of species with special status called the IUCN Red List.

Four searches on IUCN Red List were carry out in March 2016 to identify potential species with special status:

- Vertebrates in terrestrial habitats
- Plants in terrestrial habitats
- Vertebrates in wetland habitats (outside of fishes and aquatic species)
- Plants in wetland habitat

Unfortunately, search results for plants did not provide any range maps, making their localization impossible. Therefore, they are not presented in this section.

Search terms and the results are shown in the following tables. Results were shorted using range maps. Only species which range overlaps (or came close to) the Study area are shown in the following tables. In addition, species that are reported not to be present in none of the three parks (Majete, Lengwe, and Mwabvi) or the area were also shorted out using wildlife lists of Dowsett and Dowsett-Lemaire (2005).

Table 21 IUCN Terrestrial Species

Taxonomy	Location & system	Habitat	Assessment (2016)
Chordata (vertebrate)	Malawi, Terrestrial	Forest, Savanna, Shrubland, Grassland, Rocky areas	Extinct, Critically Endangered, Endangered, Vulnerable, Near Threatened
Common name	**Latin name**	**Habitat**	
Steppe Eagle	*Aquila nipalensis*	Hills and mountains	Endangered
Basra Reed-warbler	*Acrocephalus griseldis*	Marshland	Endangered
Southern Ground-hornbill	*Bucorvus leadbeateri*	Woodland and savanna	Vulnerable

Taxonomy	Location & system	Habitat	Assessment (2016)
Chordata (vertebrate)	Malawi, Terrestrial	Forest, Savanna, Shrubland, Grassland, Rocky areas	Extinct, Critically Endangered, Endangered, Vulnerable, Near Threatened
Common name	**Latin name**	**Habitat**	
Stierling's Woodpecker	*Dendropicos stierlingi*	Brachystegia woodland	Near Threatened
White-backed Vulture	*Gyps africanus*	Open wooded savanna (Acacia)	Critically Endangered
Olive-headed Weaver	*Ploceus olivaceiceps*	Brachystegia woodland	Near Threatened
Martial Eagle	*Polemaetus bellicosus*	Open woodland, wooded savanna, bushy grassland	Vulnerable
Secretary bird	*Sagittarius serpentarius*	Grasslands, lightly wooded savanna	Near Threatened
Temminck's Ground Pangolin	*Smutsia temminckii*	Savanna woodland	Vulnerable
Crowned Eagle	*Stephanoaetus coronatus*	Forest, woodland, savanna and shrubland	Near Threatened
Bateleur	*Terathopius ecaudatus*	Grasslands, savanna	Near Threatened
Lappet-faced Vulture	*Torgos tracheliotos*	Dry savanna	Endangered
African Straw-coloured Fruit-bat	*Eidolon helvum*	Riverine forest, savanna	Near Threatened
Commerson's Leafnosed Bat	*Hipposideros vittatus*	Savanna woodland habitats	Near Threatened
Elephant shrew	*Rhynchocyon cirnei shirensis*	Closed-canopy woodlands, and riparian thickets	For R. cirnei : Near Threatened For R. cirnei shirensis: not studied by IUCN but rare in the LNP (LNP Park Plan, 2005).
Black Rhinoceros	*Diceros bicornis*	Woodland, savanna and shrubland	Critically Endangered
Leopard	*Panthera pardus*	Woodland, grassland savanna and forest	Near Threatened

The following table shows the results for wetland species, these species are to be considered potentially present in Elephant marsh.

Table 22 IUCN wetland species

Taxonomy	Location & system	Habitat	Assessment
Chordata (vertebrate)	Malawi, Freshwater	Wetlands (inland)	Extinct, Critically Endangered, Endangered, Vulnerable, Near Threatened
Common name	**Latin name**	**Habitat**	
Madagascar Pond-heron	*Ardeola idae*	Swallow wetlands fringed with vegetation and adjacent trees	Endangered

Taxonomy	Location & system	Habitat	Assessment
Chordata (vertebrate)	Malawi, Freshwater	Wetlands (inland)	Extinct, Critically Endangered, Endangered, Vulnerable, Near Threatened
Common name	**Latin name**	**Habitat**	
Grey Crowned-crane	*Balearica regulorum*	wetlands such as marshes, pans and dams with tall emergent vegetation	Endangered
Blue Swallow	*Hirundo atrocaerulea*	Montane grassland	Vulnerable
African Clawless Otter	*Aonyx capensis*	Permanent river	Near Threatened
Hippopotamus	*Hippopotamus amphibius*	Wetland and permanent river	Vulnerable
Spotted-necked Otter	*Hydrictis maculicollis*	Freshwater (stream, river, reservoir)	Near Threatened

Tables 22 and 23 show that the Study area has a lot of species with IUCN status, thanks to the presence of the parks and the vast marsh.

LOCALLY RARE BIRDS

According to Dowsett-Lemaire & Dowsett (2002), the Lower Shire is a biogeographical limit for a number of thicket/forest birds with restricted distribution in South-Eastern Africa. These include the Gorgeous Bush *Shrike Malaconotus viridis*, Rudd's Apalis *ruddi*, Grey Sunbird *Nectarinia veroxii*, Woodwards' Batis *fratrum,* Barred Long-tailed *Cuckoo Cercococcyx montanus* and the Black-and-White Flycatcher *Bias musicus*; the grassland species the Lemon-breasted *Canary Serinus citrinipectus* is also a south-eastern endemic. The almost total disappearance of thicket vegetation in the Shire Valley outside wildlife reserves means that thickets in Lengwe and Mwabvi are of the utmost importance for the survival of these relatively rare species.

LOCALLY RARE PLANTS

In Majete, Kabwazi et al. (2000) notes that Holmskioldia spinescens (a deciduous shrub), Hyphaene crinata (shrub) and a Holostylon species occur in only a few areas of the reserve and should be regarded as rare.

In Lengwe, Kabwazi et al. (2000) mentions that Euphorbia lividiflora (red-flowered Euphorbia), Croton megalocarpus (tree), Croton pseudopulchellus (tree), Hygrophila pilosa (perennial herb), Maerua parviflora (shrub), Ziziphus pubescens (tree) and a species of Spermacose (Rubiacea) should be regarded as rare.

In Mwabvi Wildlife Reserve, there is a rare tree known locally as “Mwabvi” from which the name of the reserve come from.

8.7 AQUATIC ECOLOGY

The study area has been the subject of many studies on fishes, this section is therefore based on desktop review on the most important fish species.

8.7.1 Introduction

This section covers the aquatic ecology baseline with the major fish species present and a sample of some important fish species classified as 'other' fish species by the Department of Fisheries of the Lower Shire Valley. The fish species described here are mainly from the families of *Cichlidae, Cyprinidae* and *Claridae*.

Malawi is endowed with numerous water bodies that include Lakes Malawi, Malombe, Chilwa, Chiuta and the Shire River. Lake Malawi is a hot spot for fish biodiversity with an estimated over 1,000 fish species some of which are still not yet described (Ngatunga, 2001). Another important feature about the lake is that most of the fish species (over 90%) in the lake are endemic. Hence, the Lake Malawi National Park was declared a natural heritage site for fish biodiversity in the world by UNESCO.

The Malawian major water bodies are stratified for fisheries statistical and administrative reasons. In addition, Shire River is divided into 3 distinctive environments, the Upper Shire, the Middle Shire and the Lower Shire, each with distinctive features and fish species biodiversity (Osborne 2000; Tweddle & Willoughby, 1979). This section concentrates on fish from the Lower Shire.

LOWER SHIRE RIVER ECOSYTEM

The fish fauna of Malawi are divided into the Lake Malawi and the Lower Shire fish fauna. The Lake Malawi fish fauna comprise all the fish in the lake, all its tributaries and the Shire River up to the Middle Shire or the rapids.

The Lower Shire fish fauna shares the same ecology with the lower Zambezi fish species because of the absence of any physical barrier between the Lower Shire and the Zambezi River.

The Kapichira Falls and the Middle Shire rapids are physical and ecological barriers to the upstream migration of the Lower Shire fish fauna into the Lake Malawi basin (Tweddle & Willoughby, 1979). Thus, fish cannot migrate from the Lower Shire to the Middle Shire because of the gorges and waterfalls. Some fishes survive when descending the falls and the ESCOM long spillway, although many are left injured and weakened from the harshness of the spillway. Therefore, the Lower Shire and associated marshes support a Lower Zambezi fish fauna, separated physically and ecologically by the rest of the Shire River. Downstream movement of species from Lake Malawi to the Lower Shire explains the presence of a few upstream species in the Lower Shire, however due to the harshness of the ESCOM spillway and the water intake of the powerstation only a few common species are present in the Lower Shire.

Figure 62 Spillway and environmental flow (left) of 30 m3/s

8.7.2 Fisheries

The Lower Shire River sustains an important river-floodplain fishery (where fish production is highly dependent on the quantity of annual flooding) contributing to about 4.2% of total fish landings in the country (FAO, 2015). The fish in the Lower Shire are caught mainly for subsistence by small-scale fishermen providing livelihoods for about 1,830 people. These people are either gear owners or fishing crew members (Frames survey, 2015). The fisheries in the Lower Shire like in Lake Malawi are multi-species hence fishers use multiple gears to catch them. Fishery regulations are not well-enforced.

More than 60 species are reported to be caught in the Lower Shire fishery, but only three namely, “Mlamba”, the African Catfish (*Clarias gariepinus*), “Chikano” (*Clarias ngamensis*) and “Mphende”, the Tilapia (*Oreochromis mossambicus*) are of commercial importance. Both the *Clarias gariepinus* and the *Clarias ngamensis* are considered a single species. These three contribute to 90% of the total fish catch in the Lower Shire. Tilapia constitutes about 51 % of total catches from Lower Shire River and *Clarias sp*. to 42% (FAO, 2015). Although Tilapia is a worldwide invasive species, it is endemic to the Lower Shire and the Lower Zambezi River (Chimatiro, 2004).

The most recent fish catch statistics for the major fish species in Chikhwawa district are (Fish catch statistics for Chikhwawa, Kasinthula Fisheries Station, 2015):

- July 2012 to June 2013: 193.39 tonnes;
- July 2013 to June 2014: 958.63 tonnes;
- July 2014 to May 2015 : 226.70 tonnes.

There was an increment in 2013/14 in fish catches over those caught the previous year. The catch was higher than the other years because water levels were low and people were using beach seine nets as well. The total catches increased from 193 in 2012/13 to 958. However, the fish catch statistics during 2014/15 are comparable to those of 2012/13, with no remarkable peak across the months. These data are more or less accurate since there are illegal fishing activities and undeclared catches. In addition, weak supervision of data recorders is also pointed by the consultant fish expert as a reason for the variability of data.

The main fishing methods in the Lower Shire include seine nets, gill nets, fish traps, scoop nets, cast nets and encircling fish fence. Gill nets are the commonest fishing gears used and dug-out canoes and plank boats without engines are the main fishing crafts employed.

CHALLENGES

There is a seasonal fluctuation of fish catches linked to the flooding pattern of Shire River which is influenced in part by the operations of the Kamuzu Barrage (Chimatiro, 2004). Water Hyacinth blooms is another issue problem in the area adversely affecting the fishery. The challenge in managing fishery resources in Malawi is that the artisanal fishery which includes the Shire River is “open-access” in character. Due to weak enforcement by the Malawi Department of Fisheries, many fishers continue to fish without any access restrictions. In fact, as opposed to Lakes Malawi and Malombe, the fishery in the Shire River appears to be unregulated due to lack of enforcement.

The lagoons and marshy areas (such as Elephant marsh) are getting shallower and narrower due to soil deposition brought about by flooding. Hence huge soil deposition may in future affect the marshes which are hot spots for fish breeding in the area.

8.7.3 Description of the Fish Species in the Lower Shire Valley

This section presents the Tilapia, the African Catfish as well as other fish species in the Lower Shire whose catch is small and are hence characterized as “others” by Fisheries Department. These “other” species include:

- Straighfin Barb, “Matemba” (*Barbus paludinosis*);
- “Nkholokolo” (*Synodontis njassae*);
- Tigerfish (*Hydrocynus vittatus*);
- Lake Salmon, “Mpasa” (*Opsaridium microlepis*);
- Redeye labeo, “Ningwi” (*Labeo cylindricus*);
- “Kadyakolo” (*Barbus eurystomus*); and
- “Ngumbo” (*Barbus Johnstonii*).

In addition, *Marcusenius macrolepidotus* an important catch of gillnet fishery is presented hereunder.

The 49 fish species presented are either the most common or the ones with special status (IUCN assessment). In the main report, the 10 most important fish species for subsistence and commercial fisheries are presented. In annex, the 39 additional fishes are presented, all with the same level of detail. For each fish description, the following criteria has been developed by BRLi to reflect potential issues and challenges that fishes will face due to the Project implementation. Therefore, these criteria prepare the impact assessment:

- Habitat requirements and regional extent: this criterion helps to understand where the fish is present in the region and the world. It describes in which habitat the fish is usually found;
- Water quality requirements: this criterion helps to understand what the requirements of the fish are in terms of temperature, pH or turbidity;

- Water flow requirement: this criterion describes whether the fish thrives in fast moving water of slow moving water such as pools;
- Ability to pass obstacles: this important criterion describes the ability of the fish to jump or pass over obstacles as the project will involve many infrastructures such as canal, siphon and weirs;
- Life cycle (migration, spawning and maturing): this important criterion describes the life cycle of fishes;
- Important habitats and sensitive life cycle stage: this criterion describes the important habitats and life cycle stage for each fish. The term “important” designate the predilection habitat of the fish and the sensitive phase of the fish life cycle. This criterion will help to assess the significance of impact in the impact assessment;
- Actual threats and protection status: this criterion gives an actual indication on the status of the fish and whether it is rare or has an IUCN status (based on March 2016 consultation of IUCN Red List);
- Value as food source for population and value in the food chain: this criterion describes the value of the fish as a protein source for communities;
- Distribution, status of endemicity and relative abundance: this criteria is similar to the first one, it gives additional information about the relative abundance of the fish in the Study area;
- Status (native, allochthonous or invasive): this criteria describes the fish in term of its status as native, allochthonous (introduced) or invasive (introduced and aggressively competing with other species). It also describes whether the fish, if transported outside of its natural range, may become invasive or not.

As presented earlier, many species use elephant marsh either for spawning in vegetation, or as their main habitat. The terms “marshy area”, “swamps”, “pools” in the following sections all refer to ecosystems that constitute the Elephant marsh.

8.7.3.1 Tilapia (Oreochromis mossambicus)

HABITAT REQUIREMENTS AND REGIONAL EXTENT

The natural native habitat of *O. mossambicus* is the eastern coastal region of Africa where the species is found in riverine and coastal lagoon habitats (Fryer and Illes, 1972). The species is found in abundance in the Lower Zambezi river in Mozambique where it has derived its name, as the Mozambique tilapia, i.e., *O. mossambicus*. The species migrated from its natural habitat in the Zambezi River and inhabits the marshy and lagoon areas of the Lower Shire Valley (Tweddle et al., 1982) where it has been confined due to the natural barrier between the Lower Shire / Zambezi fish fauna and the Lake Malawi fish fauna. The species was introduced to the US through aquaculture and has established itself through accidental or intentional introductions in the river systems of Texas, Florida and Alabama (Brown, 1961; Courtney, 1961; Bruton and Bolt, 1975). *O. mossambicus* has also been introduced in many African and Asian countries where aquaculture is being practiced.

WATER QUALITY REQUIREMENTS

Temperature

O. mossambicus is one for the tropical fin fishes of Africa. It tolerates a wide range of temperature. The optimum temperature for growth is above 19ºC and for reproduction is above 22ºC (Trewavas, 1983). These conditions are prevalent in the Lower Zambezi River and the Lower Shire. In the natural habitats, Trewavas (1983) reported that *O. mossambicus* does not tolerate temperatures below 10ºC.

Salinity

O. mossambicus tolerates a broad range of water salinity (Trewavas, 1983). The species thrive in fresh water up to the salinity levels of 40 ppt, it can reproduce in estuarine waters with salinity levels as high as 34.5 ppt (Knaggs, 1977; Dial and Wainright, 1983). This is one of the features common to all tilapias which enable them adapt a wide range of environmental conditions and hence their world-wide distribution (Trewavas, 1983).

pH

O. mossambicus can tolerate a wide range of pH from 3.1 (acidic conditions) to 8.5 (alkaline conditions). This feature also accounts for their adaptation to a wide geographical range (Trewavas, 1983).

WATER FLOW REQUIREMENT

The *O. mossambicus* inhabits riverine and coastal lagoons (Fryer and Iles, 1972), hence does not like fast flowing waters but areas that are sheltered such as the marshes and lagoons in the rivers. In the Lower Shire, the fish inhabits the marshy areas such as Elephant and Ndindi marshes as well as the lagoons (Tweddle et al., 1982).

ABILITY TO PASS OBSTACLES

O. mossambicus as a tilapia cannot negotiate rapids as Barbus species, Opsaridium species and Labeo species (Trewavas, 1983). The *O. mossambicus* migrates to other areas when there is no physical obstacle in the water body. The *O. mossambicus* that are found in uplands is due to artificial introductions either accidentally or intentionally.

LIFE CYCLE (MIGRATION, SPAWNING AND MATURING)

Fishes in the genera “Oreochromis” are mouth brooders of eggs and young. All fish species in the family “Cichlidae” practice long-term parental care of young (Trewavas, 1983). Female *O. mossambicus* mature when they have attained a body length of 150-160 mm and males mature after attaining a longer body length of between 170 and 180 mm (Hodgkiss and Man, 1978; Arthington and Milton, 1986). However, due to the unstable flow conditions in the Lower Shire valley, the fish matures at an earlier stage (Chimatiro, 2004). The breeding season for Oreochromis species is stimulated by high minimum water temperatures (22-25^{o}C) (Trewavas, 1983) hence in the Lower Shire, Oreochromis species breed almost throughout the year due to the high temperatures, but peaking during the rainy season.

Mature males develop breeding colors, especially during the onset of the first rains and migrate to shallow waters along the river banks where they construct nests on sandy and or muddy bottoms. Mature females also develop breeding colors and are attracted to the nest by the colors of the males. When the eggs are laid on the nest, the male fertilizes them and the female picks up the fertilized eggs and incubates them in the buccal cavity situated below the lower jaw of her mouth (Trewavas, 1983). The juveniles inhabit the shallow or marshy waters and migrate to deep waters as they grow.

IMPORTANT HABITATS AND SENSITIVE LIFE CYCLE STAGE

O. mossambicus inhabits the sheltered areas of the river such as the marshy areas and lagoons. It also breeds on the shallow areas which are usually the river banks (Trewavas, 1983). Hence the marshy and lagoon areas are important habitats for all the stages of the life cycle of the species and the shallow areas and river banks are important for reproduction and recruitment of juveniles. The seining of the marshy areas and river banks especially during the breading season destroys the breeding grounds and nests of the fish.

Actual threats and protection status

O. mossambicus is not yet red listed by IUCN but it is classified as a "Near Threatened" species. Three scenarios are putting the *O. mossambicus* under threat in the Lower Shire. The closure of the Barrage at Liwonde to regulate the water flow for generating power at Nkula, Tedzani and Kapichira results in occasional reduced water levels along the marshy areas of the Lower Shire Valley, hence exposing the fish to fishers or predations and disturbs the breeding cycle (Tweddle, 2015). The second threat is the invasion of the water hyacinth which comes from the upper course of the Shire. These weeds invade the breeding sites of the fish. The third threat is the open access and poorly regulated fisheries that take place in the Lower Shire. Fishers are using inappropriate fish gears such as small meshed seine nets including mosquito nets. These gears destroy the breeding grounds and are non- selective, hence catch both juvenile and the adult fishes. Regarding protection status, although the fisheries regulations exist, there is weak enforcement in the area.

Value as food source for population and value in the food chain

Mphende (*Oreochromis mossambicus*) is the main fish species that has commercial value to the local fishers in the Lower Shire. Its catch from the Lower Shire constitutes to about 51 % of total catches from the area. The species is seconded only by the catfishes in terms of its commercial value in the Lower Shire Valley (Tweddle et al., 1982; Chimatiro, 2004). The species is important for both subsistence and commercial fishing. The species is also used for aquaculture at Kasinthula, Illovo and some small-scale fish farms in the Lower Shire.

Regarding the food chain *Oreochromis mossambicus* are generalists and opportunistic omnivores that consume detrital material, vegetation ranging from diatoms, macro-algae to rooted plants, invertebrates and small fish (Bowen 1979, Mook, 1983, Trewavas, 1983). Diets differ depending on location-specific resource availability. This fact was also reported by De Silva et al., (1984) who reported that *O. mossambicus* populations in different water bodies fed on different diets and trophic strategies ranged from detritivory to herbivory to near exclusive carnivory with individuals preying on small fish and invertebrates. This feature makes the fish adaptable a wide range of environmental conditions on the globe. In the Lower Shire, *O. mossambicus* is reported to feed mostly on algae, detritus and plankton, with preference to zooplankton (Pullin and Lowe McConnel, 1982). *O. mossambicus* is caught and eaten by people, its juveniles are predated upon by scavengers such as catfishes and predators such as tiger fish and crocodiles. Hence, *O. mossambicus* is a very important fish species in the food chain in the area.

Distribution, status of endemicity and relative abundance

The lower Shire area is rich in nutrients that are washed away from upland streams and are deposited in the valley. The nutrients boost the growth of phytoplankton and zooplanktons. The abundance of phytoplankton and zooplanktons which are natural food for tilapias creates a conducive environment for *O. mossambicus* to reproduce and grow in the area. The presence of marshes around Chikhwawa and Nsanje Districts such as Elephant marsh creates favorable environment for *O. mossambicus* to construct breeding nests, breed and raise its young ones without being predated hence there is high survival rate for the species from juvenile to adulthood (Tweddle et al, 1978). The Valley has several lagoons and oxbows along the Shire that also act as breeding grounds for *O. mossambicus* because these areas are shallow, have high primary productivity and hence abundant fish food is available for the fish. The fish catch statistics show that the catch of *O. mossambicus* has been stable over years. Hence, *O. mossambicus* is abundant in the Lower Shire.

Status (native, allochthonous or invasive)

The species is native.

O. mossambicus is a prolific breeder and suppresses all other Oreochromis species in the Lower Shire, hence *O. mossambicus* remains the predominant Oreochromis species in the Lower Shire and the lower Zambezi River. In addition, *O. mossambicus* is invasive in other region of the world. It has thrived in alien environments where it has been introduced, either intentionally or accidentally (Moyle, 1976). Intentional release has often been for the purpose of plant or pest (e.g. Mosquito) control (Moyle, 1976). Intentional release has also been done to establish populations for spot fish, bait fish or commercial fish farming (Shapovalov et al., 1981). There have been accidental releases of *O. mossambicus* from hatcheries, fish farms, aquariums and zoos (Dial and Wainright, 1983; Grabowski et al., 1984; Courtenay and Stauffer, 1990).

O. mossambicus poses a threat to local native fish species through competition for food and nesting space (Courtenay et al., 1974). *Oreochromis mossambicus* has thus been nominated by the Invasive Species Specialist Group (ISSG) to be among the 100 of the world's worst invasive alien fish species (Courtinay, 1989). Although some Lake Malawi fish fauna including tilapias may manage to descend the rapids, they do not established in the Lower Shire due to the suppression by *O. mossambicus*.

8.7.3.2 Catfishes (Clarias gariepinus)

Originally, more than 100 different species of the Genus Clarias were described in Africa. However, a systematic revision based on morphological, anatomical and biographical studies has been carried out by Teugels (1982), who recognized 32 valid species. With this revision, all the large African Catfish species now belong to the subgenus Clarias. However, in the earlier systematic studies on the large African catfish species, Boulenger (1911) recognized five species within this subgenus. The five described species were: *Clarias anguillarus*, *Clarias senegalensis*, *Clarias lazera*, *Clarias mossambicus* and *Clarias gariepinus*. In 1982, Teugels revised the subgenus Clarias and found only two species (*C. gariepinus* and *C. anguillaris*), all the catfishes in the Zambezi and Lower Shire including *C. ngamensis* are now referred to as the African Catfish, *Clarias gariepinus*.

Habitat requirements and regional extent

Clarias gariepinus, is one of the most important tropical catfish species and its distribution range is from the Nile to West Africa and from Algeria to Southern Africa. It also occurs in Asia Minor (Israel, Syria and South of Turkey). By contrast, *Clarias anguillaris* has a more restricted distribution and is found in Mauritania, most West African basins and in the Nile. *C. gariepinus* lives in freshwater lakes, rivers and swamps as well as man-made habitats, such as oxidation ponds or even sewage system (Teugels, 1982). Due to its importance in aquaculture, *C. gariepinus* was introduced in countries far from its natural habitat such as Brazil, Vietnam, Indonesia and India.

Water quality requirements

Clarias gariepinus is very tolerant to muddy water and conditions of low dissolved oxygen. Studies have shown that the species can survive turbid water where there is no oxygen at all because they are capable of respiring atmospheric air through a super-bronchial organ and can survive for days in air as long as there is moisture. This fish walks on land under damp conditions if necessary by extending pectoral spines and crawling (Skelton, 2001). The super-bronchial organ develops early in life at about 7 days after spawning when the juveniles are known as 'swim up fries' because they come to the water surface to breathe atmospheric air directly.

Furthermore, *Clarias gariepinus* can tolerate a wide range of temperature from 8°C to 35°C; salinity ranging from 0 to 12 ppt; and also has a wide range of pH, turbidity and tolerate high densities (Hecht et at 1988). Hence Clarias species are usually the last fish remaining when water bodies dry up, as was the case with Lake Chilwa when it dried up in 1996 (EAD, 2000).

WATER FLOW REQUIREMENT

Clarias species are the amongst the commonest fish species in rivers, lagoons and estuaries but are not representative of open lakes, though occasionally they may go into the Lake Malawi especially if they are migrating opposite the direction of the flow of flooded rivers. Hence during their normal life, *C. gariepinus* inhabits muddy and turbid areas of the rivers and is also found in large numbers in the marshy areas of the Lower Zambezi and Shire Rivers.

ABILITY TO PASS OBSTACLES

C. gariepinus migrates to higher ground to spawn by swimming against river flows during the rainy season when rivers flood. During the onset of first rains, the fishes congregate at the mouths of tributaries and the flooding stimulates their migration. They cannot climb or negotiate against physical obstacles. However, they may pass through dam walls and other obstacles if they are submerged by flooding waters.

LIFE CYCLE (MIGRATION, SPAWNING AND MATURING)

The size to first maturation of catfish in the Lower Shire is 193 cm (Chimatiro, 2004) which was within the range reported for the species in other water bodies (Bruton, 1979; Merron, 1996). Catfish resides in rivers as adult. In the Lower Shire, *C. gariepinus* grows fast during the first two years and reaches physiological maturity (Chimatiro, 2004). The fast growth rates during the first two years are typical of fish species that reside in unstable environments (Bruton and Allanson, 1974; Hecht et al., 1988). The fast growth rate enables juveniles to rapidly evade predation (Welcomme, 2001; Lowe McConnel, 1967). Both the mature males and females develop gonads which remain dormant until the onset of the rains. Final oocyte maturation is achieved when rivers flood. Spawning mostly takes place at night in the shallow, inundated areas of the rivers, lakes and streams (Quick and Bruton, 1983). Catfish lays a large number of small eggs which when fertilized stick on substrate such as vegetation (Welcomme, 2001). There is no parental care for ensuring the survival of the catfish offspring except by the careful choice of a suitable site and substrate. Development of eggs and larvae is rapid, and the larvae are capable of swimming within 48–72 hours after fertilization (Hecht et al., 1988).

IMPORTANT HABITATS AND SENSITIVE LIFE CYCLE STAGE

The important life cycle stage for *C. gariepinus* in the Lower Shire is during spawning migration. There is a need for flooding to stimulate final oocyte and gonad maturation. If there is less or no flooding or physical barriers to their shallow breeding sites then *C. gariepinus* breeding is adversely affected (Chimatiro, 2004; Tweddle, 2015). In addition, since there is no parental care of the fertilized eggs, there is a need to protect the shallow breeding sites such as the marshes so that fry to juvenile survival is optimized.

ACTUAL THREATS AND PROTECTION STATUS

The species is not IUCN red-listed, it is listed as being of “Least concern”, hence the populations are healthy. It is reported that reproduction in the flood plain is governed by the flood regime in terms of timing, amplitude, pattern and duration (Jackson, 1961). In the tropical and sub-tropical rivers, fishes either migrate upstream during flooding periods in order to spawn (Kok, 1980) or span during the peak flooding without migrating (Merron, 1991). Spawning for *C. gariepinus* in the Lower Shire was reported to be synchronized with the rising and peak of the flood regime (Chimatiro, 2004; Tweddle and Willoughby 1979). Hence, rising temperature and reduction in floods constitute a disturbance to the flood plain fish species.

VALUE AS FOOD SOURCE FOR POPULATION AND VALUE IN THE FOOD CHAIN

The catches from the catfishes in the Lower Shire comprise 41% of the total catch and is superseded only by that of *O. mossambicus* (Chimatiro, 2004). Clarias species are completely omnivorous, consequently they prey, scavenge or grub on virtually any available organic food including fish, birds, frogs, small mammals, reptiles, snails, crabs, shrimps, insects, other invertebrates and plant matter such as seeds and fruit and also feeds on plankton when available (Skelton, 2001). The catfish larvae are preyed upon by dragonflies for them to complete their life cycle. Frogs, predatory fish and birds also feed on the catfish fry. Hence, the catfish is an important fish species in the food chain in the Lower Shire.

DISTRIBUTION, STATUS OF ENDEMICITY AND RELATIVE ABUNDANCE

Clarias gariepinus is indigenous in the Malawian waters and is found in almost all the riverine environments. In the Lower Shire, the *C. gariepinus* is in abundance and catches have been stable over the years, constituting the second largest catch from the *O. mossambicus.*

STATUS (NATIVE, ALLOCHTHONOUS OR INVASIVE)

The species is native.

Catfishes are opportunistic feeders and will take any fish species which is abundant. They respond quickly to newly available food sources and will change their feeding patterns to match organisms freely available. The versatility of their physical adaptations enables them to survive almost all conditions (De Moor & Bruton, 1988; Bruton, 1977). When introduced outside of its native range, their generalized feeding habits and mobility make Catfishes extremely efficient predators posing a threat to indigenous fish, amphibian and invertebrate populations. Several countries have reported adverse ecological impacts after the introduction of Catfishes. Studies conducted in 1972 in central Africa suggest that these species have profound negative ecological effects on aquatic insect communities. Insect diversity in the Coleoptera order can be reduced by up to 78% and Hemiptera by 66% by Catfishes (De Moor & Bruton, 1988; Bruton & van As., 1986). Hence *C. gariepinus* is a potential invasive species if introduced in alien areas. It has been identified as agents of loss of native biodiversity.

8.7.3.3 Straightfin Barb (Barbus paludinosis)

HABITAT REQUIREMENTS AND REGIONAL EXTENT

Barbus paludinosus (matemba) is a small fish that belong to the Cyprinidae family. It is widely distributed in Malawian waters from the upper reaches of rivers, the middle and lower reaches. Work by Tweddle et al., (1998) listed a number of Barbus species and their habitats in Malawi. They are also widely distributed within Africa and are found in Burundi, Kenya, Malawi, Tanzania and Uganda.

WATER QUALITY REQUIREMENTS

B. paludinosus is a freshwater fish species that inhabits rivers, freshwater lakes, freshwater marshes and inland deltas.

WATER FLOW REQUIREMENT

Barbus paludinosus requires fast flowing rivers for spawning within the river and spawning migration. However, for habitat it prefers marshy and protected areas (Macuiane et al., 2009).

ABILITY TO PASS OBSTACLES

Barbus paludinosus does not have the ability to pass through obstacles. However, if the obstacles are submerged with flooding waters the fish can pass through.

LIFE CYCLE (MIGRATION, SPAWNING AND MATURING)

Mature male and female *B. paludinosus* respond to the physical and chemical water quality changes and congregate at river mouths. They breed throughout the year but their breeding peaks during the rainy season. Final oocyte maturation is usually accomplished by flooding. The fish migrates to upstream and spawn where there is suitable substrate such as grass, sand or gravel. The eggs hatch and the fry feed on zooplankton and detritus. As the juveniles grow older, they descend the rivers and inhabit the main river courses, marshy areas and inland deltas (Macuiane et al., 2009).

The juveniles feed mostly on zooplankton and reaches maturity within 1 to 2 years.

IMPORTANT HABITATS AND SENSITIVE LIFE CYCLE STAGE

The *B. paludinosus* in the Lower Shire is found all over the river course. However, it likes marshy areas such as the Elephant marshes for food and shelter. Other important habitats are the mouths of tributaries where the mature male and female fish congregate before onset of rains in readiness for spawning migration. Therefore, the river mouths needs to be preserved. The breeding grounds in the upper reaches of streams where the fish breed are also important. It is documented that the fish species in the Barbus and Cyprinidae have a homing instinct hence they return to the breeding grounds where they were spawned to breed as adults (Ngatunga, 2001). It is not clear whether the fish can use alternative breeding grounds if their spawned area is destroyed and is not available.

ACTUAL THREATS AND PROTECTION STATUS

B. paludinosus is readily abundant in Malawian river system and is therefore not listed as endangered or threatened fish species by IUCN; rather it is classified as being of least concern.

VALUE AS FOOD SOURCE FOR POPULATION AND VALUE IN THE FOOD CHAIN

The catch of *B. paludinosus* in the Lower Shire is low.

B. paludinosus is caught by seine nets or fish traps for both food and sale. However, due to their low catch, the catches are mostly used for subsistence consumption. *B. paludinosus* feeds on zooplankton and detritus, is caught for food and is predated upon by scavengers such as the African catfish, predators such as crocodiles and Tiger fish. Hence, the species play an important role in the food chain in the Lower Shire.

DISTRIBUTION, STATUS OF ENDEMICITY AND RELATIVE ABUNDANCE

B. paludinosus is indigenous to Malawian water bodies both in the Lake Malawi and Lower Shire fish fauna. It is widely distributed and are in abundance hence not red listed by IUCN.

STATUS (NATIVE, ALLOCHTHONOUS OR INVASIVE)

The species is native.

B. paludinosus as well as all other fish species in the Cyprinidae are not invasive. They do not easily adapt to alien environments and easily lose out when competing with locally adapted fish species.

8.7.3.4 *Synodontis njassae*

HABITAT REQUIREMENTS AND REGIONAL EXTENT

S. njassae is found in the African waters in Lake Malawi, the Lower Shire and Zambezi river (Konings, 1990). Hence, the fish is endemic to the Lake Malawi and Zambezi waters.

WATER QUALITY REQUIREMENTS

pH

The *S. njassae* prefers alkaline water conditions ranging from 7.6 to 8.4 (Konings, 1990).

Temperature

The *S. njassae* prefers water temperature ranging from 23 to 28oC (Konings, 1990)

WATER FLOW REQUIREMENT

The *S. njassae* is referred to as hardy, but prefers clean and well filtered water in rivers and lakes. However, due to its hardiness it tolerates a wide range of environmental conditions (Konings, 1990).

ABILITY TO PASS OBSTACLES

S. njassae does not climb over physical obstacles, rather it is a rock dwelling and prefers to use rocks as bed cover for their dwelling environment. Therefore, the fish cannot pass through any physical obstacles (Konings, 1990).

LIFE CYCLE (MIGRATION, SPAWNING AND MATURING)

In natural environments, the fish matures after attaining 190 mm between the first and second years (Konings, 1990). The fish is found patrolling around rock piles during their normal stay in their natural environments. The species spawns between October and December in sandy and muddy substrate. It is caught in large numbers in these substrates during the breeding season at night, suggesting that the spawning activities take place during the night. The fish natural food is zooplankton and detritus when young and it also feeds on phytoplankton as it grows and matures to adulthood (Konings, 1990).

IMPORTANT HABITATS AND SENSITIVE LIFE CYCLE STAGE

The important habitat for the *S. njassae* during its normal life as adults is piles of rocks. During spawning, its important habitats are sandy and muddy substrates. Therefore, these sites need to be protected in the Lower Shire for efficient recruitment of the species. Unlike other fish species in the Cyprinidae family, *S. njassae* does not migrate upstream to breed. Therefore, its important habitat in the Lower Shire is the river course itself, where there are rocks and shelters such as marshes.

ACTUAL THREATS AND PROTECTION STATUS

According to the IUCN, the *S. njassae* is of least concern as its stocks are healthy in the Malawian waters.

VALUE AS FOOD SOURCE FOR POPULATION AND VALUE IN THE FOOD CHAIN

S. njassae is caught by fish traps especially during its breeding season both for food and for sale. However, due to their low catch, the species is mostly used for subsistence consumption. The fish feeds on zooplankton, phytoplankton and detritus. Its young are preyed upon by scavengers and predators, hence it plays an important role in the food chain.

DISTRIBUTION, STATUS OF ENDEMICITY AND RELATIVE ABUNDANCE

S. njassae is widely distributed and in abundance in the rocky habitats in the Lake Malawi and the Lower Shire valley (Konings, 1990).

STATUS (NATIVE, ALLOCHTHONOUS OR INVASIVE)

The species is native.

The *S.njassae* is rock dwelling and has never been reported to be found outside their natural environment. It is therefore not an invasive fish species.

8.7.3.5 Tiger fish (Hydrocynus vittatus)

HABITAT REQUIREMENTS AND REGIONAL EXTENT

In Africa, tiger fishes are found in many rivers and lakes on the continent and are fierce predators with distinctive, proportionally large teeth. They are found in Congo river system and Lake Tanganyika and are the largest member of the Alestidae family. The Tiger fish in Zambezi is another famous species which is called *Hydrocynus vittatus*. This species is found in Okavango Delta, Zambezi River (Including the Lower Shire), Lake Kariba, Cabora Bassa and Jozini dam in South Africa. Both the goliath and alestidae tiger fishes are of African origin. Individual tiger fishes have interlocking, razor-sharp teeth, along with streamlined, muscular bodies and are extremely aggressive and are aquatic predators who often hunt in groups to chase the prey.

WATER QUALITY REQUIREMENTS

Hydrocynus vittatus prefers water temperatures between 19 to 28ºC, with stable pH that is around 7.5. It prefers two types of habitats, i.e., deep water of more than 1200 mm with fast flowing water and relatively deep (>700 mm) environments with no flow to fast flow (0-1.35 m/s). The species uses water column and over hanging vegetation for taking cover from its predators such as crocodiles (Skelton, 2001).

WATER FLOW REQUIREMENT

The water flow requirement for Tiger fish is either no flow at all (0 m/s) to fast flowing (0-1.35m/s) in the resident rivers. Hence, the fish thrives in a wide range of river flow velocities (Skelton, 2001).

ABILITY TO PASS OBSTACLES

The Tiger fish migrates to rivers and tributaries to breed during the rainy season, but it is a poor climbers of physical barriers unless the structure is completely submerged by the flooding waters.

LIFE CYCLE (MIGRATION, SPAWNING AND MATURING)

H. vittatus matures after 2 years in its natural habitat. It breeds for just a few days each year during the rainy season, which is usually from December to January. The ripe fishes (male and females) migrate up rivers and smaller tributaries to the breeding grounds where the water is shallow and there is submerged vegetation. The male and female fishes return to the main river where the eggs hatch. The hatched larvae and fry remain in the shallow waters as Juveniles until the next flood waters force them into the main river.

IMPORTANT HABITATS AND SENSITIVE LIFE CYCLE STAGE

Adult *H. vittatus* can adapt a wide range of habitats and environmental conditions. However, they become vulnerable as they congregate along the river habitats to breed. When the ripe fish is caught, the breeding cycle is disrupted. In addition, the fish lay eggs on shallow breeding areas where submerged substrate is available. If the substrate or the breeding grounds are not available, the fish might not be able to breed. The flooding waters also assist the juveniles to return to the main river courses. Hence, flooding is very important for breeding, survival and completion of the fish life cycle.

ACTUAL THREATS AND PROTECTION STATUS

H. vittatus is widely distributed in its natural environment in the African waters. In some water bodies, the species has been locally depleted due to heavy fishing pressure that is exerted on them, however, due to its general common abundance IUCN has listed the *H. vittatus* as being of least concern for the Central, Eastern, North Eastern, Southern and West Africa, which includes the Lower Shire.

VALUE AS FOOD SOURCE FOR POPULATION AND VALUE IN THE FOOD CHAIN

H. vittatus is a very important fish species as food for the people in the Lower Shire. It is caught for subsistence use in home or for sale (commercial). It is also used for spot (angling) and hence a commercial fishery that could attract tourists. The catches of *H. vittatus* are low compared to *O. mossambicus* and Catfishes, hence the catches are lumped together with other species in the ‘other’ fish catches category which together contribute about 10% of the total catches in the Lower Shire area. In the Lower Shire, they are caught using hook and line, gillnets and also by non-selective gears such as seine nets. *H. vittatus* occupies a very important role in the food chain among the aquatic organisms in the Lower Shire. The fish is considered primarily as a carnivore and is one of the major predators in the Lower Shire valley. It moves in schools and prey on other fish species. It swallows the prey as a whole, hence it can predate on prey fish that is up to 40% of their body size. The main predation pressure from *H. vittatus* is upon fishes of small size, the danger of predation becoming progressively less until a critical length, usually when 18-20 cm is reached, above which a prey fish is reasonably safe from predation. Although the bulk of its diet is fish, it also consumes some detritus and plant matter displaying some omnivorous characteristics. The tiger fish in the Lower Shire comes from the Zambezi River and uses the valley to find food usually preying on the tilapias and other fish species and also for spawning. The fish breeds on the sheltered lagoons and marshy areas, as such Elephant Marsh provides a suitable environment for its breeding and raising of young ones. The fish is preyed upon by crocodiles, hence species are at the center of a very important food chain in the Lower Shire.

DISTRIBUTION, STATUS OF ENDEMICITY AND RELATIVE ABUNDANCE

H. vittatus is indigenous and widely distributed to the Lower Shire and Zambezi Rivers.

STATUS (NATIVE, ALLOCHTHONOUS OR INVASIVE)

The species is native.

H. vittatus is resident of the Lower Shire and during the normal times, it is found around the marshes (Elephant and Ndindi) in search for fish to prey upon. It is not aggressive or invasive but is a predatory species. The rapids and falls in the middle Shire River keep this highly carnivorous fish from finding its way into the Lake Malawi fish fauna. Hence, the tiger fish is confined to the Lower Shire area in Malawi.

8.7.3.6 Lake Salmon (Opsaridium microlepis)

HABITAT REQUIREMENTS AND REGIONAL EXTENT

Opsaridium microlepis is endemic to Lake Malawi and is the largest of all bariliine cyprinids, attaining a weight of at least 4 kg. It is a pelagic (open water) predator, which spends most of its life in the lake but ascends affluent rivers to spawn. The fish lives in open waters throughout the year but congregates and run up larger affluent rivers to spawn during its breeding season, which is mostly at the end of the rainy season, i.e. from March to June. The fish mature after 2 to 3 years in the lake. In the Lower Shire valley, the fish descends from the middle Shire River (Tweddle and Lewis, 1983).

WATER QUALITY REQUIREMENTS

O. microlepis prefers pelagic or open water conditions of Lake Malawi, where it is endemic. The fish inhabits the Lake waters as adults. When it has attained sexual maturity it ascends rivers to breed and returns to the Lake. The fish prefers water temperatures 20 and 28^{o}C, a pH of around 7-8. The juveniles inhabit the upper river courses as yearlings and descend to the Lake when the second year floods rescind (Tweddle and Lewis, 1983).

WATER FLOW REQUIREMENT

As adults and residents of the pelagic (open water) zones of the Lake, *O. microlepis* does not have a specific water flow requirement. When the fish has ripe gonads, it requires flooding of the rivers as a stimulant for them to ascend the rivers to spawn. Mpasa is a late spawners so it does not migrate with the first flash flooding of the rivers. The spawning requirements for Mpasa is well oxygenated flowing water.

ABILITY TO PASS OBSTACLES

O. microlepis has powerful streamlined bodies that enables it to negotiate waterfalls and rapids (Tweddle and Lewis, 1983) and also speeds to catch prey fish.

Life cycle (migration, spawning and maturing)

The fish begins to gather at river mouths at the beginning of the rainy season in December, but does not migrate up the rivers until the end of the rainy season, when the waters become clear or less turbid and this time is around March to July. The peak breeding season is from April to June (Tweddle, 1982). Most Lake Salmon (Mpasa) that are caught from the Lake are taken from near river mouths during the breeding season. The spawning requirements for Mpasa is well oxygenated flowing water and silt free gravel through which the stream can percolate. Young *O. microlepis* stay in the river during the first 3-4 months of life and shoals of fry can be seen in shallow waters during and after the breeding season. Most juveniles of 7-20 cm descend to the lake or main river course with the onset of the first rains at an average age of 6 months. Juveniles of Mpasa are omnivorous feeding on zooplankton, phytoplankton, microphytes and insects. The fish has extended breeding season, which serves to reduce the chances of loss of a whole year class resulting from drought or other adverse conditions. *O. Microlepis* is a partial spawner that makes staggered runs and fractional spawning strategy and releases eggs in a series of spawning activities over a period of time to ensure that eggs hatch over a period of several months. Short periods of unfavorable conditions will have little effect on total recruitment (Tweedle and Lewis, 1983).

Important habitats and sensitive life cycle stage

The important habitats for *O. microlepis* are the river mouths during their upward migration to breeding areas or downward migration from the spawning sites. The species spawns in shallow waters upstream and it is its important habitat. Mpasa is vulnerable to catch when it migrates to the spawning grounds and when it is returning from their breeding sites upstream. The other important stage is during the juvenile stage especially when it has to spend a year in the river, waiting for the second year floods. It is possible to lose the whole year class due to drying of spawning rivers and predation.

Actual threats and protection status

Mpasa is classified as critically endangered by IUCN. The population of the fish is scarce and the catch has almost collapsed because fishes were being caught during their upward migration, meaning, they were harvested before spawning. The spawning takes place in the shallow waters hence the fish are vulnerable when spawning. Fishermen are not allowed to completely close river mouths with traps to allow the fish to reach the breeding grounds. However, these regulations have not been effectively enforced.

Value as food source for population and value in the food chain

Mpasa is a pelagic predator and in the Lake. In the Lowe Shire, Mpasa feeds mostly on young of the Cichlids such as *O. mossambicus* and other tilapias. It is less abundant in the Lower Shire probably because it mostly descends from the Upper Shire and the spillway is a harsh environment for a fish. *O. microlepis* is palatable and has been caught for both subsistence and commercial fishing. Its juveniles are preyed upon by predators such as other fish species, e.g., the catfishes and frogs. The adults are preyed upon by crocodiles, hence the Mpasa occupy an important niche in the Lower Shire area.

Distribution, status of endemicity and relative abundance

Mpasa is endemic to Lake Malawi but it is now less abundant in the water bodies of Malawi. It size to first maturity has declined and its fecundity has increased suggesting that the fish has been subjected to intense fishing pressure which targets the larger fishes. In the Lower Shire, Mpasa catches are low, hence the fish catches in the Lower Shire is lumped together in the ‘other’ fish category.

STATUS (NATIVE, ALLOCHTHONOUS OR INVASIVE)

The species is native.

O. microlepis as well as all other Cyprinids are poor colonizers of alien environments. The species is a migratory predator but is not invasive. Although the species is endemic in the Lake Malawi fish fauna through “escapees” it is present in the Lower Shire River.

8.7.3.7 Redeye labeo (Labeo cylindricus)

HABITAT REQUIREMENTS AND REGIONAL EXTENT

Labeo cylindricus has a wide distribution from Chad and the Congo basin to Kenya and Southwards to Northern Natal. In Lake Malawi, this rock dwelling Labeo inhabits areas of the lake wherever a rocky substrate on which algae grows is found. It also inhabits the middle and lower reaches of rivers (e.g. the Lower Shire) where similar environmental conditions exist (Jackson, 1961).

WATER QUALITY REQUIREMENTS

Labeo cylindricus requires well oxygenated water, temperatures ranging from 20 to 28^{o}C, pH values of 7.5 to 8.5 in the lake, rivers and streams. The species is rocky dwelling in Lake Malawi and in the Lower Shire it is also found in the sheltered areas such as marshes.

WATER FLOW REQUIREMENT

For their normal life, *L. cylindricus* does not need any water flow as it inhabits the actual river courses where shelter is available in the form of rocks. However, as a fish species in the Cyprinidae family, *L. cylindricus* is stimulated to migrate to breeding sites with the first flash floods.

ABILITY TO PASS OBSTACLES

L. cylindricus is able to climb through natural physical barriers. This fish has a wide ecological tolerance and uses its mouth and broad pectoral fins to climb damp surfaces of barrage rocks and weirs (Jackson, 1959). This feature has allowed the species to survive heavy fishing pressure compared to *Labeo mesops* which has completely disappeared from the Malawian Lake and river system.

LIFE CYCLE (MIGRATION, SPAWNING AND MATURING)

The fish reaches first sexual maturity within two years after it has spawned. This species browses on the algae that grow on rocks and other places. In the Lake, the fish has a well-marked breeding season, from December to January and the breeding season is very short because the fish is a complete spawner, i.e. all the eggs in the ovary ovulate and are spawned at the same time. The fish ascends flooded rivers and weirs (Jackson, 1959) to migrate to breeding sites. The eggs are laid among rocks, where they hatch and the juveniles grow to adulthood within two years, but return to the main river course within one year.

IMPORTANT HABITATS AND SENSITIVE LIFE CYCLE STAGE

The important habitats for *L. cylindricus* are shallow rocky areas of rivers and lakes. The fish uses these habitats for both feeding on algae and also for breeding. The important life stage is when the species is migrating to breed in the spawning sites and when the eggs have hatched into fry because the fish is a complete spawner, hence once a yearling is lost, there is a loss of all the juveniles.

ACTUAL THREATS AND PROTECTION STATUS

L. cylindricus are listed as of 'least concern' by IUCN because it is found in abundance in its endemic habitats such as the Lake Malawi basin. However, there is a need to protect the rocky and marshy areas of the Lower Shire which are the breeding sites of the fish. In addition, there is a need to ensure enough flooding to induce spawning migration of the fish.

VALUE AS FOOD SOURCE FOR POPULATION AND VALUE IN THE FOOD CHAIN

L. cylindricus is consumed by people and constitute an important fish species for both food and sale. However, its full commercial utilization is limited due to their lower abundance in the Lower Shire Valley. The fish feeds on algae on rocks and hence helps to clean up rocks. The juveniles are predated upon by carnivorous fish and the adult fish are preyed upon by large predators such as Tiger fish and crocodiles. Therefore, *L. cylindricus* occupies a niche in the food chain in the Lower Shire.

DISTRIBUTION, STATUS OF ENDEMICITY AND RELATIVE ABUNDANCE

In Malawi, the *L. cylindricus* is widely distributed in Lakes Malawi, Chiuta and Chilwa; the Shire River, including the Lower Shire. The fish used to constitute an important fishery since the 1970s and now the catches have declined especially in the Lower Shire.

STATUS (NATIVE, ALLOCHTHONOUS OR INVASIVE)

The species is native.

L. cylindricus is not among the invasive fish species. It specializes in dwelling on rock or marshy and protected areas of the river courses or the main lake.

8.7.3.8 Barbus eurystomus

HABITAT REQUIREMENTS AND REGIONAL EXTENT

B. eurystomus is endemic to Lake Malawi and its tributaries. It is found in the Lower Shire through escapees from the Middle Shire because it is found in abundance in the Lake Malawi and the Upper Shire. In the Lower Shire, it inhabits the main river course but likes the marshy areas and lagoons to avoid predators

WATER QUALITY REQUIREMENTS

The water quality requirement for *B. eurystomus* is similar to other cyprinids, i.e., temperatures ranging between 19 and 28oC and pH values between 7.5 and 8.5. In the Lower Shire, it tolerates turbid water during the rainy season (Jackson, 1959).

WATER FLOW REQUIREMENT

The species inhabits sheltered areas of the rivers or the open water. Ripe males and females congregate along the river mouths just before the first rains and they are stimulated by flooding to migrate rivers to breed (Jackson, 1959).

Ability to pass obstacles

B. eurystomus has a large size and do not pass through physical barriers unless the structures are submerged in water (Jackson, 1959).

Life cycle (migration, spawning and maturing)

The fish matures within 2 years and may grow to over 50 cm in length and attain 2.5 kg in weight (Jackson, 1959). Adult fishes spend most of their lives in lakes and or main river course but prefer sheltered areas such as marshes. The fish ripes gonads at the on-set of the first rains and migrates to flooded rivers early in the rainy season to breed. Its breeding season is very short, from November to December and it is a complete spawner (Jackson, 1959).

Important habitats and sensitive life cycle stage

B. eurystomus is caught in large numbers near river mouths at the on-set of the rains as it prepares or migrates to breeding sites. The other important life stage is the juvenile stage because the species remains in the river for a year before it returns to the main watercourse such as the Shire. Hence, there is need for the rivers to flood so that its recruitment is completed. The species also inhabits marshes for protection.

Actual threats and protection status

This species is not classified by the IUCN. However, there is a need to enforce fisheries regulations on migratory fish species because the fish is subjected to high fishing intensity during spawning migration. It should be a concern that there is a decline in the catches of *B. eurystomus* in the Malawian waters including the Lower Shire.

Value as food source for population and value in the food chain

Barbus eurystomus grows to large size and is commonly caught in gill nets and fish traps especially during the on-set of first rains as the fish ascends rivers to spawn. It is a very important food source for people in the Lower Shire. *B. eurystomus* mainly feeds on mollusks (Betram et al, 1942). The species is predated upon by tiger fish and crocodiles and hence occupy a niche in the food chain in the Lower Shire area.

Distribution, status of endemicity and relative abundance

The *B. eurystomus* is endemic and is relatively abundant, though catches show declining trends in Lake Malawi waters including the Lower Shire. In the Lower Shire, the catches are very low, hence the fish catch statistics are lumped together with the fish species that are less abundant in the area under ‘other’ fish species category.

Status (native, allochthonous or invasive)

The species is native.

B. eurystomus as any other fish species in the Cyprinidae family is a poor colonizer of alien environments when introduced. Hence, the species is not invasive but endemic in the Malawian waters.

8.7.3.9 Barbus johnstonii

HABITAT REQUIREMENTS AND REGIONAL EXTENT

The natural habitat for *B. johnstonii* is freshwater lakes and rivers. It is endemic to Lake Malawi and is found in the Lake Malawi and its tributaries in Tanzania and in the Lower Shire and lower Zambezi River in Mozambique (Jackson, 1959).

WATER QUALITY REQUIREMENTS

The water quality requirement for *B. johnstonii* is similar to other cyprinids, i.e., temperatures ranging between 19 and 28ºC and pH values between 7.5 and 8.5. In the Lower Shire, it tolerates turbid water during the rainy season (Jackson, 1959).

WATER FLOW REQUIREMENT

This freshwater fish is found in small groups in underwater habitats in rivers and lakes (Frose and Pauly 2006). Hence, there is a need to maintain adequate water levels in the Lower Shire.

ABILITY TO PASS OBSTACLES

The *B. jonhstonii* resides under water in the river course in shoals. It also migrates in groups with males and females to the breeding grounds. It cannot pass through physical barriers unless the barriers are submerged with floodwater.

LIFE CYCLE (MIGRATION, SPAWNING AND MATURING)

B. johnstonii grows to more than 30 cm in standard length and over 4 kilograms in body weight. For spawning, the species migrates towards rivers' headwaters during the rainy season. The Lake populations do not return from their spawning grounds until the dry season has started (Jackson, 1959).

IMPORTANT HABITATS AND SENSITIVE LIFE CYCLE STAGE

The important habitats for the *B. johnstonii* are the marshy areas where it resides to seek shelter in the Lower Shire. In addition, the fish stays in the breeding grounds throughout the rainy season, therefore any disturbances to the water levels in the tributaries disturb their breeding activities. The fishes are also easily caught in the shallow waters as they spend more time breeding there (Frose and Pauly 2006).

ACTUAL THREATS AND PROTECTION STATUS

B. johnstonii is listed as “Least concern” by IUCN. However, the catches in the Lower Shire have declined significantly during the recent years.

VALUE AS FOOD SOURCE FOR POPULATION AND VALUE IN THE FOOD CHAIN

B. johnstonii is omnivore, but adult fishes like to eat smaller fishes in particular. The *B. johnstonii* does not constitute an important component of the Lower Shire fisheries. It is preyed upon by predators such as Tiger fish and crocodiles. Hence, the fish plays a role in the food chain in the Lower Shire.

DISTRIBUTION, STATUS OF ENDEMICITY AND RELATIVE ABUNDANCE

The distribution of *B. johnstonii* in the Malawian waters has declined over the years. In the Lower Shire, the catches have declined, hence the species does not constitute a major fishery in the area.

STATUS (NATIVE, ALLOCHTHONOUS OR INVASIVE)

The species is native.

B. johnstonii just as any other fish species in the Cyprinidae family is a poor colonizers of alien environments when introduced. Hence, the species is not invasive but endemic in the Malawian waters.

8.7.3.10 Marcusenius macrolepidotus

HABITAT REQUIREMENTS AND REGIONAL EXTENT

M. macrolepidotus was formerly considered to be widespread but it is now restricted to the middle and Lower Zambezi river system (including the Lower Shire) and the Buzi system, south of the Zambezi (Taugels, et al. 1990).

WATER QUALITY REQUIREMENTS

The species is adapted to the freshwater demersal environment with pH ranging from 7.0 to 10; and temperature ranging from 22 to 24^{o}C.

WATER FLOW REQUIREMENT

The species inhabits well-vegetated, muddy bottom marginal habitats of rivers and flood plains. The species moves inshore after dark and has been recorded to move up tributaries in shoals during flood season.

ABILITY TO PASS OBSTACLES

The fish has no ability to negotiate physical barriers unless it is submerged in floodwater. The fish swims against the floods hence they can climb over submerged physical barriers.

LIFE CYCLE (MIGRATION, SPAWNING AND MATURING)

M. macrolepidotus breeds during the rainy season in shallow vegetated localities and the female may carry up to 6,000 eggs which spawn on the substrates usually vegetation. Juveniles grow to adults in the sheltered lagoons (Taugels, et al. 1990).

IMPORTANT HABITATS AND SENSITIVE LIFE CYCLE STAGE

The important habitats are the shallow vegetated areas in the marshy or sheltered areas such as lagoons where the fish breeds.

ACTUAL THREATS AND PROTECTION STATUS

M macrolepidotus is classified by IUCN as of least concern due to its relative abundance and wide distribution.

VALUE AS FOOD SOURCE FOR POPULATION AND VALUE IN THE FOOD CHAIN

M. macrolepidotus is classified as the fourth most important commercial fish species in the Lower Shire (gillnet fishery). The fish is caught for both subsistence and commercial fishing in the Lower Shire. The fish feeds on invertebrates, especially midge and mayfly larvae and pupae that is taken from the bottom and off plant stems, hence plays an important role in the food chain in the area (Taugels, et al. 1990).

DISTRIBUTION, STATUS OF ENDEMICITY AND RELATIVE ABUNDANCE

The fish is widely distributed in the Lowe Shire and caught in large quantities before, during and part of the rainy season at the Shire / Ruo confluence and in the open lagoons (Tweddle and Willoughby, 1979).

STATUS (NATIVE, ALLOCHTHONOUS OR INVASIVE)

The species is native.

8.7.3.11 Other fish species

This section presents fishes that are present in the Lower Shire River, but are less abundant than the previous species. Their habitats are briefly presented as well as their IUCN status (starting from near threaten). More details are provided in annex.

- ***Protopterus annectens brieni***, inhabits muddy areas. Spawns in roots of aquatic vegetation;
- ***Megalops cyprinoides***, inhabits the Shire, lagoons and swampy area. Spawns offshore;
- ***Anguilla bicolour*** and ***Anguilla nebulosa labiate***, inhabits the Lower Shire and lagoons. Classified Near threaten by the IUCN. Spawns offshore;
- ***Hippopotamyrus discorthynchus***, inhabits the Shire, lagoons and swampy area. Migrates upstream into Shire tributaries to spawn;
- ***Mormyrus longirostris***, inhabits the center of Shire rather than the banks. Migrates upstream into Shire tributaries to spawn;
- ***Alestes imberi***, inhabits lagoons and marshes. Migrates upstream into Shire tributaries and floodplain to spawn;
- ***Hemigrammopetersius barnardi***, inhabits fast flowing part of Shire. Spawns in roots of aquatic vegetation;
- ***Micralestes acutidens***, inhabits clear, and standing water (pelagic) of Shire. Migrates upstream into Shire tributaries to spawn;
- ***Distichodus mossambicus***, inhabits swift flowing water, rapids or quiet, deep, sandy or rocky pools of Shire. Migrates upstream into Shire tributaries to spawn;
- ***Barbus afrohamiltoni***, inhabits still, vegetated waters of Shire, and marginal pools and lagoons. Migrates upstream into Shire tributaries to spawn;
- ***Barbus choloensis***, inhabits of rock sills around falls. Classified as vulnerable by the IUCN due to its limited distribution. Migrates upstream into Shire tributaries to spawn;

- ***Barbus haasianus***, inhabits swamps and floodplains in well-vegetated habitats. Spawns in the Shire floodplain;
- ***Barbus kerstenii***, inhabits fast flowing, sluggish and temporary streams. Spawns in the Shire floodplain;
- ***Barbus macrotaenia***, inhabits marshy areas and slow flowing streams. Migrates upstream into Shire tributaries to spawn;
- ***Barbus marequensis***, inhabits rocky rapids and deep pools. Migrates upstream into Shire tributaries to spawn;
- ***Barbus radiatus***, inhabits marshes and marginal vegetation the Shire. Migrates upstream into Shire tributaries to spawn.
- ***Barbus trimaculatus***, inhabits shallow water near river outlets or swampy areas. Migrates upstream into Shire tributaries to spawn;
- ***Barbus lineomaculatus***, inhabits fast flowing sections of Shire. Migrates upstream into Shire tributaries to spawn;
- ***Barbus toppini***, inhabits slow flowing sections of Shire. Migrates upstream into Shire tributaries to spawn;
- ***Barbus viviparous***, inhabits flood plains of the Shire and pools and shallow streams with vegetation. Migrates upstream into Shire tributaries to spawn;
- ***Barilius zambensis***, inhabits shallow pools below rocky rapids. Migrates upstream into Shire tributaries to spawn;
- ***Labeo congoro***, inhabits strong flowing rocky stretches of Shire. Migrates upstream into Shire tributaries to spawn;
- ***Labeo altivelis***, inhabits the Shire. Migrates upstream into Shire tributaries to spawn;
- ***Leptoglanis rotundiceps***, inhabits fairly shallow water of the Shire and tributaries. Spawns in sand;
- ***Heterobanchus longifilis***, inhabits quite waters of Shire and deep pools. Migrates upstream into Shire tributaries to spawn;
- ***Malapterurus electricus***, inhabits rocks or roots in turbid or black waters with low visibility. Spawns in the Shire in dug holes;
- ***Chologlanis neumanni***, inhabits rocky and fast flowing section of Shire. Data on spawning are not available;
- ***Synodontis zambezensis***, inhabits pools and slow-flowing reaches of perennial and seasonal rivers and the Shire. Data on spawning are not available;
- ***Aplocheilichthys hutereaui***, inhabits stagnant water in pools and swamps. Spawns in the Shire floodplain;
- ***Aplocheilichthys katangae***, inhabits shallow vegetative part of Shire where it also spawns;
- ***Nothobranchius orthonotus***, inhabits temporary water pools and may also be found in swamps intermittently connected to floodplains where it also spawns in bottom sediments;
- ***Haplochromis philander***, inhabits vegetated zones of Shire where it also spawns;
- ***Psudocrenilabrus philander***, inhabits vegetated zones of Shire where it also spawns;
- ***Oreochromis placidus***, inhabits quiet pools with marginal vegetation where it also spawns;
- ***Oreochromis squamipinnis***, inhabits sheltered areas of Shire where it also spawns. The fish is classified Endangered by IUCN;
- ***Oreochromis shiranus***, inhabits lagoons and marshy areas where it also spawns;
- ***Tilapia rendalli***, inhabits well-vegetated water along Shire where it also spawns;

- ***Glossogobius giuris***, inhabits Bangula lagoon and marshy areas. The species migrates to the sea to spawn (amphidromous migration);
- ***Ctenopoma multispinis***, inhabits vegetated riverine backwaters, floodplain lagoons, swamps and isolated pans where it also spawns.

8.8 ECOLOGY STUDY LIMITATIONS

The Ecology section is based on a mix of field visits and bibliographical data. However, no invertebrate surveys data (such as insect and aquatic invertebrate) and no recent data on herpetofauna were available. In addition, there is no data on the carrying capacity of the Elephant marsh for animal at risk of conflict with human: the hippo and crocodiles. In addition, there is no up-to-date baseline surface water reliable data.

Currently under a World Bank grant, a program called the “Shire River Basin Management Program (SRBMP)” is taking place in the Study area. One of the study of this program called “Climate resilient livelihoods and sustainable natural resources management in the Elephant Marshes, Malawi“ will describe in detail ecological functions and value of the wetland in the sub-study n° 3. This study is carried out by MRAG, Southern Waters, Anchor Environmental consultants.

Sub-study 3 will address the following key objectives (MRAG, Southern Waters, Anchor Environmental, 2015):

- Describe and quantify the ecosystem services provided by the Elephant Marshes in physical terms and determine their economic and social value, including natural resources, flood control, carbon sequestration, sediment retention, water quality amelioration etc., for the whole Shire River catchment at different times in year.
- Draw comparisons with other wetlands in Africa of a similar nature;
- Determine how capacity of the system to deliver these services responds to hydromorphology and how this has changed over time;
- Determine the wetland’s sensitivity and adaptive capacity to multiple pressures, involving a description of those pressures;
- Develop and analyse up to three different future management scenarios over the next 25 years.

In addition, Sub-study n°4: “Biodiversity surveys” will characterized biodiversity for both fauna and flora in the Elephant marsh including the identification of species with special status.

Based on the advancement of these sub-studies, the full ESIA report will quote their observations.

9. REGULATORY

9.1 MALAWI POLICIES RELEVANT TO THE SHIRE VALLEY IRRIGATION PROJECT

The policy framework in support of agriculture, irrigation and sustainable natural resources management comprise the National Constitution of the Republic, the national road map Malawi Vision 2020, the umbrella national development planning instrument; the National Growth and Development Strategy (MGDS), various sectorial policies in agriculture, land, forestry, irrigation, environment; the various strategies to implement international conventions on biodiversity, sustainable development, climate change, desertification etc. Most of the policies have recently been reviewed, revised or/ and harmonized. The following sections highlight some selected policies and laws which are applicable in the planning and implementation of public sector projects, more especially those in the agricultural and irrigation sector and therefore relevant to the preparation of Environmental & Social Impact Assessment and Pest Management Plan for Shire Valley Irrigation Project.

9.1.1 The Constitution of the Republic of Malawi (1995)

A new Constitution of the Republic of Malawi was adopted in 1995. Section 13 (d) of the Constitution provides a broad framework for sustainable environmental management at various levels in Malawi. Among other issues, it calls for prudent management of the environment and accords future generations their full rights to the environment. The Constitution provides the fundamental principles that require the State to promote the welfare and development of the people by progressively adopting and implementing policies and legislation aimed at achieving gender equality, adequate nutrition, adequate health care and responsible management of the environment. Specifically for the environment, the constitution makes the following provisions:

- To manage the environment responsibly in order to:
  - Prevent degradation of the environment;
  - Provide healthy living and working environment for the people of Malawi;
  - Accord full recognition to the rights of future generations by means of environmental protection and sustainable development of natural resources;
  - Conserve and enhance the biodiversity of Malawi.
- To enhance the quality of life in rural communities and to recognize rural standards of living as a key indicator in the success of Government policies.

With respect to gender equality, the Constitution under Section 13 (e) gives the State the responsibility to achieve gender equality for women through:

- Full participation of women in all spheres of Malawian society on the basis of equality with men;
- The implementation of principles of non-discrimination and such other measures as may be required;
- The implementation of policies to address social issues such as domestic violence, security of the person, lack of maternity benefits, economic exploitation and rights to property.

In view of the environmental principles stipulated in the constitution, SVIP ensures that activities implemented under the project promotes environmental protection and sustainable socio-economic development of natural resources by effectively implementing environmental and social management as well as pest management plan in compliance with the government legislative requirements stipulated in acts, policies and approved guidelines applicable to environmental management.

The ESIA and PMP assignment also addresses gender inequality issues between men and women and measures to ensure that women are included in implementation of project both during construction and operation phases.

9.1.2 The Malawi Vision 2020

Adopted in 1998 after a long, consultative and participatory process the Malawi Vision 2020 sets out a shared vision for the long term development of the country. The main rallying and convergent point is the need for sustainable development, the development that does not compromise the ability of the resource base to provide the needs for the present and future generations. To achieve this intergenerational equity objective the Vision 2020 calls Malawians to work towards a nation which is:

“God-fearing, secure, democratically mature, environmentally sustainable, self-reliant with equal opportunities for and active participation by all, having social services, vibrant cultural and religious values and being a technologically-driven, middle-income economy by the year 2020”

Elaborating on its inspirations and options for environment and natural resources management the vision dwells on addressing environmental challenges identified in the National Environmental Action Plan (NEAP) 1994 such as controlling land degradation, arresting deforestation, preventing degradation and depletion of water resources, developing fisheries, restoring and conserving biodiversity, developing human settlement, controlling air pollution and managing climate change issues, eradicating poverty and controlling population growth and political advocacy for proper management of natural resources and the environment. All these options are squarely in line with the aspirations of the SVIP such as ensuring sustainable land water management, promoting commercial agriculture and protection and rehabilitation of watershed areas.

The ESIA and PMP assignment describes potential and actual impacts to be generated by SVIP activities on issues in the Vision 2020 such as land degradation, deforestation, degradation and depletion of water resources, diversity loss, air pollution, and poverty and land tenure. The ESIA through ESMP will recommend sight specific measures to mitigate the negative impacts and enhance the positive impacts.

9.1.3 Malawi Growth and Development Strategy II

The Malawi Growth and Development Strategy (MGDS II) of 2011 – 2016 is Malawi’s road map for the attainment of the MDGs that among many goals set out to halve the level of poverty by year 2015 and the need for ensuring environmental sustainability. The MGDS needs to be reviewed and aligned to the new Sustainable Development Goals (SDGs) but in its present form, it is still relevant to the SVIP. Agricultural production and smallholder integration into commercial activities is seen as of the Malawian economy, while strategies to target high growth sectors are being developed. Commercialization of agriculture entails improving management and making land and water use decisions that lead to improvement quality, seasonality of production and attract good prices on the market. Commercialization fuels proper land and water management as it provides incentives for irrigated agriculture.

The MGDS II has six thematic areas: Sustainable Economic Growth; Social Development; Social Support and Disaster Risk Management; Infrastructure Development; Improved Governance and Cross Cutting Issues. Out of these six thematic areas, nine priority areas pivotal to the achievement of sustainable economic growth and wealth creation have been identified among which Agriculture and Food Security, Green Belt and Water Development and Natural Resources and Environmental Management are relevant to SVIP. Inclusion of these priority areas is a clear manifestation of government commitment to irrigation development that is sensitive to social and environmental impacts.

The ESIA and PMP assignment assesses how issues of fish resources, wildlife, sanitation, malaria and HIV management are impacted by the project and designs mitigation measures to address them. The ESIA and PMP also look at how smallholder farmers are integrated into commercial farming and how this affects poverty reduction and proposes measures on how these can be enhanced.

9.1.4 National Environmental Action Plan (1994)

The National Environmental Action Plan (NEAP) developed in 1994 and updated in 2004 provides a framework for integrating the environment into all socio-economic development activities of the country. The objectives of the NEAP are to: document and analyse all major environmental issues and measures to alleviate them; promote sustainable use of natural resources in Malawi; and develop an environmental protection and management plan. The NEAP identifies the following as key environmental issues to be addressed: soil erosion, deforestation, water resources degradation and depletion, threat to fish resources, threat to biodiversity, human habitat degradation, high population growth, air pollution and climatic change. Most of the issues identified are linked to agriculture and therefore any efforts to address the issues will involve and benefit the agriculture sector.

In order to protect the environment from further degradation; the NEAP outlines actions that need to be undertaken and to ensure adequate environmental protection. The actions relevant to the SVIP include:

- Discourage cultivation on marginal lands (steep slopes and river banks) ;
- Construct permanent physical conservation structures such as storm water drains, terraces and bunds;
- Promote crop rotation;
- Promote mixed and intercropping by smallholder farmers;
- Improve land productivity through sustainable land saving technologies;
- Intensify training of farmers in improved farming practices;
- Improve management of forest resources on customary land;
- Promote proper handling and use of agrochemicals.

9.1.5 National Environmental Policy, 2004

The 2004 National Environment Policy prescribes the policy and institutional arrangements necessary for effective delivery of sustainability agenda and provides the basis for Environmental Impact Assessment and environmental management plans. The implementation of the policy is, however hampered by lack of the required legal framework and institutional arrangements to support the aspirations.

The National Environmental Policy as an umbrella framework guides different lead agencies and stakeholders when their activities affect the environment and natural resources management, including how to minimize impacts of environmental degradation. Its aspirations under different sectors considered relevant to enhance the ideals of sustainable land and water management are summarized in the overall goal of the policy that states that “the overall policy goal is the promotion of sustainable social and economic development through the sound management of the environment and natural resources”. Specifically the policy sets out many objectives that are inclined towards supporting sustainable land and water management and irrigation development in the country as advocated under SVIP. Some of the relevant objectives are as follows:

To promote environmentally sustainable agricultural development by ensuring crop and livestock production through ecologically appropriate production and management of systems and appropriate legal and institutional framework for sustainable environmental management;

- To sustainably manage forestry resources so as to maximize benefits to the nation;
- To manage fish resources for sustainable utilization and conservation of aquatic biodiversity;
- To manage and conserve wildlife resources inside and outside protected areas so as to ensure their protection, sustainable utilization and reduction of people/ wildlife conflicts; and
- To manage and use water resource efficiently and effectively so as to promote its conservation and availability in sufficient quality and acceptable quantity.

In relation to the SVIP relevant objectives under this policy, this ESIA and PMP assignment seeks to provide mitigation measures that ensure sustainable utilization and conservation of aquatic biodiversity, water resources use efficiency, human/wildlife conflicts and wildlife habitat loss.

9.1.6 National Land Policy, 2002

The 2002 Malawi National Land Policy recognizes the centrality of land as a basic resource common to all people of Malawi for their social and economic development. The policy provides opportunities for the people of Malawi to embark on a path of socially and environmentally sustainable development. In addition, the policy highlights a number of approaches for redressing problems facing land resources. Some of relevant provisions to the proposed SVIP activities are as follows:

- Recognition that agriculture development is and will continue to be the major benefactor land use sector is of the policy’s strength. The policy guarantees full legal protection to customary land tenure to the people of Malawi in order to enable the ordinary Malawians adequately participate in agricultural activities and other rural livelihoods by converting them to “customary estates”.
- The policy recognizes several sectoral policies and strategies in physical planning fisheries, environment, forestry, irrigation and wildlife and for this reason; it encourages multi-sectoral approach in land use and management at local and districts level.
- The policy recognizes environmental impact assessment of all big land development projects, and those planned in fragile ecosystems in order to protect biodiversity and water resources.

Thirteen years after the adoption of what is considered to be one of the most progressive land policies, the reviews and enactment of relevant land laws have not been completed making the implementation of the provisions of policy difficult if not impossible.

Key statutes which regulate land use are the Land Act and the Town and Country Planning Act, Number 26, 1988. These statutes deal with land tenure and land use quite comprehensively. The issues of land tenure and land use are recognized as critical in sustainable environmental management in Malawi. The Land Act and The Town and Country Planning Act highlight the sustainable use of land resources by strengthening and clearly defining security of tenure. This is essential, as people are more inclined to manage well, land that belongs to them.

In terms of the SVIP this implies that land protection and management principles should be adhered to in order to preserve land resources for the benefit of current and future generations. It also implies that the SVIP will adopt a multi-sectoral approach in protection and conservation of the land resources in question.

Chapter 10 of the Land Policy, 2002 deals with inter-sectoral coordination and relations. The chapter highlights the need for collective responsibility for monitoring of the land resources, forging strong inter-ministerial commitments to land stewardship in Malawi, feedback from land sector agencies and their regulatory processes to inform land use decision-making, recognition of the importance of maize production and food self sufficiency in a dualistic agricultural sector, and consideration for land use proposed in other sectors.

The SVIP rely on several expertises that will describe actions aiming at protecting customary land tenure, addressing gender inequality in terms of access and control over irrigated land and measures to enhance governance of land and water through local institutions such as Water Users Associations.

9.1.7 The National Irrigation Development Policy and Strategy (2011)

This is the main guiding policy in the irrigation sector and basically it seeks to increase area under sustainable irrigation, extend cropping opportunities, facilitate crop diversification, create an enabling environment for irrigated agriculture, enhance capacity for irrigated agriculture and promote a business culture in the small scale irrigated agriculture sector. It is aligned to the MGDS and realizes the importance of complying with environmental standards set in the National Environmental Policy. Most of its nine policy statements on irrigation are relevant to the SVIP however as far as ESIA and PMP considerations are concerned the following are directly relevant:

- Environmental consideration shall apply for all irrigation and drainage projects as provided for in the Environmental Impact Assessment (EIA) Guidelines for Irrigation and Drainage Projects (2002);
- Conservation measures for irrigation projects catchment areas shall be vigorously pursued to ensure availability of water resources;
- Promotion of small-scale small holder irrigation schemes in all potential areas;
- The transfer of management of government owned schemes to small holder beneficiaries in order to improve production and environmental management and
- Facilitating the participation of private sector in construction and maintenance of the irrigation schemes and in crop marketing from the schemes.

Under one of the specific development strategies that seek to identify and develop areas with irrigation potential to facilitate utilization of irrigable land in Malawi, the policy makes some demands with regard to environmental and social management considerations as follows:

- All irrigation development shall be integrated with other natural resource management activities to protect and conserve the environment;
- Environmental analysis shall be made to ensure that unacceptable environmental impacts are avoided and that features such as high water tables, salinity and erosion are monitored;
- Projects shall be designed, implemented and managed in compliance with the EIA guidelines for irrigation and drainage projects as defined by EAD; and,
- The impact of irrigation development on health shall be closely monitored and mitigated.

The ESIA and PMP assignment will include measures that will ensure integration of irrigation and natural resources activities and that issues such as salinity, soil erosion and human health are monitored and mitigated.

9.1.8 The National Forest Policy of Malawi (1996)

Forestry resources play a major part in supporting livelihoods, infrastructure development and energy besides providing habitat for animals and providing protection for soil and water resources for agriculture and domestic use. The ecological services provided by forests in providing protection of watersheds that supply water to irrigation schemes are very important for sustainable irrigation development in Malawi making the sector policy relevant to SVIP.

The 2006 National Forestry Policy calls for a reduction in the dependence on wood fuel as a source of energy through switching to alternative sources of fuel and adopting wood fuel-saving devices.

The policy is being revised. Realising that biomass will remain a significant source of energy for the foreseeable future the new policy is realistic and advocates the promotion of sustainable charcoal production.

The project will have minimal impact on forest, as it takes place in an agricultural area. The ESIA and PMP assignment will provide measures for sustainable utilization and protection of forest resources through control of opening up land for cultivation on environmentally fragile areas such as wetlands and riverbanks.

9.1.9 National Disaster Risk Management (NDRM) Policy 2015

The overall goal of the NDRM Policy is to sustainably reduce disaster losses in lives and in the social, economic and environmental assets of communities and of the nation. The policy aimes at creating and providing enabling framework for the establishment of a comprehensive disaster risk management system in Malawi. The priority areas of the policy focuses on include mainstreaming of disaster risk management into sustainable development, establishment of comprehensive system for disaster risk identification, assessment and monitoring, development and strengthening of a people centred early warning system, promotion of a culture of safety, adoption of resilience enhancing interventions and the reduction of underlying risks. The strategies to implement the policy cut across several sectors including infrastructure development, agricultural diversification, microfinance initiatives, disaster risk insurance, social support schemes, reforestation and river training.

This policy is very relevant to the SVIP as the project will be implemented in areas that are prone to floods.

9.1.10 National Water Resources Policy 2005

The 2005 National Water Resources Policy whose aim is to ensure sustainable management and utilisation of water resources is very much relevant to SVIP. It is meant to address all aspects of water including resource management, development and service delivery.

The policy relating to riverbank cultivation states: “there shall be no agricultural and infrastructure construction activities below the 477-metre above mean sea level contour line along Lake Malawi and below the 100-year flood water level along rivers, except where written authority from the responsible Minister is granted”. The 477 –metre above sea level and the 100- year water flood level limits are very relevant and care must be taken that the proposed SVIP irrigation areas do not violate this limit without consent from the responsible minister.

The ESIA and PMP assignment will provide measures for monitoring compliance to this provision to ensure there is no cultivation or infrastructure construction in the specified low laying areas and flood prone areas.

9.1.11 National Wildlife Policy 2000

The National Wildlife Policy 2000 aims at ensuring proper conservation and management of the wildlife resources in order to provide for sustainable utilisation and equitable access to the resources and fair sharing of the benefits from the resources for both present and future generations. It recognizes that wildlife forms the basis for the tourism industry in Malawi which is overwhelmingly nature-based and has potential for increased contribution to GDP. The National Wildlife Policy seeks to meet a number of objectives including ensuring adequate protection of representative ecosystems and their biological diversity through promotion and adoption of appropriate land and water management practices that adhere to the principles of sustainable use and enhancing public awareness and understanding of the importance of wildlife conservation and management and its close relationships with other forms of land use.

The ESIA and PMP assignment will consider the potential and actual threats posed by the SVIP on the terrestrial and aquatic habitants of wildlife in the Study area and institute mitigation measures that would protect wildlife from negative impacts caused by the activities of the project. Actual impacts to be generated by construction of main canal through Lengwe National Park and Majete Wildlife Reserve will be assessed and mitigation measures to reduce the adverse impacts will be instituted.

Malawi lacks a wetland policy, therefore there are no official protection of Elephant marsh. Wetland issues are only marginally presentes in this policy.

9.1.12 National Gender Policy 2012 – 2017

The 2012 – 2017 National Gender Policy recognizes that women play important roles in agriculture; they constitute 70% of full time farmers, carry out most of the agricultural work, and produce most of food for home consumption and therefore they ensure household nutrition security. This contribution is however not matched with their access to and control over resources such as land and capital and their enjoyment of benefits from management and use of natural resources.

Strengthening of gender mainstreaming and women empowerment at all levels in order to facilitate attainment of gender equality and equity in Malawi is the main purpose and the goal is to reduce gender inequalities and enhance participation of women, men, girls and boys in socio economic development processes. The policy has seven objectives and those directly relevant to SVIP are:

- To ensure women and girls sexual and reproductive health rights, and HIV AIDS status are improved;
- To strengthen gender mainstreaming in all sectors of the economy;
- To reduce poverty among women and other vulnerable groups (orphans, widows, people living with HIV and AIDS, persons with disabilities, the elderly) through economic empowerment; and,
- To promote women’s participation in decision making positions in both politics and public life.

The policy identifies a number of priority areas including gender in health, gender in agriculture, food security and nutrition, gender in natural resources, environment and climate change management, gender in governance and human rights and gender and economic development. All these priority areas are relevant to SVIP. For instance, the policy ensures that women and other vulnerable groups have access to and control over agricultural productive resources, technologies and markets for cash crops, food and nutrition security. In natural resources management the policy ensures that all gender groups value and own natural resources and their environment and that gender is mainstreamed in natural resource and the environment. On economic development, the policy advocates that gender issues are mainstreamed in all poverty reduction and economic empowerment initiatives and that women participation in economic empowerment initiatives is increased and strengthened.

Various expertises involve in the sVIP will prepare interventions that ensure that women and other vulnerable groups have access to land and water under SVIP and that women and men participate actively in natural resources management activities. Employment by the contractors particularly during the construction phase should not be biased towards men and that the benefits accruing from project activities benefit both men and women equally.

9.1.13 National HIV/AIDS Policy, 2012

The national HIV/AIDS policy highlights that HIV/AIDS impact on the country is quite significant and affects a range of socio-economic activities be it in agriculture, fisheries, public sector, private sector, tourism, urban areas, rural areas among others. HIV/AIDS prevalence in the country varies from one region to the other and from rural to urban areas. The highest rate is in the Southern Region and the lowest in the Northern Region. Prevalence rate is high in urban areas as compared to the rural areas.

National HIV/AIDS Policy identifies migrant workers and women among highly vulnerable people to transmission of HIV/AIDS and other sexually transmitted diseases. An application of migrant workers is that some single male migrant workers would be at an increased likelihood of contracting HIV/AIDS. The reason is that some migrant workers may approach and indulge in casual sexual intercourse with infected local female partners in the surrounding local communities or some sex workers in the targeted irrigation schemes. In addition, increased disposal of income from migrant workers may enhance some workers to indulge in extra-marital affairs with either local girls or married women within the surrounding villages. These sexual activities would enhance the spread of HIV/AIDS among workers and local people. In order to minimize the risks, this ESIA and PMP study recommends various mitigation measures.

9.1.14 National Land Resources Management Policy and Strategy, 2000

The overall goal of this policy is to promote the efficient, diversified and sustainable use of land based resources both for agriculture and other uses in order to avoid sectoral land use conflicts and ensure sustainable socio-economic development. Some of the selected policy objectives are to promote integrated land conservation measures in all forms of agricultural practices, and to protect and preserve environmentally fragile areas such as steep slopes, stream banks, water sheds and dambos. The policy is not explicit on the issue of riverbank cultivation as it provides no guidance on the size of buffer zones along rivers and the recommended management practices of such zones.

This policy is quite relevant in the implementation of the proposed SVIP because a number of the activities fall within the framework of this policy such as integration with land conservation and the protection and preservation of environmentally fragile areas.

9.2 LEGAL FRAMEWORK

9.2.1 Environment Management Act, 1996

This Act provides for the creation of regulations on all aspects of environmental management, so that gaps or inconsistencies in sectoral legislation may be easily rectified.

The Act under Section 24 specifies the types and sizes of activities in Malawi that require an Environmental Impact Assessment (EIA) before they can be implemented. A prescribed list of projects to which (EIA) applies is provided in the Guidelines for EIA, 1997.

The Act further outlines the EIA process to be followed in Malawi; and requires that all project developers in both the public and private sectors comply with the process. The Act under section 26 (3) further requires that no licensing authority issue any license for a project for which an EIA is required unless the Director of Environmental Affairs (DEA) has given consent to proceed; on the basis of a satisfactory EIA or non-requirement of an EIA. Non-compliance with the EIA requirements is an offence and attracts penalties.

Preparation of this ESIA and PMP for the SVIP is in compliance with provision of the Act stipulated in Section 24 and 26.

9.2.2 Land Act (1965)

There are two main statutes which regulate land use are the Land Act (1965) and the Town and Country Planning Act, Number 26, 1988. These statutes deal with land tenure and land use quite comprehensively. The issues of land tenure and land use are recognized as critical in sustainable environmental management in Malawi. The Land Act and The Town and Country Planning Act highlight the sustainable use of land resources by strengthening and clearly defining security of tenure. This is essential, as people are more inclined to manage well land that they know belongs to them. The proposal to transfer the government owned schemes to local people is within this framework.

The Land Act (Cap 59.01) is the principle legal framework in land administration and management. Under this Act, land is classified as follows:

PUBLIC LAND

This land includes all land, which is occupied by the government and any other land, not being customary land or private land. By implication it also includes:

- Any land which was public land within the meaning of Nyasaland or Malawi African Trust Land Orders (Now repealed).
- Any land held by the Government consequent or upon a reversion thereof from any freehold or leasehold estate.

PRIVATE LAND

This includes all land, which is owned, held or occupied under freehold title, or a leasehold title or a certificate of claim or which is registered as private under the Registered Land Act (Cap 58.01).

CUSTOMARY LAND TENURE

Customary land includes all land which is held, used or occupied under customary law but does not include public or private land. All Customary land is vested in the President of the country. The president delegates his stewardship roles to traditional authorities. Customary land is governed by customary law which is a complex mixture of community rules of conduct, leadership roles and principles relating to land control and access. Customary tenure implies that the land is not owned as such but held in trust by a chief on behalf of the people. Customary tenure rules vary from area to area but core principles on management, access and control are similar.

The SVIP activities are being earmarked for about 42,000 hactares which includes 14,000 hectares privately owned by Illovo Sugar Estates. This implies that major decisions concerning land will basically be made by traditional authorities under the framework of the local Government Act 1998. This also implies that decisions on land acquisition and proposals to change land uses should be discussed with local authorities in tandem with the provisions of Local Government Act, 1998.

9.2.3 Lands Acquisition Act (1971)

The Lands Acquisition Act (Cap 58:04) sets out in detail, the procedures for acquisition of customary land and freehold land. The processes and procedures for proclamation of the land to be acquired in this project especially for the for development of irrigation infrastructure 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.

9.2.4 Cultural Heritage Regulation

Cultural resources are nowadays protected in almost every country by national legislations and international conventions. This also applies to Malawi, which has provisions for the protection of cultural resources in its National Cultural Policy and its Monuments and Relics Act. The Project is also committed to undertake its activities in compliance with the World Bank Group's safeguard policies on cultural resources.

The Malawi Department of Antiquities (MDoA) was founded in 1967 by an Act of Parliament with the mandate to study, preserve, conserve and protect the country's cultural and national heritage. Its offices are located in Lilongwe, which also houses other divisions of the Department of Culture.

The two most important legal frameworks are the Monuments and Relics Act of 1990 and the Malawi Cultural Policy (2014). The latter, which has been approved by President Peter Mutharika in 2015, provides guidelines for proper implementation processes on issues such as heritage protection.

Section 5.7.8, Objective 8 of the Policy is that cultural factors need to be taken into account in development projects, policies and programmes for the nation. Its first strategy asserts that, "development projects include a cultural heritage impact assessment".

The need for cultural heritage impact assessments are not mentioned in the Monuments and Relics Act of 1990 but it provides statutory protection against the threat of development on declared monuments, historical buildings, archaeological, paleontological, geological, anthropological, ethnological, and other heritage sites to enable their preservation.

Section 29. (1) of the Monuments and Relics Act reads, “A person in charge of any survey, excavation, exploration, construction or new development shall, at the earliest stages of planning for such activities, give notice to the Minister to enable, where necessary, rescue archaeology to be carried out in accordance with subsection (2)”. Section 29 (2) mentions that Rescue archaeology of a monument or relic under subsection (1) shall be carried out by the Chief Antiquities Officer or any qualified person with an excavation permit issued by the Minister, and the cost of such work shall, unless the Minister otherwise directs, be borne by the person in charge of any survey, excavation, exploration, construction or other development.

The Monuments and Relics Act provides clear definitions of cultural resources in its tangible forms, comprising both movable and immovable physical cultural heritage of the following types:

- Places, buildings and structures of cultural significance ;
- Places and objects to which oral traditions are attached or which are associated with living heritage such as ethnographic art and objects ;
- Historical settlements, townscapes and sites of significance relating to the history of slavery;
- Landscapes and natural features of cultural significance;
- Geological sites of scientific or cultural importance;
- Archaeological and paleontological sites and objects;
- Graves and burial grounds.

The protection of intangible expressions of cultural heritage in contrast does not appear in the Monuments and Relics Act. Hence, no provisions are made for its protection in the context of development projects.

9.2.5 Water Resources Act (2013)

The Act provides for the management, conservation, use and control of water resources; for the acquisition and regulation of rights to use water. It creates the National Water Resources Authority (NWRA) to replace the National Water Resources Board and also creates Catchment Committees for different river basins such as the Shire River basin where SVIP irrigation activities will be implemented. It also sets appropriate standards and techniques for the investigation, use, control, protection, management and administration of water resources and regulates public and private activities which may influence quality, quantity, distribution, use or management of water resources and also sets out the coordination, allocation and delegation of responsibilities. It enforces use of water resources; domestic, livestock watering, irrigation and agriculture, industrial, commercial and mining, recreation, hydro-electric power generation and other uses in ways which minimize harmful effects to the environment, control pollution and to promote the safe storage, treatment, discharge and disposal of waste and effluents.

One of the key provisions of the Act relevant to SVIP is that it prohibits persons from cultivating or carrying out activities within the bed and banks of water courses and lakes and the adjacent land strips except as determined by the Authority created by the Act. It also enforces water rights (permits), water abstraction, water pollution control and building of dams. For SVIP a water abstraction right will have to be acquired from NWRA for the intake at Kapichira Dam.

This is a very important Act and the ESIA and PMP provide measures to ensure proper quality (pollution), quantity, distribution, use or management of water resources within the project sites. The ESIA and PMP assignment recommend measures for controlling cultivating or carrying out of activities within the beds and banks of watercourses and lakes as provided by the Act.

9.2.6 Pesticides Act (2000)

This Act provides for the control and management of the import, export, manufacture, distribution, storage, disposal and use of pesticides. The Act also establishes the Pesticides Control Board that enforces the provisions of the Act relating to pesticides and other incidental matters. It therefore protects the importation and use of expired products that can be hazardous to the environment and human health. This is relevant to the proposed SVIP as in pursuit of increased production use will be made of production enhancing technologies including use of pesticides and herbicides which if not properly regulated can harm the environment and human health thereby contravening with World Bank and African Development Bank's operational policies on safeguards. The PMP will include measures for ensuring proper and safe use and storage of agrochemicals and safe disposal of empty containers to avoid contamination of water resources and poisoning. This may include training of farmers on handling and safe use of agrochemicals, use of protective clothing, disposal, dangers of using expired products and public health. This must also target agro-dealers emphasizing on the need for approval from the Pesticide Control Board for clearing, importation and certification of chemicals.

9.2.7 Forestry Act (1997)

The Forestry Act provides for participatory forestry, forest management, forestry research, forestry education, forest industries, protection and rehabilitation of environmentally fragile areas. The act among other things seeks to: augment, protect and manage trees and forests on customary land in order to meet basic fuelwood and forest produce needs of local communities and for the conservation of soil and water; promote community involvement in the conservation of trees and forests in forest reserves and protected forest areas; prevent resources degradation and to increase socio-economic benefits; promote community involvement in conservation of trees and forests; promote optimal land use practices through agroforestry in small holders farming systems; protect fragile areas such as steep slopes, river banks, water catchment and to conserve and enhance biodiversity.

The Act is very relevant to the SVIP as trees and forests are important for sustenance of ecological integrity of watersheds. This ESIA and PMP assignment therefore advocates integration of irrigation activities with natural resources management activities such as tree planting and riverbank protection.

9.2.8 Irrigation Act, 2001

The Act is central to SVIP since it provides for the sustainable development and management of irrigation, protection of the environment from irrigation related degradation, establishment of the National Irrigation Board, the Irrigation Fund and other matters related to irrigation development in Malawi.

It even mandates farmers to maintain irrigation canals, drains and other associated infrastructure in their holdings and prohibits people from engaging in practices which are destructive or potentially destructive to the catchment area of a river that provides water for irrigation. It goes further and prohibits livestock grazing, setting or causing to set fire on irrigation schemes or farms. Recognizing the destructive effects of fires, puts the responsibility for averting, fighting or extinguishing fire on irrigation schemes or farms in the hands of everybody. Although the Act is silent on the maintainance of buffer zones along riverbanks it prohibits any action that are destructive to the catchment. Issues of livestock, fire management and catchment protection are very pertnent to SVIP and therefore this Act is very relevant.

Measures to control livestock grazing, bushfires, to enhance riverbank protection, stabilization of water dams, proper construction of water delivery and storage systems including stabilization of embankments, protection of water intake points should are proposed in the various expertises engaged for the SVIP.

9.2.9 Occupational Safety, Health and Welfare Act (1997)

The Act makes provisions for the regulation of conditions of employment in workplaces with regard to safety, health and welfare of employees. It also provides for the inspection of certain plant and machinery, the prevention and regulation of accidents occurring to persons employed or authorised to go into the workplace, and for some related matters. The Act requires registration of workplaces and defines duties and responsibilities of employers and employees with regard to health, safety and welfare and the notification, and investigation of accidents, dangerous occurrences and industrial diseases. In relation to SVIP, the Act is relevant as the construction of canals, drains and ancillary facilities will require labour and use of motorized machinery. In addition, use and application of agrochemicals require safe handling and safe disposal of empty chemical containers. All these pose great environmental, health and safety hazards if not managed properly. The ESIA and PMP assignment will propose mitigation measures to reduce accidents at work place especially during the construction phase and measures to reduce the occurrence of water borne diseases.

9.2.10 National Parks and Wildlife Act (2004)

The Act makes provisions for the protection and conservation of rare, endangered and endemic wild plants and animals. It also provides for sustainable utilization of wildlife and minimization of human-wildlife conflict. More importantly, the act also promotes local community participation and private sector involvement in conservation and management of wildlife. Section 23 of the Act requires an impact assessment to be undertaken for any activity that may generate in adverse impacts on wildlife. The Act requires that the assessment should provide an account of species, communities and habitats to be affected and the extent to which the wildlife will be affected. Further to that, the Act requires that the impact assessment report proposes measures and actions to abate adverse impacts on wildlife and habitats. In relation to SVIP, the Act is relevant as the development of the intake structure and irrigation infrastructure will affect activities in Lengwe National Park and Majete Game Reserves. The ESIA assignment proposes mitigation measures to reduce adverse impacts that could be generated by project activities during construction and operation phases of the irrigation infrastructure.

9.2.11 Fisheries Conservation and Management Act (1997)

The Act makes provisions for the conservation and management of fish resources in Malawi. Changing water flow in the Shire due to reduced flows could negatively affect fish spawning in the Elephant Marsh and biodiversity of the Shire River. Increased application of agrochemicals in the fields could adversely affect fish resources in the Lower Shire. The ESIA and PMP assignment proposes mitigation measures to reduce adverse impacts that could be generated by project activities especially flows reduction into the Elephant Marsh.

9.3 FUNDING AGENCY POLICIES

Due to financial assistance from the WB and the AfDB, the Project will need to implement the safeguard policies of those respective institutions. In addition, the IFC Performance Standard may also be relevant for the public-private partnership (PPP) implementation arrangements.

The following sections present both the World Bank Operationnal Policies and the IFC Performance Standards. Most AfDB policies are less constraining than those of the WB and IFC, they are not necessarily presented hereunder.

9.3.1 Environmental Assessment (Operational Policy 4.01)

World Bank's environmental assessment operational policy requires that all projects proposed for Bank financing are screened for potential environmental and social impacts. The policy is triggered if a project is likely to have adverse environmental risks and impacts in its area of influence.

According to OP 4.01 the Bank classifies proposed projects into one of four categories, depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts. The SVIP is classified as Category A.

Category A: A proposed project is classified as Category "A" if it is likely to have significant adverse environmental and social impacts that are sensitive, diverse, or unprecedented. These impacts may affect an area broader than the sites or facilities subject to physical works. EA for a Category A project examines the project's potential negative and positive environmental and social impacts, compares them with those of feasible alternatives (including the "without project" situation), and recommends any measures needed to prevent, minimize, mitigate or compensate for adverse impacts and improve environmental and social performance.

Construction of water intake structure, bulk water irrigation infrastructure and irrigation development on 42,000 ha in Chikwawa and Nsanje will have environmental impacts, which require mitigation. Therefore, undertaking ESIA and PMP study for SVIP is in tandem with this Operational Policy.

OP 4.01 also requires that prior to project appraisal, the Government of Malawi will approve and disclose the EIA report in places publicly accessible to affected groups including local NGOs. The Government of Malawi must officially submit the approved report to the Bank; and authorize the Bank to disclose the document at its Info-shop in Washington DC. In commissioning the formulation of the ESIA and by making the document available to the public, the proposed project will be in compliance with BP 17.50.

9.3.2 Pest Management (OP 4.09)

The procurement of any pesticide in a Bank-financed project is contingent on an assessment of the nature and degree of associated risks, taking into account the proposed use and the intended users. With respect to the classification of pesticides and their specific formulations, the Bank refers to the World Health Organization's Recommended Classification of Pesticides by Hazard and Guidelines to Classification (Geneva: WHO 1994-95). The following criteria apply to the selection and use of pesticides in Bank-financed projects:

- They must have negligible adverse human health effects ;
- They must be shown to be effective against the target species ;
- They must have minimal effect on non-target species and the natural environment. The methods, timing, and frequency of pesticide application are aimed to minimize damage to natural enemies;
- Their use must take into account the need to prevent the development of resistance in pests.

At a minimum, pesticide production, use and management should comply with FAO's Guidelines for Packaging and storage of Pesticides, Guidelines on Good Labelling Practice for Pesticides, and Guidelines for the Disposal of Waste Pesticide Containers on the Farm. The Bank does not finance formulated products that fall in WHO classes IA and IB, or formulations of products in Class II, if (a) the country lacks restrictions on their distribution and use; or (b) they are likely to be used by, or be accessible to, lay personnel, farmers, or others without training, equipment, and facilities to handle, store, and apply these products properly.

The proposed project will trigger OP 4.09 since there will be increased use of agro-chemicals on the irrigation fields both managed by commercial farmers and smallholder farmers. However, procurement of pesticides will not be financed until experience demonstrates that the local capacity exists to adequately manage their environmental and social impacts in compliance with OP 4.09 as described above.

9.3.3 Involuntary Resettlement

The objective of OP 4.12 is to avoid or minimize involuntary resettlement where feasible by exploring all viable alternative project designs. Where resettlement is unavoidable, OP 4.12 is intended to assist displaced persons in maintaining or improving their living standards. It encourages community participation in planning and implementing resettlement and in providing assistance to affected people. This policy is triggered not only if physical relocation occurs, but also by any taking of land resulting in: (i) relocation or loss of shelter; (ii) loss of assets or access to assets; and (iii) loss of income sources or means of livelihood, whether or not the affected people must move to another location. For the SVIP, a Resettlement Policy Framework (RPF) is currently being prepared to guide land acquisition, reorganization and involuntary resettlement if required.

IFC Performance Standards may be triggered in case of a PPP, however the construction of the Project is funded by the World Bank, and the PPP only applies to the operation phase, where no resettlement will take place.

9.3.4 Cultural heritage

The WB's safeguard policy on cultural heritage is known as OP 4.11 – Physical Cultural Resources. In point 2 of its introduction it reads, "Physical cultural resources are important as sources of valuable scientific and historical information, as assets for economic and social development, and as integral parts of a people's cultural identity and practices". It further states that "physical cultural resources in projects proposed for Bank financing need to follow the EA sequence of: screening; developing terms of reference (TORs); collecting baseline data; impact assessment; and formulating mitigating measures and a management plan".

The identification of appropriate measures for avoiding or mitigating adverse impacts as part of the EA process is another important element in OP 4.11. "These measures may range from full site protection to selective mitigation, including salvage and documentation, in cases where a portion or all of the physical cultural resources may be lost".

As an integral part of the EA process, OP 4.11 states that "the borrower will need to develop a physical cultural resources management plan, that includes measures for avoiding or mitigating any adverse impacts on physical cultural resources, provisions for managing chance finds, any necessary measures for strengthening institutional capacity, and a monitoring system to track the progress of these activities".

The WB also has Bank Procedures or BPs, which in this case refers to BP 4.11 – Physical Cultural Resources. A Task Team (TT) needs to advise the borrower "on the provisions of OP 4.11 and their application as an integral part of the Bank's environmental assessment (EA) process as set out in OP/BP 4.01, Environmental Assessment". An important aspect of BP 4.11 is the consultation process. It reads "since many physical cultural resources are not documented, or protected by law, consultation is an important means of identifying such resources, documenting their presence and significance, assessing potential impacts, and exploring mitigation options. Therefore, the TT reviews the mechanisms established by the borrower for consultation on the physical cultural resources aspects of the EA, in order to ensure that the consultations include meetings with project-affected groups, concerned government authorities and relevant non-governmental organizations". Capacity Assessment is a further element that will be assessed by the TT. It states that, "the EA assesses the borrower's capacity for implementing the proposed mitigating measures and for managing chance finds, and where appropriate, recommends capacity building measures".

The AfDB has likewise adopted provisions for heritage protection in its operational safeguards. It states that "The borrower or client is responsible for ensuring that project sites and designs avoid significant damage to cultural heritage, including both tangible and intangible cultural heritage". It further mentions that, "the borrower needs to draw on indigenous knowledge to identify its importance, and incorporate the views of these communities into the decision making process. The purpose of the consultation is to assess, present, and agree with communities on acceptable financial and nonfinancial compensatory measures". An important paragraph concerns tangible heritage in which it is stated that, "the project shall not remove any tangible cultural heritage unless the following conditions are met:

- No technically or financially feasible alternatives to removal are available;
- The overall benefits of the project substantially outweigh the anticipated cultural heritage loss from removal;
- Any removal is conducted in accordance with relevant provisions of national and/or local laws, regulations, and protected area management plans and uses internationally accepted best available techniques".

The IFC comprises Policy and Performance Standards on Environmental and Social Sustainability and equally includes cultural heritage protection as set out in Performance Standard 8. The latter "recognizes the importance of cultural heritage for current and future generations". Consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage, this Performance Standard aims to protect irreplaceable cultural heritage and to guide clients on protecting cultural heritage in the course of their business operations". The objectives of the IFC's Performance Standard 8 are:

- To protect cultural heritage from the adverse impacts of project activities and support its preservation;
- To promote the equitable sharing of benefits from the use of cultural heritage in business activities.

The IFC lists the following requirements in Performance Standard 8:

- Internationally recognized practices for the protection and support of cultural heritage
- Chance find procedures
- Consultation with affected communities
- Appropriate mitigation in cases where the client will have to significantly alter, damage or remove any important cultural heritage

An important aspect of the IFC's Performance Standard 8 refers to complying with relevant national law on the protection of cultural heritage, including national law implementing the host country's obligations under the Convention Concerning the Protection of the World Cultural and Natural Heritage. In the case of this Study area, this specific element of the IFC's Performance Standard 8 may apply since some site are on the tentative submission list of cultural properties, which the Government of Malawi intends to consider for inscription on the World Heritage List.

The IFC's performance standard regarding cultural heritage also states that "the social and environmental risks and impacts identification process should determine when the proposed location of a project is in areas where cultural heritage is expected to be found, either during construction or operations". The client has the obligation to implement cultural heritage chance find procedures in the event that cultural heritage is discovered. "The client will not disturb any chance find further until an assessment by a competent specialist is made and actions consistent with the requirements of this performance standard are identified".

IMPLICATION FOR THE PROJECT

The Project's adherence to the WB's, the AfDB's and IFC's safeguard policies and National requirement bind the borrower to actively engage with the protection of the impact area's cultural resources and to implement adequate mitigation measures that conform to international standards of heritage protection. A requirement has already been fulfilled in this baseline report since with this baseline, we have provide an identification of the Study area cultural heritage sites, whether rescue archaeology (salvage) shall be done or not is the government's decision. Other requirements in terms of mitigation measures and chance find procedures will be presented in the full ESIA.

9.3.5 Stakeholder Engagement and Communication Plan

During the operation phase, the PPP shall implement a Stakeholder Engagement Plan (SEP) in order to ensure ongoing communication with stakeholders and communities and to take into account grievances. This SEP is in fact a requirement from IFC performance standards as shown hereunder. The ESMP details the content of such plan.

IFC Performance Standards n°1 "Assessment and Management of Environmental and Social Risks and Impacts" requirements in term of engagement and communication are as follow:

- Section 2 : this Performance Standard supports the use of an effective grievance mechanism that can facilitate early indication of, and prompt remediation for those who believe that they have been harmed by a client's actions
- Section 25: Stakeholder engagement is the basis for building strong, constructive, and responsive relationships that are essential for the successful management of a project's environmental and social impacts. Stakeholder engagement is an ongoing process that may involve, in varying degrees, the following elements: stakeholder analysis and planning, disclosure and dissemination of information, consultation and participation, grievance mechanism, and ongoing reporting to Affected Communities.
- Section 27: The client will develop and implement a Stakeholder Engagement Plan that is scaled to the project risks and impacts and development stage, and be tailored to the characteristics and interests of the Affected Communities. Where applicable, the Stakeholder Engagement Plan will include differentiated measures to allow the effective participation of those identified as disadvantaged or vulnerable.
- Section 29 : Disclosure of relevant project information helps Affected Communities and other stakeholders understand the risks, impacts and opportunities of the project. The client will provide Affected Communities with access to relevant information on: (i) the purpose, nature, and scale of the project; (ii) the duration of proposed project activities; (iii) any risks to and potential impacts on such communities and relevant mitigation measures; (iv) the envisaged stakeholder engagement process; and (v) the grievance mechanism

- Section 34 : Clients will implement and maintain a procedure for external communications that includes methods to (i) receive and register external communications from the public; (ii) screen and assess the issues raised and determine how to address them; (iii) provide, track, and document responses, if any; and (iv) adjust the management program, as appropriate. In addition, clients are encouraged to make publicly available periodic reports on their environmental and social sustainability
- Section 35 : where there are Affected Communities, the client will establish a grievance mechanism to receive and facilitate resolution of Affected Communities' concerns and grievances about the client's environmental and social performance. The grievance mechanism should be scaled to the risks and adverse impacts of the project and have Affected Communities as its primary user. It should seek to resolve concerns promptly, using an understandable and transparent consultative process that is culturally appropriate and readily accessible, and at no cost and without retribution to the party that originated the issue or concern. The mechanism should not impede access to judicial or administrative remedies. The client will inform the Affected Communities about the mechanism in the course of the stakeholder engagement process
- Section 36 : The client will provide periodic reports to the Affected Communities that describe progress with implementation of the project Action Plans on issues that involve ongoing risk to or impacts on Affected Communities and on issues that the consultation process or grievance mechanism have identified as a concern to those Communities. The frequency of these reports will be proportionate to the concerns of Affected Communities but not less than annually.

9.3.6 Natural habitats (OP 4.04)

This policy recognizes that the conservation of natural habitats is essential to safeguard their unique biodiversity and to maintain environmental services and products for human society and for long-term sustainable development.

Habitat classification as presented in the policy has been used in the ESIA. The Policy distinguishes natural habitats from manmade habitats and also describes what a "critical habitat" is. Critical habitats are (a) legally protected, (b) officially proposed for protection, (c) identified by authoritative sources for their high conservation value, or (d) recognized as protected by traditional local communities.

10. CONCLUSION

This baseline report covers various topics from the biophysical environment to the socioeconomic aspects of the Study area. It describes the main challenges and issues that people face in terms of livelihood strategies and presents the main environmental sensitivities.

The followings are the most important baseline elements and issues that were described in this report.

PHYSICAL ENVIRONMENT

Hydrology

Flow in the Shire River is highly regulated by the water level in Lake Malawi, in conjunction with the lake's natural outflow controls (a sand bar at 471.5 m above sea level , across the mouth of the Shire), and by the artificial influence of Kamuzu Barrage at Liwonde

The average annual flow for Shire River is 395 m³/s at Kapichira Dam and 489 m³/s at Chiromo Bridge. During dry year, the average annual flow for Shire River is 242 m³/s at Kapichira Dam and 287 m³/s at Chiromo Bridge.

The upstream part of the basin at Kapichira Dam controls approximately 80% of the average annual flow of the whole basin at Chiromo Bridge. The intermediary part of the basin from Kapichira to Chiromo (including Mwanza but not Ruo) only contributes for about 5%. The remaining 15% are driven by the Ruo River.

During the dry season, 95% of the total flow at Chiromo are controlled by the upstream basin at Kapichira. The contribution of the intermediary basin is close to nil and the inflow of the Ruo River brings about 5%.

Shire brings constant water to the system and with higher proportion than Ruo (95 % during the dry season and 75% during the wet season), but when the inundation is at its peak, Ruo is almost equally responsible (44%) for surface of inundated area than Shire (52-66%). The contribution of seepages and groundwater to local hydrology is unknown as there is currently no study available regarding groundwater hydrology.

With climate change, it must be expected that the variability of flow will increase, and that the extremes (both floods and droughts) will be more pronounced.

Water quality

There is currently a lack of reliable information on surface water quality. However, available data indicate a high level of total suspended solids and iron in the Shire, while nitrate and phosphate in the do not seem to be an issue. On the other hand, in Shire tributaries, nitrate and phosphate level indicate that the system is Mesotrophic. Mesotrophic systems are usually productive with a risk of nuisance growth of aquatic plant but low risk of toxic algal blooms. There is no data on coliforms (fecal and total) although given the high population density, coliforms are a potential issue.

Groundwater is brackish to saline, heavy metals such as lead are sometimes also present in high concentration and are a risk for human health.

The frequent unsuitability of groundwater and the scarcity of perennial rivers forces people to fetch water in the Shire, exposing themselves to crocodiles and to unsuitable drinking water quality.

Soil and erosion

Erosion in the catchment in an important and well documented issue.

Most of the transported materials from the Shire River are deposited in the central part of the valley, around the main channel. The provenance of the great majority of the sediments in the Western part of the Lower Shire valley is from the West and North West hills which form the catchment area of the series of small rivers and streams tributary to the Shire River.

The combination of a decreasing and degrading vegetation cover (through human activities) of the hills and foot slopes together with dominance of hard setting soils with compact structures and surface sealing on the foot slopes of the hills and subsequent pediment slopes is very conducive to accelerated runoff and erosion.

From Chikwawa to Namitalala River, the deposits in the floodplain area consist of stratified sandy and silty alluvium. In the central part of the valley, deep poorly drained sandy soils are found without much soil development. More to the West soils are still deep, but have a more variable texture and generally better drainage and show incipient soil formation. It is reported that some salinity and alkalinity may occur in depressions with clayey soils and at the edge of marshes.

From Namitalala River to Mafume/Lalanje River, in the area called Makande Plain, Vertisols are by far dominant, which is not surprising because Makande means “clay-soil”.

From Mafume/Lalanje River in the Southern part of the Study area, only few documented results of soil investigations are available. The little information available show a complex pattern of Luvisols, Cambisol and Fluvisols, but no Vertisols.

The presence of Vertisols in the future command area is important. Heavy Vertisols are not suitable for most crops and require high management level which are not likely to be met, they may cover up to 4,000 ha of the command area and are concentrated in Zone C and B in Makande Plain.

SOCIOECONOMIC

Population of Chikwawa district is estimated at 434,648 and 238,103 in Nsanje District.

Settlements in the study area are largely nucleated around social infrastructures such as markets, schools and water supplies. Communities are organized according to families and relations in the area with common cultural beliefs and language.

Livelihood

The economy of the study area is largely agro-based with households engaged in rainfed crop production. Maize is the main food crop grown in the project area while cotton is the main cash crop grown by smallholder though sugarcane cultivated in Illovo sugar estates could be regarded as the main cash earner. Livestock production and fish farming is also an activity. Approximately 12 percent of the farm families own livestock. In terms of fishery, about 1,830 people are involved in this activity benefiting an insignificant percentage of households

Land

About two thirds of Shire Valley Agricultural Development Division (SVADD) is customary land, controlled by the Chiefs (Traditionnal authorities).

Land holding size for majority of communities in the Study area ranges from 0.1 ha to 1 ha.

Health issues

South of Malawi is suffering from malaria with a high level of permanent transmission (with seasonal variations). Large irrigation schemes do not change the prevalence of this disease.

A survey in Chikwawa district in 2012 showed that 45% of the mothers and 18% of the children were infected with urinary schistosomiasis. Schistosomiasis is the group of infectious diseases the most closely linked with irrigation schemes.

Cultural heritage

Due to the long presence of human in the Study area, many observed cultural heritage sites are made up of archaeological artifacts, mostly characterized by pottery scatters dating from the Early Iron age (2 thousand years BC). Due to flash floods and sheetflood erosion, these sites, that were superficially observed by the consultant, can move rapidly and may not be at their initial location once works starts. Important cultural heritage sites are sacred shrines some of which have been submitted in 2010 on the tentative list to acquire the UNESCO status of World Heritage Site.

Natural heritage

The Study area has three gazette parks: Majete, Lengwe and Mwabvi. Mwabvi is outside of the project right of way, while Majete and Lengwe are directly concerned by the Project canal alignment route.

Majete’s landscape value resides in the Shire and its rapids and the Kapichira falls. Lengwe, and especially its eastern part, is highly valued for having one of the last Nyala population in the region confined in the rare thicket ecosystem. Mwabvi is made of small green hills that stands out in the dominated agriculture landscape.

Elephant marsh is also a major landscape feature in the Study are as it covers 500 km^2. It is dominated by tall grasses, its economic significance is unfortunately not well balanced with its ecological value has the marsh is progressively reclaimed for agriculture without any formal management.

ECOLOGY

The Study area is largely dominated by agriculture where natural habitats are confined to parks between which they are no ecological continuity. Majete and Lengwe each have a certain number of large mammals, Majete with its recent change of management, has reintroduced many charismatic species such as the elephant, lion, etc., all are confined to the park with an electric fence. Lengwe suffers from poaching, illegal wood clearing and encroachment and heavy pressure from surrounding activities. The rarest habitat in the area, the thickets of the Old Lengwe, is where the Nyala population is located. The almost total disappearance of thicket vegetation in the Shire Valley outside wildlife reserves means that thickets in Lengwe and Mwabvi are of the utmost importance for the survival of relatively rare species and the Nyala. Conflict between wandering buffalos and the large sugar estates is also an issue.

Elephant marsh has been delineated partly using a standardize method, it also allowed to highlight the growing pressure from incursion of subsistence farmers covering almost half of the wetland and leading to erosion and silt deposition in the marsh. Historically, the marsh had been for a long time a modified habitat, prior to Liwonde barrage construction, it was dependent on the Lake level and for more than 25 years in the 19^{th} century the marsh was dry and completely reclaimed for agriculture.

In terms of aquatic ecology, the area is part of the Lower Shire/Lower Zambezi system. The Lower Shire is connected to the Lower Zambezi system and fish from this system move upstream as far as the Kapichira dam. Kapichira and other rapids upstream are impassable obstacles for Zambezi fishes. Many fishes in the Study area are dependent of Shire tributaries and on the Elephant marsh to spawn, the onset of the rainy season is the main trigger for spawning. In terms of fishery, the main catch are the African Catfish and the native Tilapia. Fishery management is rather poor and catch figures are not coherent between years.

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Annex A: Cultural Heritage Site, Assessment of Value

The following table assesses the value of several cultural heritage sites within the study area. Only sites that were identified by the Consultant have been assessed (CK46 to CK 86).

Figure 63 Assessment of cultural sites value

Site	Data	Site Significance
CK46	Elevated open air site behind Papa James' concession; dense surface scatters of archaeological material; decorated pottery	High Priority
CK47	Flat open site in cultivated fields; small amount of undecorated pottery	Medium Priority
CK48	Graveyard Sande Village	High Priority
CK49	Flat open air site; lots of burnt earth and small amounts of undecorated pottery	Medium Priority
CK50	Sacred Forest behind Chief Lundu's Residency	High Priority
CK51	Lundu Chifunda (Enthronement Site of Lundu Chiefs)	High Priority
CK52	Mawira Sacred Water (next to Mwanza River)	High Priority
CK53	Mangalangala Sacred Hill	High Priority
CK54	Graveyard outside Thimu Village	High Priority
CK55	Flat open air site in cultivated field with dense surface scatters of archaeological material; decorated pottery, stone artefacts, daga remains	High Priority
CK56	Flat open air site in cultivated field with small amounts of decorated pottery	Medium Priority
CK57	Isolated find spot, concussive stone in cultivated field	Low Priority
CK58	Isolated find spot, concussive and grinding stone in cultivated field	Low Priority
CK59	Graveyard (Nyamphora Village)	High Priority
CK60	Open air site in cultivated field; small amounts of undecorated pottery	Medium Priority
CK61	Flat open air site in cultivated field between Mango trees; fairly dense surface scatters of undecorated pottery	Medium Priority
CK62	Elevated open air site with dense surface scatters of archaeological material; decorated pottery, daga remains	High Priority
CK63	Elevated open air site with termite mound; small amounts of pottery and daga remains	Medium Priority
CK64	Elevated open air site with associated termite mound; dense surface scatters of archaeological material; decorated pottery, daga remains	High Priority
CK65	Elevated open air site with termite mound; small amounts of pottery and daga remains	Medium Priority
CK66	Elevated open air site with termite mound; small amounts of pottery and lots of daga remains	Medium Priority
CK67	Elevated open air site with termite mound; freshly broken pottery remains	Medium Priority
CK68	Elevated open air site and associated termite mound; freshly broken pottery remains	Medium Priority
CK69	Flat open air site in cotton field; fairly dense scatter of undecorated pottery and daga remains	Medium Priority
CK70	Flat open air site with termite heap; fairly dense scatter of pottery and daga	Medium Priority
CK71	Isolated find spot huge slag piece	Low Priority
CK72	Flat open air site; small amounts of undecorated pottery and charcoal	Medium Priority
CK73	Elevated site with termite mound; small amounts of eroded pottery	Medium Priority

Site	Data	Site Significance
CK74	Elevated open air site; small amounts of eroded pot sherds	Medium Priority
CK75	Open air site with lots of gullies; numerous pot sherds	Medium Priority
CK76	Flat open air site behind modern household; dense scatters of archaeological material; pottery well embedded in the soil (primary context)	High Priority
CK77	Flat open air site in between modern households; dense scatters of archaeological material; pottery well embedded in the soil (primary context)	High Priority
CK78	Flat open air site in modern household; dense scatters of archaeological material; pottery well embedded in the soil (primary context)	High Priority
CK79	same site type as 061	High Priority
CK80	Flat open air site, surface of an actual village; dense scatters of archaeological material; pottery well embedded in the soil (primary context)	High Priority
CK81	Flat open air site in between modern households; dense scatters of archaeological material; pottery well embedded in the soil (primary context)	High Priority
CK82	Elevated open air site with termite mound; undecorated pottery and daga remains	Medium Priority
CK83	Elevated open air site with termite mound; decorated pottery and two metal objects	Medium Priority
CK84	Graveyard of Kholongo Village	High Priority
CK85	Flat open air site in a gully; two decorated pottery sherds resembling Nkhope ware; primary context unclear	Medium Priority
CK86	Flat open air site between two Baobab trees; dense scatters of pottery well embedded in the soil	High Priority

Annex B: Additional fish species in the Lower Shire River

PROTOPTERUS ANNECTENS BRIENI

Habitat requirements and regional extent

Protopterus annectens brieni is widely distributed in Africa from the Democratic Republic of Congo to Southern Africa, including the Lower Zambezi river basin. In Southern Africa it only occurs in Malawi in the Lower Shire. The fish feeds mainly through prey on slow moving bottom dwelling creatures such as snails, insects and worms but also may prey on fish and other amphibians (Skelton, 1983).

Water quality requirement

It is common in the marshy areas especially in the lagoons (Tweddle and Willoughby, 1979), and also in large river systems associated with flood plains or non- perennial tributary streams which flow through flat country (Bell-Cross and Minsull, 1988). With its well-developed lungs it survives in the mud when rivers dry up.

Flow requirement

It thrives in non-perennial tributary streams because it is able to breathe atmospheric oxygen directly due to its lungs (Bell-Cross and Minsull, 1988). It has ability through its gills and lungs to breathe in and out water; when the floods recede it excavates a burrow in shallow water, deep enough to take its body, and by the time the water has disappeared the lung fish is encased in a thin membranous cocoon made from secreted mucus and mud (Bell-Cross and Minsull, 1988). This conditions last until the habitat is again filled with water.

Ability to pass through obstacles

The species does not have any climbing ability and cannot pass through any obstacles.

Life cycle (migration and spawning, maturation)

During the wet season, mature female uses its U shaped burrow which is excavated to a depth of nearly 60 cm for spawning purposes. The nest is usually placed among the roots of aquatic vegetation where the male will mate with several females during the breeding season. The female lays white eggs of 4 mm in diameter. The male aerates the eggs with body and fin movements and afford protection of the young for a while after incubation (Bell-Cross and Minsull, 1988)

Important habitats and sensitive life cycle stage

The important habitats for the lung fish are flood plains, especially the lagoons and marshy areas. Due to the presence of the fish only in the Lower Shire flood plain and non- perennial streams, fishes are threatened for survival during the dry season, when they are dug up by people or predators.

Identification of their actual threats and protection status

There is no protection measure for the fish in Malawi due to its less importance for both food and sale.

Value as a food source for the population and their value in the food chain

The fish is eaten by some people but not liked by many people due to its snake like features. Hence in the Lower Shire the fish has low value as a source of food.

Distribution and status of their endemicity and relative abundance

The population distribution of lung fish is limited and it is uncommon throughout its distribution range. It is indigenous in the Lower Shire area in Malawi.

Value as subsistence food or commercial fishing

The lung fish is eaten by very few people in Malawi, hence it has little value as food or for commercial fishing.

Status (native, allochthonous or invasive)

The species is native.

The lung fish is not invasive in alien areas if introduced. It is associated with local habitats and hence is not migratory.

MEGALOPS CYPRINOIDES

Habitat requirement and regional extent

M. cyprinoides is widely distributed. It is found in the Indo-Pacific, the Persian Gulf, Red Sea and Natal, South Africa, Society Islands, North to South Korea, New South Wales and Micronesia. The species is reported far inland in the Lower Shire of Malawi due to their wide spread in the Lower Zambezi river. It is also reported in South China Sea, Taiwan Strait and East China (Bills et al., 2010).

Water quality requirement

Megalops cyprinoides tolerates a wide range of habitats. It thrives in marine, brackish, bethopelagic and amphidromous environments. It prefers temperatures between 22 to 24oC. It tolerates a wide range of pH between 5.2-9.1 (Bills et al., 2010).

Flow requirement

Adults are generally found at sea, but young ones inhabit rive mouths, inner bays and mangrove forests. In fresh water like the Shire River, they inhabit in rivers, lagoons and swampy backwaters (Tweddle and Willoughby, 1979).

Ability to pass through obstacles

The young ones inhabit the fresh water rivers cannot climb over obstacles, unless the structure is fully submerged in water.

Life cycles (migration, spawning, maturation)

The species is believed to spawn offshore, but locations of spawning grounds and subsequent dispersal of larvae remain uncertain. The Juveniles ascend rivers and live in freshwater and then goes back to the sea as they mature. The fish found in the Shire River migrate from the Indian Ocean through the Lower Zambezi (Bills et al., 2010).

Important habitats and sensitive life cycle stage

The juveniles inhabit the Lower Shire, hence this is their important stage. Their habitat is the river mouth and in the Lower Shire the species has been recorded only at the Shire / Ruo confluence (Tweddle and Willoughby, 1979).

Identification of their actual threats and protection status

M. cyprinoides is widely abundant world-wide and its protection status with IUCN is of least concern.

Value as food source for the population and their value in the food chain

M. cyprinoides is a food source for the people but catches are too small to constitute a commercial or subsistence fishery. In addition, it is found at the Shire / Ruo confluence only as juveniles and it feeds mostly on other fish species due to its carnivorous nature.

Distribution status of their endemicity and relative abundance

M. cyprinoides is not widely distributed in the Lower Shire as it is found only at Ruo / Shire confluence.

Value as subsistence food source or commercial fishing

The catch for *M. cyprinoides* is very small an insignificant to constitute a subsistence or commercial fishing.

Status (native, allochthonous or invasive)

The species is native

M. cyprinoides is not an invasive species. Its breeding habitat which is in the off shore areas of the sea makes the species not able to invade rivers where they live as juveniles.

ANGUILLA SPECIES (EELS)

There are two related A. bicolour bicolour and A. nebulosa labiate.

Habitat requirement and regional extent

A. bicolour bicolour is restricted to East Africa. In the Lower Shire, it is found at Bangula lagoon. *A. nebulosa labiate* is fairly common in the Shire River and its tributaries but not in Lake Malawi (Tweddle and Willoughby, 1979).

Water quality requirement

The Anguilla species prefer riverine environments and in sheltered areas such as lagoons.

Flow requirement

The species requires normal river flow

Ability to pass through obstacles

The *Anguilla species* are poor climbers, cannot negotiate through physical barriers

Life cycle (migration, spawning and maturation)

Eels begin their lives in the ocean and spend most of their lives in freshwater, returning to the ocean to die. The eels breed and spawn in the Ocean and the larvae migrate and metamorphose into transparent larvae stage called “glass eels”. The glass eels enter estuaries and migrates streams. In the freshwater glass eels metamorphose into elvers, which are small eels. The eels mature after 5 – 20 years in freshwater. After maturity they migrate back to the sea to breed. The fish caught in the Lower Shire are the immature eels which reside the fresh waters (Schmidt, 1912).

Important habitats and sensitive life cycle stage

Eels from juvenile up to adulthood are residents of the freshwater river courses. Their important life stage is in the ocean where the spawning takes place (Schmidt, 1912).

Identification of their actual threats and protection status

Eels are Near Threaten fish species world-wide by the IUCN.

Value as a food source for the population and their value in the food chain

Eels are food as adults or juveniles, however in the Lower Shire only a few specimens are caught in the main river banks as they bask in the sun.

Distribution status of their endemicity and relative abundance

The fish is fairly abundant throughout the river estuaries in the Lower Shire.

Value as subsistence food source or commercial fishing

Eels are fished for subsistence food by local people in the Lower Shire.

Status (native, allochthonous or invasive)

The species is native.

Eels are not invasive species, they only use the river course (freshwater) to grow from juveniles to adulthood.

HIPPOPOTAMYRUS DISCORTHYNCHUS

Habitat requirement and regional extent

The fish is commonly found in Africa, Cunene, Okavango, Buzi, Pumbwe, Zambezi and the Lower Shire (Bills et al., 2010).

Water quality requirement

The species tolerates tropical conditions of temperature ranging from 22 to 28ºC, freshwater and pH between 5.0 to 8.0 (Bills et al., 2010).

Flow requirement

H. discorthunchus is nocturnal shoaling species which favours large river channels with soft bottom and fringing vegetation. In the Lower Shire, it is found exclusively in the main river course especially in the sheltered bays, lagoons and swampy areas (Bills et al., 2010).

Ability to pass through obstacles

H. discorthynchus has no ability to pass through physical barriers unless the structures are submerged in water.

Life cycle (migration, spawning, maturation)

The fish breeds during the rainy season and females carry up to 5,000 eggs. The fish migrates upstream into the tributaries to breeding during the rainy season (Bills et al., 2010).

Important habitats and sensitive life cycle stage

As any other migratory fish species, *H. discorthynchus* important habitats are the tributaries where the fish spawn and the important stage is during breeding in the rainy season (Bills et al., 2010).

Identification of their actual threats and protection status

H. discorthynchus is classified as of least concern by the IUCN.

Value as a food source for the population and their value in the food chain

The fish is a very important food source for people in the Lower Shire especially during the rainy season. The fish feeds on bottom living invertebrates and insect larvae at night, hence forms a very important part of the food chain in the Lower Shire (Bills et al., 2010).

Distribution status of their endemicity and relative abundance

The species is indigenous in the Lower Shire and is found in abundance throughout the river system with catches raising during the rainy season.

Value as substance food source or commercial fishing

The fishes are used as food for subsistence and there is also potential for commercial fish especially during the rainy season when catches increase.

Status (native, allochthonous or invasive

The species is native

H. discorthynchus does not have invasive abilities.

Mormyrus longirostris

Mormyrus longirostris, is commonly known as the eastern bottle-nosed mormyrid and belongs to the elephant-snout fish in the family Mormyridae.

Habitat requirement and regional extent

M. longirostris is found in abundance across the plains of Africa in freshwater habitats, including the lower and middle Zambezi, lower Sabi and Ludi rivers and in the Luapula-Moero-Bangwelo (Zambian Congo system). It inhabits the Ruvuma and Rufiji rivers in Tanzania, lakes Malawi, Tanganyika and Rukwa and other eastward-flowing rivers in Tanzania (Skelton, 2001).

Water quality requirement

The species lives in caves and muddy areas with soft bottoms. It hides in weeds and characteristically forms small shoals (Skelton, 2001).

Flow requirement

The species inhabits the center of the main river bed where water flow is fast.

Ability to pass obstacles

The species cannot pass through obstacles and physical barriers, unless if they are submerged in flooded water.

Life cycle (migration, spawning, maturation)

Mature males and females actively breed at night, during the rainy season. The fish migrate upstream in rivers after the water has receded. The migrations are at irregular intervals. Females may breed between 10,000 and 70,000 eggs at a time. The fish mature after one year and the maximum body length is 75 cm (Skelton, 2001).

Important habitats and sensitive life cycle stage

The fish inhabits the centre of the main river course rather than the banks. Their important stage is when the fish are breeding during the rainy season because they ascend the streams when the flood waters have receded hence becomes vulnerable to catch by both humans and predators (Skelton, 2001).

Identification of their actual threats and protection status

The species is classified as of least concern in the IUCN Red List.

Value as food source for the population and their value in the food chain

The fish is harvested for food with bait and hook, especially at Chiromo (Tweddle and Willoughby, 1979). The fish feeds primarily on weeds and insects, but also on other small invertebrates, such as small fish and fish eggs. They hunt using electricity and can give a mild electric shock to defend itself from predators (Skelton, 2001).

Distribution status of their endemicity and relative abundance

The fish is found in the Lower Shire and Lake Malawi and is fairly abundant in the Malawian waters.

Value as subsistence or commercial fishing

The species does not have any commercial value but it is caught for food.

Status (native, allochthonous or invasive

The species is native. *M. longirostris* is not an invasive fish species.

ALESTES IMBERI

Habitat requirement and regional extent

Alestes imberi is now known as *Brycinus imberi*. The species is widely distributed from the Congo river basin to the Pongolo river system in Natal (Jubb, 1967). This species, also known as caracin, is the only of the two caracins that are found in Lake Malawi. The species is found in the Lower Zambezi and the Lower Shire. In the Lower Shire, the species is caught in small quantities at Chiromo and Ruo rivers (Jubb, 1967).

Water quality requirement

The species inhabits fresh water with temperatures ranging from 20^{o}C to 28^{o}C, pH range 7.0 to 8.5 (Jubb, 1967).

Flow requirement

The species swims in shoals around estuaries and sheltered waters in the Lake and in the rivers they live in sheltered lagoons and marshes (Jackson, 1961).

Ability to pass through obstacles

A. imberi cannot pass through physical barriers or obstacles because it does not have climbing abilities. However, it may pass through physical barriers if they are submerged in water.

Life cycle (migration, spawning, maturation)

The species breeds during the rainy season, migrating to spawning sites after rains. *Brycinus imberi* migrates to tributary rivers and floodplains when the rivers come down. (Bell-Cross and Minshull 1987). It is known to migrate and congregate at river mouths while waiting for suitable conditions to trigger off the breeding migrations upstream (Bell-Cross and Minshull 1987).

Important habitats and sensitive life cycle stage

Its important habitats are estuaries and sheltered waters and their important stage is when they are juveniles

Identification of their actual threats and protection sites

The species is abundant throughout the water systems of Malawi and are classified as of least concern by the IUCN.

Value as food source for the population and their value in the food chain

The fish is caught for food, but is also preyed upon by the tiger fish in the Lower Shire. The fish feeds on insects, tiny fishes, vegetable matters (Konings 1990) and crustaceans (Bell-Cross and Minshull 1987).

Distribution status of their endemicity and relative abundance

The species is in abundance in Lake Malawi and its catchment but in the Lower Shire the fish are caught in small quantities in the Shire and Ruo rivers and not to constitute an economic activity (Tweddle and Willoughby, 1979).

Value for subsistence food or commercial fishing

The fish is caught for food in small quantities. The fish is suitable for aquarium trade and hence has a commercial value.

Status (native, allochthonous or invasive)

A. imberi is native and does not have invasive qualities.

HEMIGRAMMOPETERSIUS BARNARDI

Hemigrammopetersius is a genus of Africa tetras that contains two described species, *H. bernardi* and *H. pulcher*.

Habitat requirement and regional extent

H. bernadi is widespread and locally abundant in the lower Zambezi, Lake Malawi, Pungwe and Buzi Rivers (Bills et al., 2010).

Water requirement

The fish is found in the upper and middle Shire where the temperatures range from 24ºC to 27ºC (Bills et al., 2010).

Flow requirement

The fish requires fast flowing rivers and it is very common in the lower reaches of the Mwanza river near the confluence with the Lower Shire. Hence mostly inhabits the margins of larger streams, rivers and lakes and it is often associated with the fringes of marginal vegetation (Tweddle and Willoughby, 1979).

Ability to pass through obstacles

The fish resides in the shallow and vegetative areas of the lower reaches and confluence of rivers, hence they do not have ability to negotiate through physical barriers.

Life cycle (migration, spawning, maturation)

The breeding biology is not well described but thought to breed during the rainy season in the vegetative habits of the lower reaches of rivers.

Important habitats and sensitive life cycle stage

The fish inhabits shallow and marshy areas of rivers, hence these are their important habitats. In the Lower Shire, the important habitat is the mouth of the Mwanza and Shire rivers.

Identification of their actual threats and protection status

The species is listed as on least concern by IUCN due to its abundance in the Malawian waters.

Value as food source for the population and their value in the food chain

H. barnadi is not abundant in the Lower Shire but in the lower reaches of the Mwanza River it is caught for food. The fishes are also preyed upon by tiger fish in the Lower Shire.

Distribution status of their endemicity and relative abundance

H. barnadi is indigenous in the Upper and Middle Shire and Lower Reaches of the Mwanza River. In the Lower Shire, the species has not been well established probably due to predation by tiger fish and competition with other species in the area (Tweddle and Willoughby, 1979).

Value as subsistence food source or commercial fishing

In the Upper and Middle Shire and also the lower reaches of Mwanza River, *H. barnadi* is a very important fish species for subsistence fishing. The fish has low commercial value. However, in the Lower Shire the species is less abundance to constitute a viable fishing venture for subsistence and commercial fishing.

Status (native, allochthonous or invasive)

H. barnadi is native and does not have any invasive characteristics.

MICRALESTES ACUTIDENS

Habitat requirements and regional extent

Micralestes is a genus of African tetras. There are currently 17 species in this genus. It is widely distributed in Africa from Sudan to South Africa and as far as east Nigeria on the western side of the continent. It is reported to have spread from Congo and Zambezi basins, including the Cunene and Okavango, and east coast rivers to the phongolo (Skelton, 2001). This species is the only characin found in the northern tributaries of the upper Zambezi system in Zambia (Tweddle et al., 2004).

Water quality requirements throughout their life cycle

M. acutidens is a freshwater pelagic fish species that prefer a pH range of 6.2 - 8.0 and tropical conditions of temperature range between 22°C - 26°C (Skelton, 2001).

Water flow requirement

M. acutidens as a pelagic fish species shoals in clear, flowing or standing, open water of lakes and rivers (Skelton, 1993). In the Lower Shire, it is found in areas where there is fringing vegetation (Tweddle and Willoughby, 1979).

Ability to pass obstacles

M. acutidens does not have the ability to pass through physical barriers, however, since it is potamodromus, i.e., practice spawning migrations to up-streams (Skelton, 1993), it may pass through physical obstacles if they are submerged in water.

Life cycle (migration, spawning, maturing)

The species matures after a year and they congregate the river mouths and migrate up-streams to breed during the first rains. The species are however partial spawners and hence they have moderate fecundity. A typical mature female has less than 700 eggs ripe eggs in her gonads. The mature males and female migrate in shoals upstream after first rains and since they are partial spawners, they breed throughout the rainy season (Skelton, 2001).

Important habitats and sensitive life cycle stage

M. acutidens lives normally in open clear waters with fringing vegetation, hence aquatic vegetation is important for its normal life. During breeding, up-stream environment is important for its recruitment. The species is a partial spawners hence it makes several rounds to the breeding sites to breed through-out the rainy season. Hence, the length of the rainy season is important for its recruitment (Skelton, 2001).

Actual threats and protection status

M. acutidens has a wide distribution, with no known major widespread threats and therefore it is classified by IUCN as of least concern.

Value as food source for population and value in the food chain

The species is omnivorous, often feeding from surface waters on winged insects; also takes insect larvae, crustaceans and eggs and fry of other fish. It is food for humans but it is also preyed upon by tiger fish. It is also used as bait for the Tiger fish.

Distribution and status of endemicity, relative abundance

M. acutidens are indigenous in the Lower Shire and are widely distributed in the Lower Shire and Lower Zambezi River.

Value as subsistence food source or commercial fishing

M. acutidens is caught mostly as a source of food for subsistence by the local fishermen. It does not have a commercial value as a species except for being used as bait for catching Tiger fish.

Status (native, allochthonous or invasive)

M. acutens is native and does not have invasive qualities.

Distichodus mossambicus (Nkupe)

Habitat requirements and regional extent

D. mossambicus is found in the middle and lower Zambezi (including Lake Kariba), Pungwe and Buzi rivers (Mozambique). It is closely related species the *D. schenga* which is also found in the Lower Shire (Bills et al., 2010).

Water quality requirements throughout their life cycle

D. mossambicus is a tropical pelagic freshwater fish species which prefers temperatures between 19 and 28^{o}C (Bell-Cross and Minshull, 1988).

Water flow requirement

The species inhabits swift flowing water, rapids or quiet, deep, sandy or rocky pools (Bell-Cross and Minshull, 1988).

Ability to pass obstacles

The fish migrates up-streams to breed during the rainy season but does not have abilities to negotiate through physical barriers unless if fully submerged in flooding water.

Life cycle (migration, spawning, maturing)

The fish matures after two years. The mature males and females migrate to river mouths and breeds during the rainy season by migrating to suitable sites (Skelton, 2001).

Important habitats and sensitive life cycle stage

D. mossambicus is found only in the mainstreams of larger rivers and prefers riverine habitats. Its important stage is when the ripe males and females are in the river mouths in readiness for spawning migration. The spawning sites up-streams are also important habitats for their life cycle and recruitment.

Actual threats and protection status

Although *D. mossambicus* and its related species the *D. schenga* are only found in the Lower Shire and its tributary the Ruo River they are classified as Least Concern by IUCN.

Value as food source for population and value in the food chain

The Distichodus species are caught in less quantities to constitute and economic activity. The fish is omnivorous hence feeds on insects, snails, small fish and aquatic weeds. It is used as bait for angling especially the Tiger fish.

Distribution and status of endemicity, relative abundance

The *D. mossambicus* and *D. schenga* are confined to the Lower Shire in Chiromo and are found in the Shire and Ruo rivers. They are not abundant to constitute a commercial fishery (Tweddle and Willoughby, 1979).

Value as subsistence food source or commercial fishing

The Distichodus species are caught for subsistence fishing due to their low abundance in the Lower Shire and Ruo rivers. They do not have commercial value except as bait for angling.

Status (native, allochthonous or invasive)

The Distichodus species is native and does not have invasive qualities.

BARBUS AFROHAMILTONI

Habitat requirements and regional extent

The fish is found in lowveld reaches of tropical east coast rivers from the lower Zambezi to the Phongolo; unconfirmed reports from the upper Zambezi, Kafue, Nata and Zambian Congo (Lake Bangweulu) systems (Bills, et al., 2010). In Malawi, it is found in dry season pools of the Thangadzi River in Mwabvi Wildlife reserve (Tweddle and Willoughby, 1979).

Water quality requirements throughout their life cycle

The species is freshwater tropical benthopelagic species requiring water temperatures between 19 and 28^{o}C.

Water flow requirement

The species inhabits still, vegetated waters associated with main river channels of large rivers, and favors marginal pools and lagoons which may be isolated from the main channel (Bills, et al., 2010).

Ability to pass obstacles

The species does not have the ability to pass through physical barriers

Life cycle (migration, spawning, maturing)

The species ascends the Shire river tributaries such as Thangadzi River to breed during the rainy season (Tweddle and Willoughby, 1979).

Important habitats and sensitive life cycle stage

The important habitats for the species are the seasonal pools that are cut off from main rivers during flooding

Actual threats and protection status

The species has no particular status.

Value as food source for population and value in the food chain

Barbus afrohamiltoni is caught for food by humans and its diet is mainly insects.

Distribution and status of endemicity, relative abundance

Barbus afrohamiltoni has limited distribution in the Study area and is only found in the vegetative waters associated with main river channels in the Mwabvi Wildlife Reserve (Tweddle and Willoughby, 1979).

Value as subsistence food source or commercial fishing

The fishes are caught for subsistence among the local communities

Status (native, allochthonous or invasive)

B. afrohamiltoni is native and does not have any invasive qualities.

BARBUS CHOLOENSIS

Habitat requirements and regional extent

B. choloensis is restricted to the Lower Shire, Lower Zambezi system in Malawi (Skelton, 1993). It is also found in Mwabvi, Ruo and Nswadzi rivers. The species is common in Ruo River above the Zoa falls.

Water quality requirements throughout their life cycle

The species is tropical freshwater benthopelagic restricted to the Lower Sire and Zambezi river system (Skelton, 1993).

Water flow requirement

The species prefers running water and rocky habitats

Ability to pass obstacles

The species does not have ability to negotiate physical barriers

Life cycle (migration, spawning, maturing)

The species breeds in rivers during the rainy season (details not available).

Important habitats and sensitive life cycle stage

It inhabits a series of rock sills upstream of falls (Tweddle and Willoughby, 1979)

Actual threats and protection status

The species is classified as vulnerable by the IUCN due to their limited distribution

Value as food source for population and value in the food chain

The fishes are caught for food for humans. Information about their feeding biology is limited.

Distribution and status of endemicity, relative abundance

It is limited to the Lower Shire (in the Mwabvi River) and Ruo rivers. Fishes are found in abundance in the Ruo River (Tweddle and Willoughby, 1979) (Tweddle and Willoughby, 1979).

Value as subsistence food source or commercial fishing

The species is important as a subsistence food source

Status (native, allochthonous or invasive)

B. choloensis is native and does not have invasive characteristics.

BARBUS HAASIANUS

Habitat requirements and regional extent

The species is widely distributed and in Africa, it is found in the Okavango, Upper and Lower Zambezi, Kafue, and Pungwe systems. It is also found in the middle Congo basin, in the upper Lulua (Kasai drainage), in the upper Congo basin in the upper Lualaba, Luapula, Lake Bangweulu and Bangweulu swamps (Betram, 1943).

Water quality requirements throughout their life cycle

Barbus haasianus is a tropic bethopelagic fish species and is adapted to temperatures between 19^{o}C to 28^{o}C (Betram, 1943).

Water flow requirement

The fish inhabits swamps and floodplains in well-vegetated habitats (Skelton, 1993).

Ability to pass obstacles

The fish does not have abilities to pass through physical barriers

Life cycle (migration, spawning, maturing)

Mature males develop rose red colors and together with the females, they make lateral movements onto floodplains to spawn as the floodwaters rise (Tweddle *et al.* 2004).

Important habitats and sensitive life cycle stage

The important habitats are swamps and floodplains and their important stage is the flooding season as the species migrates to spawn in the floodplains.

Actual threats and protection status

The species has no special status.

Value as food source for population and value in the food chain

The fish feeds mainly insect larvae and zooplankton and is used as food for humans and also bait for angling

Distribution and status of endemicity, relative abundance

The fish is restricted to the Lower Shire in Malawi.

Value as subsistence food source or commercial fishing

The fish is used for subsistence consumption and aquarium trade

Status (native, allochthonous or invasive)

B. *haasianus* is native and does not have invasive characteristics.

BARBUS KERSTENII

Habitat requirements and regional extent

B. kerstenii is a bentho-pelagic tropical fish species. In Africa, it is found in Cunene, Okavango, upper and Lower Zambezi, tributaries of the lower Zambezi such as the Shire River. It is also found in the Pungwe, Buzi and Kafue systems. In the African lakes, fishes are found in Lake Victoria, Tanganyika, Edward and Kivu basins. The species is also found in the Lake Malawi system, the Upper Congo system and coastal river basins in Kenya and Tanzania (Skelton, 1993).

Water quality requirements throughout their life cycle

The species is fresh water; bentho-pelagic preferring a pH range of 6.5 - 7.5 and a temperature of 23°C - 26°C (Skelton, 1993).

Water flow requirement

The species has a wide range of environmental conditions, it inhabits lakes and rivers, especially fast flowing, sluggish and temporary streams. It also inhabits mountain streams and along vegetated fringes of large rivers and in rocky bottom environments (Tweddle and Willoughby, 1979).

Ability to pass obstacles

The fish moves fast in shoals and may pass through physical barriers if they are submerged with flooded water.

Life cycle (migration, spawning, maturing)

The fish migrates up stream and breeds in the flood plains during the rainy season. The mature and males and females congregate the river mouths before the rainy season and up-stream migration (Skelton, 1993).

Important habitats and sensitive life cycle stage

The important habitats are up-stream breeding ground and flood plains where the fish spawn.

Actual threats and protection status

The fish is classified as being of least concern because of their wide distribution

Value as food source for population and value in the food chain

The fish is caught for food, feeds on insects, debris, mollusks, plant material, seeds and algae.

Distribution and status of endemicity, relative abundance

The species is widely distributed in the African waters and in Malawi it is found in both the Lake Malawi and Lower Shire systems.

Value as subsistence food source or commercial fishing

The fish is caught for subsistence consumption

Status (native, allochthonous or invasive)

The species is native and not invasive when introduced into alien environments.

BARBUS MACROTAENIA

Habitat requirements and regional extent

B. macrotaenia is found in Lake Malawi, Shire River (Lower Zambezi system) and Buzi River. It is also reported in Pungwe River (Bills et al., 2010)

Water quality requirements throughout their life cycle

The species occurs in the streams in the Lower Shire as well as sheltered inshore areas of lakes. In Lake Malawi, it is found in the shelter of floating Islands of reeds (Skelton, 1993).

Water flow requirement

The species does not prefer fast flowing rivers hence resides in the shelters or marshy habitats.

Ability to pass obstacles

The species is not able to pass through physical obstacles unless if they are submerged in flooded water.

Life cycle (migration, spawning, maturing)

B. macrotaenia migrates upstream during the rainy season to breed and breeds in marshy habitats (Tweddle and Willoughby, 1979).

Important habitats and sensitive life cycle stage

The important habitats for the species in the Lower Shire are marshy areas such as the elephant and Ndinde marshes. The important life style stage is during spawning migrations in streams.

Actual threats and protection status

The species is classified by IUCN as of least concern because it is widely distributed and has no known major widespread threat (Bills et al., 2010).

Value as food source for population and value in the food chain

The fish is harvested for human consumption and their diet is mainly zooplankton and small insects.

Distribution and status of endemicity, relative abundance

The species is widely distributed in both the Lake Malawi and Lower Shire systems

Value as subsistence food source or commercial fishing

The species is used as food for humans but it is also used in the aquarium trade.

Status (native, allochtonous or invasive)

The species is native and does not have invasive characteristics when introduced in alien habitats.

BARBUS MAREQUENSIS

Habitat requirements and regional extent

The fish is widely distributed in Malawi; Mozambique; South Africa (Gauteng, KwaZulu-Natal, Limpopo Province, Mpumalanga); Swaziland; Zambia; Zimbabwe. They inhabit the middle and lower Zambezi systems in Zambia and Zimbabwe south to the Phongolo River in South Africa. In Malawi, it is found in the Lower Shire which shares the same ecological conditions with the Lower Zambezi (Bills, et al, 2010).

Water quality requirements throughout their life cycle

The species is tropical fish species preferring fast flowing waters with temperatures ranging from 20ºC to 28ºC (Bills et al., 2010).

Water flow requirement

The species prefers flowing waters of larger streams and rivers. They can also inhabit dams but the population in dams is low. Preferred habitats of larger adults are the rocky rapids and deeper pools (Bills et al., 2010).

Ability to pass obstacles

The species does not have ability to pass through physical obstacles. The IUCN reports that their conservation efforts are affected by dam weir obstruction (Bills et al., 2007).

Life cycle (migration, spawning, maturing)

B. marequensis is a full migrant; it migrates in rivers to breed during the rainy season.

Important habitats and sensitive life cycle stage

The important habitats are large streams and deep dams. The species migrates to breed in streams during the rainy season so its important life stage is during the breeding season in streams.

Actual threats and protection status

The species is classified as of least concern by the IUCN because it is widely distributed and is in abundance.

Value as food source for population and value in the food chain

The species is a benthic (bottom) feeder, preying mostly on zooplankton and other small benthic organisms and insects. It is also caught and used as food for humans.

Distribution and status of endemicity, relative abundance

The species is widely distributed and found in abundance in the Lake Malawi and Lower Shire systems.

Value as subsistence food source or commercial fishing

The fish is caught as food for humans.

Status (native, allochthonous or invasive)

B. marequensis is native and does not have invasive qualities.

BARBUS RADIATUS

Habitat requirements and regional extent

B. radiates is widely distributed in Africa. It is found in Aswa River in Uganda southwards along the whole coast of East Africa up to the Limpopo, Inkomati and Umbelezi River systems in Transvaal, South Africa. It is also found in the upper Congo drainage including the Malagarazi system and Lakes Bangweulu and Mweru, the whole Zambezi system including the Lower Shire and Okavango, and as far as the Cuanza and Cunene Rivers in Angola and the upper Kasaï in the Democratic Republic of Congo and Angola (Poll, 1967).

Water quality requirements throughout their life cycle

B. radiates is a tropical fish species, preferring temperature ranges from 20 to 28^{o}C.

Water flow requirement

The species inhabits marshes and marginal vegetation of streams, rivers and lakes. The fish is active in subdued light and at night (Skelton, 1993).

Ability to pass obstacles

The species does not have ability to pass through obstacles and physical barriers

Life cycle (migration, spawning, maturing)

The species migrates up stream to breed during the rainy season and attains maturity after 2 years.

Important habitats and sensitive life cycle stage

The important habitats for the fish are marshy and marginal vegetation areas of the Lower Shire and the important life stage is during spawning migration and when the fishes are in the breeding grounds in streams (Skelton, 1993).

Actual threats and protection status

B. radiates is classified as of least concern by the IUCN because it is widely distributed.

Value as food source for population and value in the food chain

B. radiates feeds on benthic organisms and is caught for human food.

Distribution and status of endemicity, relative abundance

The species is widely distributed throughout the Lake Malawi and Lower Shire systems

Value as subsistence food source or commercial fishing

The people in the Lower Shire catch the *B. radiates* for food.

Status (native, allochthonous or invasive)

B. radiates is native and does not have invasive qualities when introduced into alien habitats.

BARBUS TRIMACULATUS

Habitat requirements and regional extent

B. trimaculatus is widely distributed throughout sub-Saharan Africa, from the upper Congo to the east coast in Tanzania and south to Natal, South Africa. In Malawi it occurs in all streams, including the Lower Shire as well as in Lakes Malawi, Chilwa and Chiuta (Bills et al., 2010).

Water quality requirements throughout their life cycle

B. trimaculatus is benthopelagic, potamodromous tropical fish species that requires water temperatures ranging from 20 to 28^{o}C (Konings, 1990).

Water flow requirement

The species does not like fast flowing waters. It is found in shallow water near river outlets or close to swampy areas (Konings 1990).

Ability to pass obstacles

B. trimaculators does not have the ability to pass through physical barriers.

Life cycle (migration, spawning, maturing)

B. trimaculatus breeds during the rainy season, with shoals of ripe adults moving upstream in spate after rain. Females produce as many as 8,000 eggs (Skelton 1993).

Important habitats and sensitive life cycle stage

B. trimaculatus inhabits a wide range of habitats, especially where there is vegetation. It occurs in main channels of large rivers and penetrates high into some tributary systems and may also be present in isolated floodplain pools. Its important stage is when it is found in isolated flood pools where it is easily preyed upon by predators or caught by humans (Skelton, 1993).

Actual threats and protection status

The species is classified as of least concern by the IUCN because of its wide distribution.

Value as food source for population and value in the food chain

The species is caught for consumption by humans. The fish feeds on insects and other small organisms, and seeds of plants.

Distribution and status of endemicity, relative abundance

The fish is widely distributed in Malawi and it is indigenous in the Lake Malawi and Lower Shire river system.

Value as subsistence food source or commercial fishing

The fish is caught for human consumption. It is also used in aquaculture and large aquariums

Status (native, allochthonous or invasive)

B. trimaculatus is native and does not have invasive qualities.

BARBUS LINEOMACULATUS

Habitat requirements and regional extent

The species is widely distributed in Africa. It is found in Cunene, Okavango, Zambezi and Limpopo systems, common in Zimbabwe and Zambia; also widespread in Central and East Africa, In the southern and eastern Africa, it is distributed from the upper Congo River basin. It is also found in the Mweru-Luapula and Bangweulu-Chambeshi areas of the upper Congo River basin. In Malawi, fishes are found in both the Lake Malawi and Lower Shire systems (Skelton, 1991).

Water quality requirements throughout their life cycle

B. lineomaculatus is a tropical freshwater benthopelagic and potamodromous fish species that prefers temperatures ranging from 22°C - 25°C (Skelton, 1991).

Water flow requirement

The fish requires flowing rivers because it inhabits a wide range of river habitats from small streams to large rivers.

Ability to pass obstacles

The fish does not have the ability to pass through physical barriers and obstacles

Life cycle (migration, spawning, maturing)

The species migrates upstream to breed in flooded grassy areas (Skelton, 1993).

Important habitats and sensitive life cycle stage

The habitats are the main courses of both small and large rivers where they reside and the important stage is when they are breeding is shallow grassy habitats.

Actual threats and protection status

The species is classified as of least concern by the IUCN because it is widely distributed with no known major wide spread threat.

Value as food source for population and value in the food chain

The fish feeds mainly on insects and it is a valuable food source for humans

Distribution and status of endemicity, relative abundance

The species is indigenous to Lake Malawi and Lower Shire systems. It is widely distributed with no known major wide spread threat.

Value as subsistence food source or commercial fishing

The fish is mainly used as a source of food for subsistence

Status (native, allochthonous or invasive)

B. lineomaculatus is native and does not have invasive abilities.

BARBUS TOPPINI

Habitat requirements and regional extent

This species is found in east Africa from Kenya to South Africa. In Eastern Africa, the species are found in the Lower Tana and Sabaki drainages and Northern Ewaso Nyiro. In Malawi, the species are found in Lakes Chiuta and Chilwa and the Lower Shire River (Skelton 1993).

Water quality requirements throughout their life cycle

The species is tropical freshwater benthopelagic fish species. It prefers a neutral water pH 7.0 and a temperature of 22 to 26^{o}C (Skelton, 1993).

Water flow requirement

The species does not like fast flowing rivers, but slow flowing sections of rivers.

Ability to pass obstacles

The species does not ability to pass through physical obstacles

Life cycle (migration, spawning, maturing)

The fish migrates river tributaries to breed during the first rains (Skelton, 2001).

Important habitats and sensitive life cycle stage

The species is usually found in vegetated, non- or slow flowing sections of rivers and river margins. It is also found in marginal lagoons, isolated pans in floodplains. Hence, each stage is important because of its presence in shallow waters.

Actual threats and protection status

The fish is classified by IUCN as of least concern because it has wide distribution with no known threat.

Value as food source for population and value in the food chain

The species feeds on small aquatic organisms and is harvested for human food

Distribution and status of endemicity, relative abundance

The fish is widely distributed and is indigenous in Lake Malawi and Lower Shire systems

Value as subsistence food source or commercial fishing

The fish is mainly used as a subsistence source of food for human

Status (native, allochthonous or invasive)

Barbus toppini is native and does not have invasive capabilities.

Barbus viviparous

Habitat requirements and regional extent

B. viviparous originated from the Zambian Congo system and is prevalent on the Congo and Okavango river systems. Only isolated populations occur in Malawi (Skelton, 1993).

Water quality requirements throughout their life cycle

The species is a tropical freshwater, benthopelagic fish species, preferring a pH range of 6.5 - 7.0 and a temperature of 22°C - 24°C (Skelton, 1993).

Water flow requirement

The fish does not require fast flowing river flows. It is found in flood plains in the Lower Shire and in pools and shallow streams with vegetation (Skelton, 1993).

Ability to pass obstacles

The species does not have the ability to pass through physical barriers

Life cycle (migration, spawning, maturing)

The species migrates upstream to spawn after heavy rains

Important habitats and sensitive life cycle stage

B. viviparous lives in shallow waters and pools that represent their important habitats. They migrate to spawn in rivers immediately after a heavy down pour rain (Skelton, 1993).

Actual threats and protection status

The species is classified as of least concern by IUCN because they are wide spread

Value as food source for population and value in the food chain

The fish is harvested for human population. The *B. viviparous* feeds on detritus, algae, seeds, small invertebrates (Skelton, 1993) and aquatic insects larvae (Bell-Cross and Minshull, 1988).

Distribution and status of endemicity, relative abundance

The fish is indigenous and widespread in Malawi.

Value as subsistence food source or commercial fishing

The fish is mostly harvested for human consumption.

Status (native, allochthonous or invasive)

The species is native and does not have invasive characteristics.

BARILIUS ZAMBENSIS **SYNONYMOUS WITH** OPSARIDIUM ZAMBEZENSIS

Habitat requirements and regional extent

In Africa, the species is widely distributed in the upper Kasai, Zambezi, Okavango, Pungwe, Limpopo and Buzi river systems (Leveque and Daget, 1984).

Water quality requirements throughout their life cycle

It is a tropical fish preferring water temperatures ranging from 20 to 28ºC (Leveque and Daget, 1984).

Water flow requirement

The fish does not require fast flowing waters because it is usually found in clear, flowing waters of larger perennial rivers, frequenting pools below rocky rapids (Lévêque and Daget 1984). It is also found in quiet water with aquatic cover. It lives in shoals, usually in shallow water over sandy bottoms (Leveque and Daget, 1984).

Ability to pass obstacles

The species does not have the ability to pass through physical barriers

Life cycle (migration, spawning, maturing)

O. zambezensis breeds during the rainy season. It migrates rivers and tributaries to breed in swallow vegetative spawning grounds.

Important habitats and sensitive life cycle stage

The important habitats for *O. zambezensis* in the Lower Shire are the flood plains and pools below rocky falls. The important life cycle period is during spawning migration.

Actual threats and protection status

The *O. zambezensis* is classified as of least concern by the IUCN because the species is wide spread with no known threats.

Value as food source for population and value in the food chain

The species feeds on aquatic larvae and insects, shrimps and small crustaceans (Bell-Cross and Minshull, 1988) and it is harvested for human food.

Distribution and status of endemicity, relative abundance

O. zambezensis is widely distributed is in abundance with no known threats to their extinction.

Value as subsistence food source or commercial fishing

The species is harvested as a source of subsistence food for local people.

Status (native, allochthonous or invasive)

O. zambezensis is native and is not invasive when introduced into alien areas.

LABEO CONGORO

Habitat requirements and regional extent

The fish is widely distributed in Africa from the Democratic Republic of Congo to South Africa. It is also found in Malagarasi, and Rufiji and Ruaha river systems and in the Lower Shire in Malawi (Bills et al., 2010).

Water quality requirements throughout their life cycle

The species is tropical and prefers temperature range from 20 to 28ºC (Bills et al., 2010).

Water flow requirement

L. congoro prefers strong flowing rocky stretches of larger perennial rivers (Bills et al., 2010)

Ability to pass obstacles

The species has ability to climb physical barriers especially if they are submerged in flooding waters.

Life cycle (migration, spawning, maturing)

The fishes are full migrant species. They are stimulated by swollen water levels in rivers and they migrate up-streams to breed.

Important habitats and sensitive life cycle stage

Important habitats are river mouths during the rainy season. It is also the time when they are caught in large numbers with ripe gonads.

Actual threats and protection status

The fish is classified by IUCN as of least concern

Value as food source for population and value in the food chain

The diet for the fish is algae 'aufwuchs' which it grazes from rocks and firm surfaces including the backs of hippos leaving characteristic tracks. The fish is an important source of food for humans (Bills et al., 2010).

Distribution and status of endemicity, relative abundance

The species is widespread distribution in the Lower Shire, although it is subjected to high fishing intensity.

Value as subsistence food source or commercial fishing

The fish is harvested for both food and sale

Status (native, allochthonous or invasive)

The fish is native and does not have any invasive qualities.

LABEO ALTIVELIS

Habitat requirements and regional extent

This species is found in Africa from the Democratic Republic of Congo to Zimbabwe and Mozambique. It is also found from the upper Congo River and the Luapula-Mweru region and Lake Bangweulu of the Democratic Republic of the Congo (Reid 1985). In Malawi, it is found in the Lower Shire River (Bills et al., 2010).

Water quality requirements throughout their life cycle

The species is a tropical freshwater benthopelgic and potamodromous fish species. Its temperature range is 19 to 28^{o}C (Bills et al., 2010).

Water flow requirement

Labeo altivelis prefers large rivers but also inhabits lakes and dams.

Ability to pass obstacles

The species has the ability to climb rocks and physical barriers to graze algae. It can pass through physical obstacles especially if they are submerged in water.

Life cycle (migration, spawning, maturing)

Mature males and females congregate on river mouths during the onset of rains and migrate upstream into tributaries to breed during the rainy season. From October to December, mature fish gather and migrate to the spawning grounds. They go up to the spawning grounds and under-go one massive short duration spawning between January and March (Bills et al., 2010).

Important habitats and sensitive life cycle stage

The most important habitats are the river mouths and shallow spawning grounds upstream. The species migrates upstream in mass moving out of the stream to the flood plains, this is therefore an important life cycle period.

Actual threats and protection status

The fish has no special status.

Value as food source for population and value in the food chain

The fish grazes algae and ‘aufwuchs’ from rocks and it is an important food fish species for humans (Bills et al., 2010).

Distribution and status of endemicity, relative abundance

The fish is indigenous in the Lower Shire

Value as subsistence food source or commercial fishing

The fish is caught for both food and sale

Status (native, allochthonous or invasive)

Labeo altivelis is native and does not have invasive capabilities.

LEPTOGLANIS ROTUNDICEPS **SYNONYMOUS WITH** ZAIREICHTHYS ROTINDICEPS

Habitat requirements and regional extent

The species has a wide distribution in Africa from the Democratic Republic of Congo to Kenya to South Africa. It is also found in Lubumbashi River, in the middle and lower Zambezi as well as the Lake Malawi catchment area. The species is not found in the Shire River but in the tributaries of the Shire River (Skelton, 1991).

Water quality requirements throughout their life cycle

It is a tropical fish requiring water temperatures ranging from 19ºC to 28ºC (Skelton, 1991).

Water flow requirement

The species does not require high water flow, but inhabits fairly shallow water. It is usually buried in the sand and leaves only a protruding eye (Bell-Cross and Minshull, 1988).

Ability to pass obstacles

The species cannot climb up physical barriers

Life cycle (migration, spawning, maturing)

The fish breeds in the streams where it resides. The female lays very few eggs of between 12 to 16 which are large in diameter (3-5 mm) hence the fish is believe to practice parental care (Skelton, 1993).

Important habitats and sensitive life cycle stage

The important habitats are the shallow sandy areas of the tributaries of the Shire River where the fish resides and spawns

Actual threats and protection status

The species is classified as of least concern by IUCN

Value as food source for population and value in the food chain

The fish feeds on minute organisms but they are harvested for human food.

Distribution and status of endemicity, relative abundance

The fish is thought to be abundant throughout their native environments

Value as subsistence food source or commercial fishing

The fish is harvested and used for food by humans

Status (native, allochthonous or invasive)

Leptoglanis rotundiceps or *Zaireichthys rotindiceps* is native and does not have invasive characteristics.

HETEROBANCHUS LONGIFILIS

Habitat requirements and regional extent

The species is wide distributed all over the African continent. In Malawi, it is found in all the water systems (Skelton, 1993).

Water quality requirements throughout their life cycle

H. longifilis requires tropical temperatures between 19 to 22ºC (Skelton, 1993).

Water flow requirement

The species is found in quite waters with deep pools and stretches, not necessarily associated with vegetation, in larger waterways and main river channels (Teugels *et al.* 1990).

Ability to pass obstacles

The species cannot climb over physical barriers

Life cycle (migration, spawning, maturing)

The species under-goes a spawning migration from the normal dry season habitat into the tributary rivers and floodplains during the rainy season (Teugels *et al.* 1990), eggs and juveniles are found among plants roots in shallow water. It lives for 12 or more years.

Important habitats and sensitive life cycle stage

The important habitats are tributary rivers and flood plains where the fish breed.

Actual threats and protection status

The species is classified by IUCN as of least concern because it is widely distributed.

Value as food source for population and value in the food chain

The fish is eaten by humans as food it is one of the large fish species in the Shire and may weigh up to 15 kg. The species is an omnivore scavenger that mostly and actively feed at night. The diet is any available food, including invertebrates and insects while young, fish and other small vertebrates when they are grown up (Teugels et al., 1990).

Distribution and status of endemicity, relative abundance

The fish is found in all the water system of Malawi.

Value as subsistence food source or commercial fishing

The fish is caught for both subsistence and for sale

Status (native, allochthonous or invasive)

The fish is native and does not have any invasive characteristics

MALAPTERURUS ELECTRICUS

Habitat requirements and regional extent

M. electricus is widely distributed in Africa. They are found in Zambezi, Nile, Niger, Volta rivers and lakes Chad and Tanganyika (Hee, 2000).

Water quality requirements throughout their life cycle

The species requires temperatures ranging from 23 to 30ºC and pH of 6.5 to 8.2 (Hee, 2000).

Water flow requirement

The species does not like fast flowing water but are generally found among rocks or roots in turbid or black waters with low visibility. It favors sluggish or standing water.

Ability to pass obstacles

The fish does not have ability to climb over physical obstacles

Life cycle (migration, spawning, maturing)

When mature, the fish pairs up and the breeding pairs dig holes which are used as nests. The holes may be as deed at 3 meters and are usually excavated in clay banks that are submerged in water 1–3 m deep. The eggs hatch and the young ones move into the deep waters as they grow. (Hee, 2000).

Important habitats and sensitive life cycle stage

The important habitats are the nesting holes and the important life cycle stage is when the pairs are breeding in the nets and when the eggs have hatched into larvae in the nesting holes.

Actual threats and protection status

The species is classified as of least concern by the IUCN

Value as food source for population and value in the food chain

The fishes are harvested and used as food for humans. The diet of the species is live fish, and earthworms. It generates electric current to stun the prey.

Distribution and status of endemicity, relative abundance

In the Lower Shire, the fish is caught in the river (Shire and Ruo) and in the marshes of the Shire River.

Value as subsistence food source or commercial fishing

The fishes are caught for both subsistence and sale. They are also used as game fish.

Status (native, allochthonous or invasive)

M. electricus is native and does not have invasive capabilities.

CHOLOGLANIS NEUMANNI

Habitat requirements and regional extent

C. neumanni is widely distributed in all the African waters, including the Limpopo, Kafue and Zambezi river systems (Bills, et al., 2010).

Water quality requirements throughout their life cycle

The species requires water temperatures between 20 to 26^{o}C and pH of 6.0-7.5 (Bills et al., 2010).

Water flow requirement

The fish inhabits both the rocky and fast flowing rivers and the Lake environment (Bills et al., 2010).

Ability to pass obstacles

The species does not have ability to pass through physical obstacles

Life cycle (migration, spawning, maturing)

Data on breeding and spawning is limited.

Important habitats and sensitive life cycle stage

No data is available

Actual threats and protection status

No data is available for the species classification

Value as food source for population and value in the food chain

The fish feeds on bio-cover on rocks and grazes on algae

Distribution and status of endemicity, relative abundance

The fish is indigenous to Lake Malawi and Lower Shire systems and is widely distributed

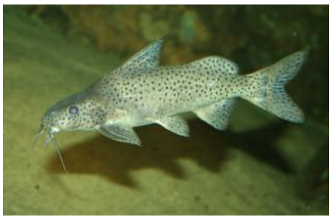
Value as subsistence food source or commercial fishing

The fish is caught for food for the local people

Status (native, allochthonous or invasive)

The species is native and does not have any invasive qualities.

SYNODONTIS ZAMBEZENSIS



Habitat requirements and regional extent

This species is known from middle and lower Zambezi River, south to the Phongolo River in South Africa (Skelton, 1991).

Water quality requirements throughout their life cycle

It is a tropical fish adapting to a wide range of pH 6.5 -7.8 and temperatures between 18.5ºC to 25ºC (Skelton, 2001).

Water flow requirement

The species is found in lower reaches of riverine habitats in larger streams and rivers (Tweddle and Willoughby, 1979).

Ability to pass obstacles

The species does not have the ability to pass through physical barriers

Life cycle (migration, spawning, maturing)

The spawning process is not reported but thought to breed during the rainy season

Important habitats and sensitive life cycle stage

The fish resides in pools and slow-flowing reaches of perennial and seasonal rivers. The species prefers riverine habitats to flood plains. It finds shelter in holes or crevice or on the underside of logs, frequently in an upside down position.

Actual threats and protection status

The species is classified as of least concern by the IUCN

Value as food source for population and value in the food chain

The fishes are harvested as food for the human population.

Distribution and status of endemicity, relative abundance

The species is in abundance in the Lower Shire

Value as subsistence food source or commercial fishing

The fish is harvested for food

Status (native, allochthonous or invasive)

The species is native and does not have any invasive qualities.

APLOCHEILICHTHYS HUTEREAUI

Habitat requirements and regional extent

The species is found in Lakes and river drainages in Chad, Central African Republic, Sudan, Uganda, the Congo, Zambia, Botswana, Namibia and the Lower Shire in Malawi (Bills, et al., 2010).

Water quality requirements throughout their life cycle

The species is tropical benthopelagic species preferring temperatures between 20^{o}C and 28^{o}C (Bills et al., 2010).

Water flow requirement

The species does not require flowing rivers but prefers stagnant water in pools and swamps.

Ability to pass obstacles

The fish cannot pass through physical obstacles

Life cycle (migration, spawning, maturing)

The fish does not migrate to breed but breeds in the marshy areas of the flood plains during the rainy season (Skelton, 1993).

Important habitats and sensitive life cycle stage

The important habits are the swamps, floods plains and marshes which the fish normally inhabits and also use for spawning.

Actual threats and protection status

Not classified by IUCN due to insufficient data

Value as food source for population and value in the food chain

The fish feeds on benthic organisms and are in turn harvested as food for humans

Distribution and status of endemicity, relative abundance

The fish is seasonally caught in the Lower shire especially in the marshy areas and lagoons, especially at the end of the rainy season.

Value as subsistence food source or commercial fishing

The fish is harvested as food for humans

Status (native, allochtonous or invasive)

The fish is native and is not invasive when introduced into alien areas.

APLOCHEILICHTHYS KATANGAE

Habitat requirements and regional extent

A. katangae is widely distributed in southern Africa. It inhabits rivers and lakes of the southern Democratic Republic of Congo, eastern Angola, Botswana, Zambia, Zimbabwe, Malawi, Mozambique, South Africa and Namibia (Wildekamp, 1995).

Water quality requirements throughout their life cycle

The species is freshwater benthopelagic, preferring a pH range of 6.5 - 7.2 and temperature ranging from 20°C - 28°C (Wildekamp, 1995).

Water flow requirement

A. katangae does not inhabit fast flowing rivers but shallow vegetative habitats.

Ability to pass obstacles

A. katangae does not have abilities to pass through physical barriers

Life cycle (migration, spawning, maturing)

The species is serial spawners that lays eggs on vegetation within their habitats; hence the species is non-migratory (Wildekamp, 1995).

Important habitats and sensitive life cycle stage

The species is found in schools mainly in the shallow and vegetated part of small rivers, brooks and swamps, and in the shallow parts of lakes. Its important stage is during breeding because it requires vegetative habitats.

Actual threats and protection status

The species is classified as of least concern by the IUCN due to their wide distribution throughout the Southern African region.

Value as food source for population and value in the food chain

The fish feeds on insect larvae, daphnia and other small invertebrates. It is harvested for human consumption.

Distribution and status of endemicity, relative abundance

The species is indigenous in the marshy areas of the Lower Shire and are widely distributed.

Value as subsistence food source or commercial fishing

The fish is harvested for consumption by humans

Status as allochtonous or invasive species

A. katangae is native and is not invasive

NOTHOBRANCHIUS ORTHONOTUS

Habitat requirements and regional extent

The distribution of this species extends from Malawi and Mozambiaque, south to KwaZulu-Natal, South Africa. In Eastern Africa, it is only known to occur in the Lower Shire in Malawi (Skelton, 1991).

Water quality requirements throughout their life cycle

It is a tropical fish species preferring temperatures ranging from 20 to 28^{o}C.

Water flow requirement

N. orthonotus inhabits temporary water pools and may also be found in swamps intermittently connected to floodplains

Ability to pass obstacles

The fish does not have ability to pass through physical barriers

Life cycle (migration, spawning, maturing)

The fish species is not migratory but lays eggs in the bottom sediments. Soon after the water in the pool dries up, and the adult fish die. The eggs hatch during the following rainy season when the pan or pool re-fills. The fish grows to maturity in a few weeks followed by spawning for an extended period (Bills et al., 2010).

Important habitats and sensitive life cycle stage

Important habitats are the pools where the fish spawns and lives its annual life. The hatching of eggs depends upon the refilling of the pool during the next rainy season.

Actual threats and protection status

In Malawi, the fish is classified as vulnerable because it is found only in the Lower Shire. It is threatened by spraying agricultural fields and road building projects.

Value as food source for population and value in the food chain

The fish feeds on insects and aquatic invertebrates (Bills, et al., 2010).

Distribution and status of endemicity, relative abundance

The fish is endemic in the Lower Shire only in Malawi, but found in abundance.

Value as subsistence food source or commercial fishing

Fishes are harvested as food for human consumption.

Status (native, allochthonous or invasive)

The fish is native and is not invasive

HAPLOCHROMIS PHILANDER

Habitat requirements and regional extent

The species is found in Southern Africa from the Kasai branch of Congo River all the way to Natal, South Africa. It is found in the Lower Shire in Malawi and has its relative synonyms among the endemic *Haplochromine species* of Lake Malawi (www.malawicichlids.com).

Water quality requirements throughout their life cycle

This is a tropical fish preferring pH around 7.0 and temperature ranging from 20 to 25ºC

Water flow requirement

The species is found in various habitats, from flowing waters to lakes and isolated sinkholes, but usually prefers vegetated zones

Ability to pass obstacles

The fish does not have abilities to pass through physical barriers

Life cycle (migration, spawning, maturing)

It breeds from August to late February and mature males identify and defend a territory, construct a simple cleared nest and attract ripe females. Females collect the eggs almost immediately after laying a batch and incubates eggs in her mouth for 12-14 days at 26°C. Parent guards the young for 5-7 days, keeping them into her mouth when approached by predators or divers (Skelton, 1991).

Important habitats and sensitive life cycle stage

The important habitats are the breeding grounds where the nests are constructed and also the nursery areas where the female brood her eggs and guard the young.

Actual threats and protection status

The species has not been evaluated by the IUCN, so their threats are unknown.

Value as food source for population and value in the food chain

The species feeds on insects, shrimps and even small fish. The fish is harvested for human consumption.

Distribution and status of endemicity, relative abundance

The species is widely distributed in the Lower Shire and are found in abundance.

Value as subsistence food source or commercial fishing

The fish is caught for human food at home or for sale

Status (native, allochthonous or invasive)

The species is native and is not invasive

PSUDOCRENILABRUS PHILANDER

Habitat requirements and regional extent

The fish widely distributed in Africa from the Orange River system and southern Natal northwards throughout southern Africa, extending to southern Congo basin tributaries and Lake Malawi. It is also found in the Lower Zambezi and Lower Shire River (Bills et al., 2010).

Water quality requirements throughout their life cycle

The species is freshwater benthopelagic fish which prefers pH around neutral 7.0 and temperatures ranging from 22°C - 25°C (Bills et al., 2010).

Water flow requirement

P. philander has adapted to a wide range of habitats, from flowing waters to lakes and isolated sinkholes and usually prefers vegetated zones of rivers (Bills et al., 2010).

Ability to pass obstacles

The species does not have migratory qualities hence cannot pass through physical obstacles.

Life cycle (migration, spawning, maturing)

The species breeds from early September to late March. Mature males build a nest and defend the territory in which the nest is constructed. The males attract ripe females to breed at the nest. The eggs are fertilized and collected by the female to mouth brood. The females withdraw to a nursery to brood the eggs until juvenile stage. Usually during spawning, the female lays batches of eggs on a substratum which the male begins to inseminate. Female collects the eggs almost immediately after laying a batch and incubates eggs in her mouth for 12-14 days at 26°C. When the juveniles are released, the female guards the young for 5-7 days, keeping them into her mouth when it senses potential danger (Trewavas, 1983).

Important habitats and sensitive life cycle stage

The important habitats are the breeding grounds where nests are constructed and the nursery grounds where the female brood her eggs and juveniles.

Actual threats and protection status

The actual threats and protection status are unknown because the fish has not been evaluated by the IUCN

Value as food source for population and value in the food chain

The diet of *P. philander* are small insects, shrimps and even small fish (Trewavas, 1983).

Distribution and status of endemicity, relative abundance

The fish is indigenous to the Lake Malawi and Lower Shire systems

Value as subsistence food source or commercial fishing

The fish is harvested for human consumption

Status (native, allochthonous or invasive)

P. philander is native and is not invasive fish species

OREOCHROMIS PLACIDUS

habitat requirements and regional extent

The species is referred to “Black tilapia” and their distribution in Africa is from the Lower Zambezi and southwards in the lower parts of the Sabi, Lundi, Pungwe and Buzi Rivers; Ruvuma River on the Tanzanian-Mozambique border; Lake Rutumba, Lupululu system, and the Lupuledi west of Lindi. Previously, two subspecies were recognized: *Oreochromis placidus placidus* and *Oreohromis placidus ruvumae* (Trewavas, 1983).

Water quality requirements throughout their life cycle

O. placidus is freshwater, brackish and benthopelagic fish species that tolerates a wide range of environmental conditions. Its temperature tolerance range is 19 to 28ºC (Trewavas, 1983).

Water flow requirement

O. placidus prefers quiet pools with marginal vegetation and hence do not prefer fast flowing rivers (Trewavas, 1983).

Ability to pass obstacles

The species cannot pass through physical barriers, as it does not have any climbing or migration ability.

Life cycle (migration, spawning, maturing)

The species is non-migratory. Mature males develop colors which they use to attract females to nests that are built on well-defended territories on the banks of the river. Breeding males are very dark grey on head and body with throat and all fins black; with a red or orange margin on the dorsal and grey or black marblings on the gill-cover. The male fertilizes the eggs which are incubated by the female until they hatch and the young are released to start looking for their own food (Trewavas, 1983).

Important habitats and sensitive life cycle stage

The important habitats are the marshy areas where the fish resides and breeding grounds where nests are constructed. The nursery areas for the females which are shallow vegetative areas are also important habitats for the species.

Actual threats and protection status

The species is listed by IUCN as of least concern because they are widely distributed in the Malawian water bodies.

Value as food source for population and value in the food chain

Fishes are harvested for food. The diet of *O. placidus* is mainly zooplankton while young, but as it grows, it specializes on phytoplankton and detritus (Trewavas, 1983).

Distribution and status of endemicity, relative abundance

The species is widely distributed in the Lakes and Rivers in Malawi.

Value as subsistence food source or commercial fishing

The fish is harvested for human consumption

Status (native, allochthonous or invasive)

O.placidus is native and has a narrow environmental tolerance range; it is not invasive.

OREOCHROMIS SQUAMIPINNIS

Habitat requirements and regional extent

The *O. squamipinnis* is one of the endemic cichlids (tilapias) to Lake Malawi. It is found in its tributary, the Shire river from the Upper, through Lake Malombe to the far down in the Lower Shire (Trewavas, 1983).

Water quality requirements throughout their life cycle

O. squamipinnis is a tropical fish species preferring temperature from 19 to 28^{o}C. It is endemic to the Lake Malawi and Lower Shire systems (Trewavas, 1983).

Water flow requirement

The species inhabits open water areas of the Lake but migrate to shallow areas to breeding during the rainy season. It also inhabits sheltered areas of the Lower Shire (Trewavas, 1983).

Ability to pass obstacles

O. squamippinis cannot pass through physical barriers

Life cycle (migration, spawning, maturing)

Mature males develop blue colors on the heads and build nests on well-defended territories in shallow areas. It can be the Lake or riverbed or riverbanks. The male fertilizes eggs as the female lays them and the female incubates the eggs until hatching. The juveniles are released in shallow and vegetated areas to find their own food (Trewavas, 1983).

Important habitats and sensitive life cycle stage

The important habitats for the species are shallow breeding areas during the rainy season and the important stage is at juvenile stage when they are left in marshy shallow areas to look for their own food.

Actual threats and protection status

The fish has been subjected to heavy fishing pressure and are hence classified as Endangered by IUCN.

Value as food source for population and value in the food chain

O.squamippinis is palatable fish species in the Chambo group, hence it is harvested as food for humans. The diet of Chambo is mostly plankton and detritus (Trewavas, 1983).

Distribution and status of endemicity, relative abundance

O. squamipinnis is endemic to the Malawian waters and their catches have declined significantly hence they are no longer abundance (Fisheries Department 2004).

Value as subsistence food source or commercial fishing

O. squamipinnis is harvested for food as well as for sale.

Status (native, allochthonous or invasive)

O. squamipinnis is native and is not invasive

ORECHROMIS SHIRANUS SHIRANUS

Habitat requirements and regional extent

O. shiranus is endemic to the Lake Malawi system including the Shire River and its tributaries up to the Lower Shire. The sub genus chilwae are found in Lake Chilwa and Chiuta (Trewavas, 1983).

Water quality requirements throughout their life cycle

The species is tropical tilapias preferring water temperatures between 22 to 43ºC. It tolerates a wide range of salinity and pH (Trewavas, 1983).

Water flow requirement

The species resides in sheltered and shallow areas of the Lake as well as lagoons and marshy areas of the Upper and the Lower Shire (Trewavas, 1983).

Ability to pass obstacles

The fish does not have migratory qualities; hence it cannot pass through physical obstacles

Life cycle (migration, spawning, maturing)

The fish does not exhibit migratory behavior. Mature males migrate to the shallow and marshy areas where they establish a territory and defend it against intruders. They attract females through breeding colors to the nest. The female lays her eggs which are fertilized by the male. The females brood the eggs until they hatch and the juveniles are released in shallow and marshy areas to go and look for their own food (Trewavas, 1983).

Important habitats and sensitive life cycle stage

Important habitats are the shallow breeding and nursery areas and the important stage is during juvenile when they are left to look for their own food in the shallow areas.

Actual threats and protection status

IUCN has not yet evaluated the *O. shiranus shiranus*

8. Value as food source for population and value in the food chain

The diet of *O. shiranus* is mainly detritus and phytoplankton. The fish is harvested for food for human consumption.

Distribution and status of endemicity, relative abundance

O. shiranus is widely distributed in the Shire River above the Murchison rapids and its tributaries; upper Shire; Lake Malawi and its tributary rivers, streams and lagoons; Lake Chilwa and its basin in Malawi and Mozambique (Trewavwa, 1983).

Value as subsistence food source or commercial fishing

O. shiranus is harvested for human consumption. It is also widely used in aquaculture in ponds and cages.

Status (native, allochthonous or invasive)

O. shiranus is native and is not invasive fish species

TILAPIA RENDALLI

Habitat requirements and regional extent

Tilapia rendalli has a wide distribution in Africa from the Senegal and Niger Rivers, the Congo to Kenya, and much of southern Africa. It has been introduced elsewhere, usually for weed control and aquaculture (Philippart and Ruwet, 1982).

Water quality requirements throughout their life cycle

It is has a wide range of temperature tolerance (8-41°C) (Philippart and Ruwet 1982) and salinity to 19 ppt (Skelton 1993).

Water flow requirement

Tilapia rendalli is a benthopelagic species that prefers quiet, well-vegetated water along river littorals or backwaters, floodplains and swamps (Philippart and Ruwet, 1982).

Ability to pass obstacles

The species does not have migratory abilities hence cannot pass through physical barriers

Life cycle (migration, spawning, maturing)

This tilapia does not mouth brood eggs and young. The fish prefers a sloping spawning ground near the marginal fringe of vegetation (Philippart and Ruwet 1982). It builds nest in shallow water where both parents guard the eggs and young.

Important habitats and sensitive life cycle stage

Important habitats are shallow vegetative areas where the males build nests and where both the male and females guard their young ones.

Actual threats and protection status

The species is listed by IUCN as of least concern.

Value as food source for population and value in the food chain

T. rendalli juveniles feeds on plankton as juveniles but switch to higher plants and also algae, insects and crustaceans as adults (Trewavas, 1983).

Distribution and status of endemicity, relative abundance

T. rendalli is widely distributed and abundant in the Lake Malawi and the Lower Shire systems.

Value as subsistence food source or commercial fishing

The fish is harvested for human food. They are also used to control weeds in aquaculture ponds.

Status (native, allochthonous or invasive)

T. rendalli is native. It has been reported to have devastating effects when introduced into alien areas through aquaculture where it is invasive.

GLOSSOGOBIUS GIURIS

habitat requirements and regional extent

The species is well distributed world-wide in Asia, Europe, China, Australia and Africa (Bills et al., 2010).

Water quality requirements throughout their life cycle

This is a marine, freshwater, brackish benthopelagic, amphidromous fish species which prefers tropical temperatures around 25°C (Bills et al., 2010).

Water flow requirement

It is mostly found in freshwater estuaries in the Lower Shire but also enters the sea. It also occurs in canals, ditches and ponds. They are also found in clear to turbid streams with rock, gravel or sand bottoms and in medium to large rivers (Bills et al., 2010).

Ability to pass obstacles

The fish cannot pass through physical barriers

Life cycle (migration, spawning, maturing)

The species is reported to have a marine larval stage, but can breed in fresh water (small juveniles are present in high upstream reaches of rivers or in land-locked lagoons). It has been recorded breeding during the 'dry' season in northern Australia and in summer in South Africa, hence it may have variable breeding seasons or breeds throughout the year (Bills et al., 2010).

Important habitats and sensitive life cycle stage

In the Lower Shire, the important habitats are sheltered lagoons and marshy areas.

Actual threats and protection status

The fish is listed as of least concern by the IUCN due to their world-wide distribution.

Value as food source for population and value in the food chain

Fishes are caught for human consumption. The diet of the species comprises small insects, crustaceans and small fish (Bills et al., 2010).

Distribution and status of endemicity, relative abundance

In Malawi, the species is found in Lake Chiuta and Lower Shire in large numbers at Bangula lagoon (Tweddle and Willoughby, 1979).

Value as subsistence food source or commercial fishing

The species is harvested for food and sale

Status (native, allochthonous or invasive)

G. giuris is native and does not have invasive capabilities

CTENOPOMA MULTISPINIS

Habitat requirements and regional extent

Ctenopoma multispine is known from the Democratic Republic of Congo to South Africa. It is present in the southern tributaries of the Congo River basin and occurs in the Lower Shire River in Malawi. It is also present in the Okavango and Kwazulu Natal (Skelton, 2001).

Water quality requirements throughout their life cycle

It prefers saline conditions and temperatures ranging from 20 to 28^{o}C (Skelton, 2001).

Water flow requirement

The species does not like fast flowing rivers but vegetated riverine backwaters, floodplain lagoons, swamps and isolated pans (Skelton 2001).

Ability to pass obstacles

The species has climbing abilities and may negotiate physical barriers as long as they are wet.

Life cycle (migration, spawning, maturing)

The species congregates in groups to breed in its breeding grounds. The eggs are scattered around and not guarded. It can endure warm stagnant waters and is known to leave the water and move overland to alternative sites in wet weather or at night (Skelton 1993). Tweddle *et al.* (2004) observed it moving out from the Zambezi River onto newly flooded grasslands to breed in mats of grounded vegetation on the overflowing riverbank.

Important habitats and sensitive life cycle stage

Important habitats are the vegetative marshy areas where they reside and flood plain lagoons where they breed on vegetation (Skelton, 2001).

Actual threats and protection status

The species does not have any special status.

Value as food source for population and value in the food chain

The fish feeds on any suitably small creature, including insects, shrimps, and small fish. Well camouflaged, *C. multispinis* hunts by slowly stalking prey. It is harvested for human consumption.

Distribution and status of endemicity, relative abundance

The species in Malawi is confined only to the Lower Shire.

Value as subsistence food source or commercial fishing

Fishes are used for human food and have a commercial value in aquarium trade

Status (native, allochthonous or invasive)

C. multispinis is native and does not have invasive capabilities.

Annex C: Review of the Option Assessment report (2016) and the Inception report of the Feasibility Study

This critical review is based on the latest available document from the Korea Rural Corporation (KRC) in Joint Venture with Dasan Consultants co., LTD., GK Works Civil and Structural Engineers the "draft Option Assessment report (January, 2016)". It is also based on the FS Final Inception Report.

The goal is to provide KRC with a first set of recommandations before the full ESIA is completed.

WATER AVAILABILITY AND HYDROLOGY

The proposed and ongoing Technical Feasibility Study (TFS) for the Shire Valley Irrigation Project (SVIP) by Korea Rural Corporation (KRC) for the Ministry of Agriculture, Irrigation and Water Development (MoAIWD) of the Government of Malawi (GoM) were critically reviewed.

The following two documents were collected:

- [1] KRC (2015) Final Version of the Inception Report; KRC, DASAN and GK Works for MoAIWD, 14th October 2015.
- [2] KRC (2016) Draft Version of the Options Assessment Report; KRC, DASAN and GK Works for MoAIWD, 31st January 2016.

The following key issues were analyzed in:

- Water Availability ([1] §4.4.9 and [2] §3.9 and §3.10.2).
- Use of Other Water Resources ([1] §4.4.11 and [2] §3.1.1).

The following sections consist in a critical review of the chapters of the TFS documents listed above.

Water Availability

Information Sources

The information sources used in the TFS include the following studies:

- CODA (2008) Final Reports, Final Main Report and Final EIA Report for Shire Valley Irrigation Project Phase 1; CODA and Partners of Kenya, June 2008.
- COB (2010) High Level Canal Project Review Report for ILLOVO Sugar Nchalo within the framework of the Shire Valley Irrigation Project; COB for ILLOVO, June 2010.
- ATKINS (2011) Final Report for Water Availability on the Shire River at Kapichira Dam for the proposed Shire Valley Irrigation Project; ATKINS for WB, March 2011.
- ATKINS & Wellfield (2011) Final Version of Main Report and Annexes for Component 1 – Water Resources Assessment within the framework of the Second National Water Development Project (NWDPII); ATKINS and Wellfield for MoAIWD, April 2011.
- NORPLAN (2013) Final Report for Study on Water Availability for Irrigation and Hydropower Production on Shire River at Kapichira Falls within the framework of the Shire River Basin Management Program (Phase 1); NORPLAN for MoAIWD, April 2013.
- BRLi (2015) Final Version of the Preliminary Assessment Report of the Public Private Partnership Feasibility Study for the Shire Valley Irrigation Project; BRLi for MoAIWD, October 2015.

Comments

The documents listed above and used as references in the TFS are completely relevant for the purpose of the SVIP.

The following additional and recent documents could have been collected:

- JICA (2014) Final Reports of Volumes 1, 2, 3 and 4 for Project for National Water Resources Master Plan in the Republic of Malawi; JICA, CTI, Oriental Consultants and NEWJEC for MoAIWD, December 2014.
- SMEC (2014) Draft Final Version of Report and Appendixes for National Irrigation Master Plan and Investment Framework; SMEC for MoAIWD, November 2014.
- PWC (2015) Draft Preliminary Report on Potential Crops – Agronomic Diagnostic and Market Opportunity Analysis – Formulation of the Agricultural Development Planning Strategy within the framework of the Shire Valley Irrigation Project; PWD for MoAWID, November 2015.

Water Demands

The following water demands have been taken in account in the TFS:

- Water demand for the generation of electricity:
- Existing Kapichira I: 134.6 m³/s.
- Planned Kapichira II:
  - Case I: 134.6 m³/s,
  - Case II: 67.3 m³/s,
  - Case III: 0 m³/s.
- Water demand for irrigation:
  - With Illovo Estate (Net Irrigation Area: 42,500 ha): 43.5 m³/s,
  - Without Illovo Estate (Net Irrigation Area: 29,741 ha): 30.5 m³/s.

Comments

Concerning the water demand for irrigation, the three following assumptions have been retained in the TFS:

- Two main scenarios have been taken in account for the maximum irrigable area: 42,500 with Illovo and 29,741 without Illovo.
- This assumption is very relevant as Illovo's Estate position toward the SVIP is not yet established and whether including or not Illovo Estate has major implications on the project.
- A constant value for irrigation water requirement - equal to the peak month demand - for the whole year (while it has monthly estimates).
- This assumption is secure for the canal design, but overestimates the water needs for irrigation especially as the Kapichira reservoir plays a crucial buffer role. A monthly approach would be more tailored for the project.
- A fixed cropped pattern with 44% of the irrigable area in sugarcane for the whole year, 56% cotton from May to October, 19% Maize / 19% Millet / 19% Sorghum from November to April.
- This assumption is quite restrictive in terms of possible cropping pattern alternatives. The hypothesis used to evaluate water demand for irrigation will have to be consistent with the Agricultural Development Planning Strategy (PWC, 2015).

No drinking water supply water demand for Chikwawa and Nsanje Districts has been taken in account in the TFS. An integrated approach in the implementation of the SVIP would provide water for both irrigation purposes and drinking water needs, given the current issues with groundwater quality (see section on groundwater) and the risk of crocodiles attack in Shire (see section on wetland ecology).

No minimum touristic flow for Kapichira Falls has been taken in account in the TFS. During the baseline mission, it has been informed by ESCOM and Majete Wildlife Reserve that a minimum flow of 50 m³/s in the Shire River at Kapichira Falls is required for tourism (sight view of Kapichira falls, important touristic attraction of Majete visitors).

No minimum environmental flow for Elephant Marsh, an important wetland area with a diverse aquatic fauna and flora (Bartlett et al, 1991), has been taken in account in the TFS. It has been reported that there is no formal requirement for discharge of environmental flow at the hydropower production dam sites on the Shire River. A method for determining Environmental Flow Requirement (EFR) was developed and is detailed in Annex II – Surface Water of Component 1 for WRIS (ATKINS, 2011).

Water Resources

The TFS for SVIP only considers the water resource available in the Shire River at the reservoir of the Kapichira Electric Power Station (or Kapichira Dam) where is located the water intake of the Feeder Canal on the right bank of the river. This location has the advantage of abstracting water directly from the existing reservoir upstream Kapichira and reducing the length of the Feeder Canal (cost reducing) as well as to limit the impact on Majete Wildlife Reserve (COB, 2010).

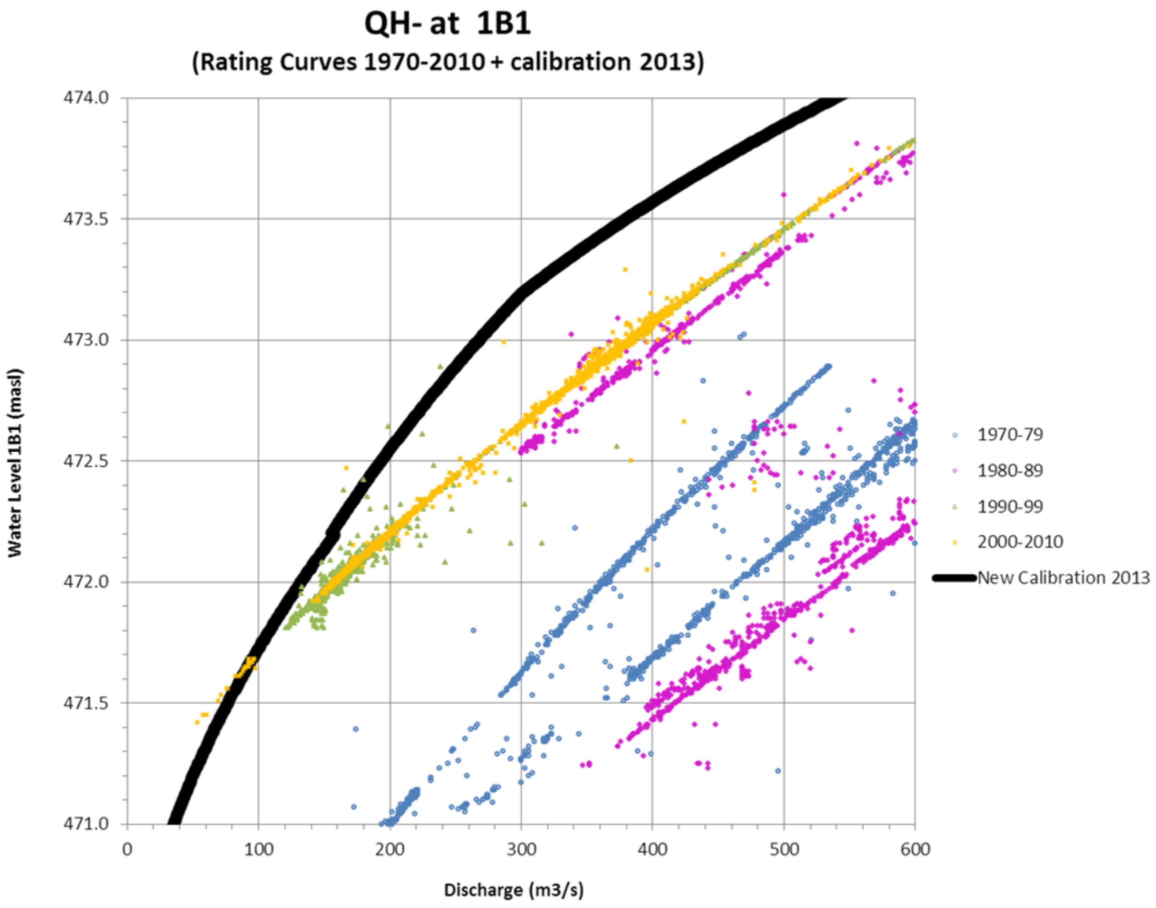
The water resources estimates on the Shire River at Kapichira Dam from WASVIP (ATKINS, 2011) based on the water flow measurement at Chikwawa station 1L12, were retained in the TFS for SVIP. The reference value of 337 m^3/s corresponds to the Dry Season Average (Aug~Nov).

Comments

The estimate of water resources of 337 m^3/s corresponding to the Dry Season Average (Aug~Nov) is confident with the estimates from (ATKINS, 2011) and (NORPLAN, 2013).

The assessment of water resources in the Shire River at Kapichira dam is problematic due to uncertainties in the reliability of historic flow data. It is recommended that historic data have to be checked with reliable measurements in order to update the rating curves of the existing hydrometric stations 1B1 downstream Kamuzu Barrage and 1L12 in Chikwawa (any change in the physical characteristics of the river cross-sections could influence the rating curves and then the calculation of flow records). It is also mentioned that ATKINS projections for available flow might be optimistic in that consideration as shown in the Figure 64 and confirmed by the discussions with ESCOM during the baseline mission.

Figure 64 Rating Curves for Shire River at Liwonde, used 1970 to 2012, and new estimated rating curve based on hydraulic modelling for use after 2003.



Source: NORPLAN, 2013

- Data available in the closest station from the project in Chikwawa (1L12) are only from 1977 to 1998. ATKINS has done a derivation of a long-term flow record at Chikwawa based on correlation between flows at 1B1 and 1L12.
- Flows rates may be affected by man-made causes in the operation of the Kamuzu Barrage in Liwonde.

In the same way to the water demands, a monthly approach applied to water resources would be more tailored for SVIP.

<u>Water Balance</u>

The assessment of water availability at Kapichira Dam in the TFS for SVIP by KRC compared to ATKINS (2011) and NORPLAN (2013) is given in the Table 23.

Table 23 Review of Water Availability at Kapichira Dam

Division	ATKINS (2011)	NORPLAN (2013)	TFS for SVIP (KRC, 2016)
Kapichira I max. (case I)	134.6 m³/s	134.6 m³/s	134.6 m³/s
Kapichira II max. (case I)	134.6 m³/s	134.6 m³/s	134.6 m³/s
SVIP max. (with Illovo)	55.0 m³/s	37.0 m³/s	43.5 m³/s
Water Demands	324.2 m³/s	306.2 m³/s	312.7 m³/s
Water Resources	337.0 m³/s	337.0 m³/s	337.0 m³/s
Water Availability	337 – 324.2 = 12.8 m³/s	337 – 306.2 = 30.8 m³/s	337 – 312.7 = 24.3 m³/s

Source: KRC, 2016

In addition to the results in terms of water availability shown in Table 23, it seems that the water demands is satisfied over 50% of time (median year).

Comments

The water balance is established in the TFS for a median year. The water availability should be assessed for a quinquennial or decennial dry year, and should be addressed by applying a monthly approach, as was done in Preliminary Assessment Report of PPP (BRLi, 2015)

As mentioned above, it is important to recall that no water demands for drinking water supply water demand for Chikwawa and Nsanje Districts, for minimum touristic flow for Kapichira Falls and for minimum environmental flow have been taken in account in the TFS.

In these considerations, the conclusions of the TFS in terms of water availability might be optimistic.

Use of Other Water Resources

Information Sources

The information sources used in the TFS include the following studies concerned groundwater resources:

- Ayers (1976): Ayers, R. S. and D. W. Westcot. 1976. Water Quality for Agriculture. Food and Agriculture Organization of the United Nations: Rome.
- Bath (1980): Bath (1980) Hydrochemistry in Groundwater Development: Report on advisory visit to Malawi- Institute of Geological Sciences, Report No. WD/OS/80/20 pp.54.
- (FAO, 1985): Water quality for agriculture by R.S. Ayers and D.W. Westcot – FAO Irrigation and Drainage Paper 29, 1985 © FAO.
- DoW/UNDP (1986): Department of Water/UNDP, (1986), National water resources master plan.
- Chavula (1989): Chavula G. M. S., (1989), An assessment of groundwater potential for small scale crop.
- Monjerezi (2012): Quality of Groundwater Resources in Chikhwawa, Lower Shire Valley, Malawi Water Quality, Exposure and Health, 2012, Volume 4, Number 1, Page 39 - Maurice Monjerezi, Cosmo Ngongondo.

Moreover, a team of water quality specialists from the Water Quality Laboratory of the Ministry of Agriculture, Irrigation and Water Development based in Blantyre was tasked to collect 28 water samples from boreholes in predetermined blocks.

Comments

It should be noted that no source is specified for surface water resources in the TFS.

Concerning the groundwater resources, the documents listed above and used as references in the TFS are completely relevant for the purpose of the SVIP.

The following additional and recent documents could have been collected:

- Sehatzadeh (2011): Groundwater Modelling in the Chikwawa district, lower Shire area of southern Malawi; Media Sehatzadeh, Department of GeoSciences, University of Oslo, Master of Science in Geoscience; June, 2011.
- Clark (2014): An analysis of water point mapping data for the Chikwawa District, Malawi and a review of its use within the water sector; Holly Clark, Department of Civil and Environmental Engineering, University of Strathclyde, Master of Science in Hydrogeology; August, 2014.
- Wild (2014): Groundwater quality and potential arsenic contamination from a geochemical perspective to bedrock geology in the Chikwawa district, Malawi; Lisa Maria Wild, Department of Civil and Environmental Engineering, University of Strathclyde, Master of Science in Hydrogeology; August, 2014.

Surface Water Resources

10 dam sites located on the right-bank Shire tributaries have been identified in the TFS by KRC as potential sites for additional water intakes. They are listed in the Table 24.

Table 24 Potential Dam Sites to Develop Surface Water Resources

River	Catchment Area (km²)	Type	Length (m)	Height (m)	Crest Height (masl)	Storage Capacity (m³)
Mwambezi	156.3	Dam	74	13	156	275,100
Nthumba	69.4	Dam	184	7	139	918,300
Kakoma	50.2	Dam	123	14	163	771,600
Mwanza	1,618.1	Intake Barrage				
Nkombedzi Wa Fodya	244.1	Dam	112	18	168	22,891,400
Phwadzi	188.4	Dam	254	7	137	835,300
Namikalango	142.6	Dam	294	6	114	595,400
Mafume	44.8	Dam	106	8	183	7,336,700
Lalanje	53.0	Dam	395	36	94	454,500
Thangadzi	307.6	Dam	142	17	91	8,658,200

Source: KRC, 2016

Comments

There is no information about:

- The method applied to estimate the water availability at the potential dam sites listed above.
- The cost estimates for the building of these large hydraulics infrastructures.

As observed during the baseline mission then confirmed by satellite imagery analysis, the tributary river beds are mobile: river bed can move of several tens of meters after severe floods as shown in Figure 65.

Figure 65 Abandoned and Current Meanders of the Thangadzi River

Source: Google Earth – Image ©2016 CNES/Astrium

Consequently any structure on tributary rivers have to be carefully designed as these rivers are highly erosive and can shift position from one year to another. River bed stabilization with gabion is highly recommended in sensitive areas. Dams and weirs on these rivers are not recommended. At the wrap up meeting of the baseline mission, the SVIP Coordination Team for MoAIWD indicated that these options would very probably be rejected.

It would be very relevant to estimate the water availability in the Shire River downstream the outflow of the Kapichira Hydropower Station in the main water course. Only the question of maintaining the current pumping system has arisen in the TFS for the SVIP, but not the question of adding new pumping stations as a complement to the gravity canal system.

Indeed, the proposed SVIP, with a water irrigation demand of 43.5 m^3/s represents a significant new consumptive demand in the Lower Shire. However, the Kapichira Dam has a much larger non-consumptive demand for power generation (and for a minimum touristic flow) which is likely to take precedence over irrigation requirements at times of low flows. This means that at times of low flows, irrigation demands from the SVIP would not be exercised and downstream flows would be prioritized for power generation demands.

Soil Characterization

The SVIP Feasibility Study is currently being carried out by Korean Rural Corporation (KRC). This review is based on the KRC October 2015 Inception Report (Govt. Malawi and Korea RC, 2015), the draft Options Assessment Report dated 31 January 2016 (Govt. Malawi and Korea RC, 2016), further data and documents received from KRC, discussions in Blantyre office and on-site visits in Lower Shire Valley.

Inception report quotes re technical aspects of soil survey and classification (4.2.4. Soil Survey) read as follows (abbreviated, and in *italic*s), followed by BRL comments.

1) Review of References (Inception report section 4.2.4)

A soil map of the project area of Phase I was obtained from the tender documents of CODA (2008), produced from soil surveys by SOGREAH (1992). SOGREAH executed field survey for soil using the "Soil survey maps and land classification maps of the Kasinthula Irrigation Project" (Lockwood Survey Corporation, 1968), covering 15,000ha with 254 pits.

The soil map in the tender documents of CODA (2008) shall be used for the 15,000 ha in the Phase I area after ascertaining their correctness through some cross checking surveys. Our field survey for soil shall be concentrated in the area of Phase II and the rest area of Phase I.

Comments from BRLi: The name SOGREAH is clearly on these CODA maps. Whether SOGREAH (1992) copied information from Lockwood (1968) cannot be ascertained. SOGREAH (1992) used Soil Taxonomy (US system) and Lockwood (1968) most likely their own system, but certainly not Soil Taxonomy or FAO as these were not in use at that time.

It is doubtful whether "*some cross checking surveys*" are sufficient to ascertain the reliability of these data which passed through several hands and have not been seen by BRLi in complete form with full descriptions and analytical data. The question is also whether the present survey team is able to properly correlate these different soil classification systems with FAO. BRLi could not establish clear and logical patterns in the spatial distribution of mapped soil units and have doubt about the reliability of this soil map which covers only Phase 1 part 1 (and not Zone A).

A comment can be given on availability of other data. Apart from some other less important data, there is one important database, namely Illovo (2015). This database could be very useful for comparison and correlation with the results of the Feasibility Study. There is one aspect which should be taken into account, namely that Illovo description and soil classification is done according to the South African Soil Classification (SA Soil Classification Working Group, 1991). Although an attempt to correlate with WRB/FAO system was made, this only happened at the highest level and included incorrect interpretation.

2) Field Survey (Inception report section 4.2.4)

Preliminary survey shall be implemented at about 40 points and make a best survey plan basically referred to the FAO soil survey manual and the FAO classification system. And then semi-detailed soil survey at about 360 points through auger-hole and soil pit profile description, and in-situ tests on water table, percolation, penetration, etc. Soil properties to be observed: soil horizon, soil texture and gravel content, soil moisture, colour, mottles, structure, pores, drainage, roots, etc.

3) Sampling and Analysis (Inception report section 4.2.4)

Approximately 1,000 soil samples to be taken separately or in a mixture from topsoil or subsoil horizons. Soil samples should be delivered right after air-dried to an official or certified soil laboratory. From this analyses the following soil properties shall be analyzed: soil texture, soil pH, available potassium, total nitrogen, and available phosphorus, organic matter, nitrogen, calcium carbonate, gypsum, electrical conductivity, CEC, BS, ESP, SAR, bulk density, etc.

Comments BRLi on Field Survey and Sampling and Analysis: During first meeting in Blantyre BRLi was informed that KRC had already done about 1300 observations (including 300 pits) and taken about 1100 samples for laboratory analysis. The soil survey was not yet completed, thus more observations are expected to be added. However, in one area, namely the southern part of Zone C (a) the survey was brought to a halt by the local community. KRC also confirmed that they were using the two essential FAO documents for soil description and soil classification, namely FAO (2006) and IUSS Working Group WRB (2015). The conclusion on points 2) and 3) is that these items are well underway.

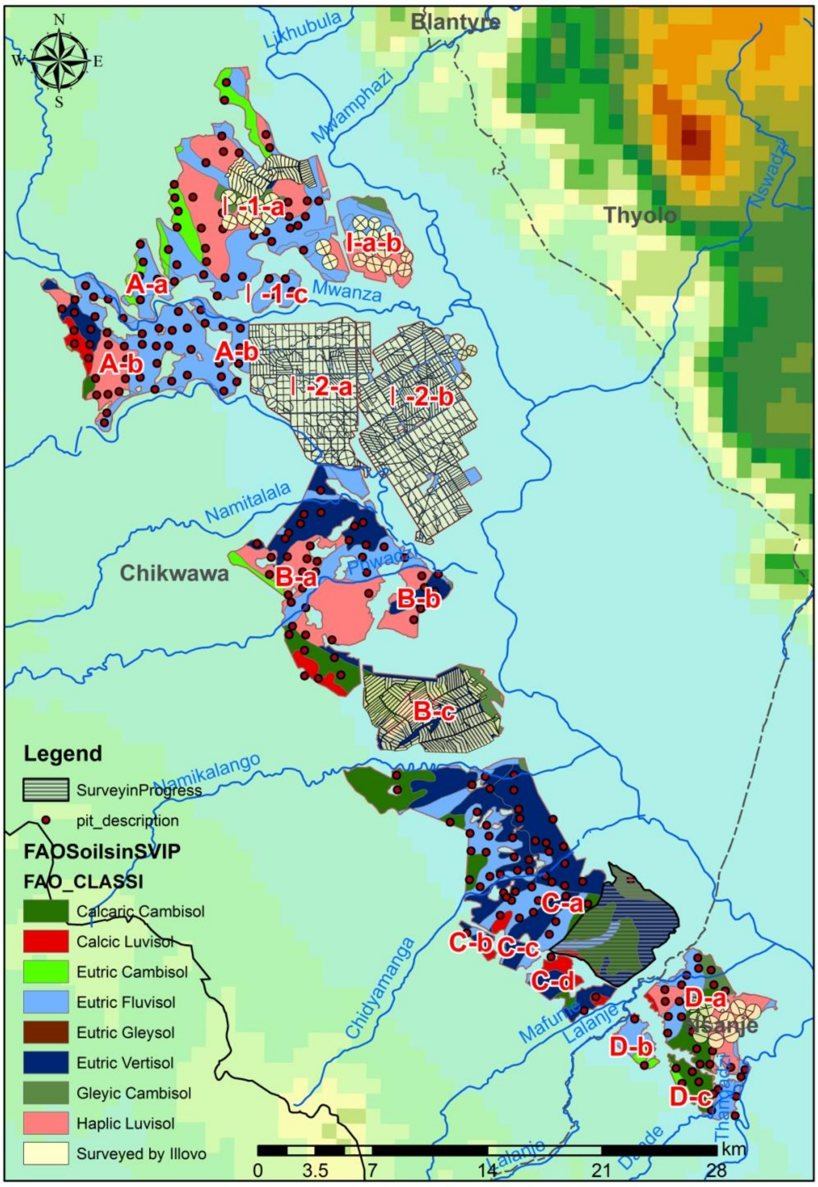
4) Soil Classification (Inception report section 4.2.4)

Field soil classification procedure is as follows: (1) survey points are located on a topography map and their coordinates saved in a GPS unit; (2) land use and crops observed around are recorded: (3) soil lumps dug by an auger are aligned from top to bottom or soil horizons divided to describe soil horizons; (4) final soil classification: the soil types set temporarily in the field should be confirmed to be grouped by the FAO Classification after close examination of field descriptions and soil properties.

Comments from BRLi: During the site visit and soil inspection trip the above procedure was observed. Point 1 and 2 are routine and no problem. Point 3 is not sufficient to fully describe soil horizons. This method fails to describe much more than colour and texture, as material brought up by an auger is altered and mixed. The hard and dry soils BRLi saw were very difficult to auger and material that came out was pulverised. Similar problems with wet and moist lumps ; augerings are only good for checks. Field soil classification should of course in the first place be done in a pit. BRLi regrets to report on 4) soil classification that KRC at this stage was not able to provide adequate FAO or WRB soil classification from soil pits that were examined. Although BRLi received a large database of photos taken from pits and landscape, comprehensive soil profile descriptions (apart from few incomplete) and lists of soil classifications attached to observations were not available or made available.

At this stage the KRC should have developed a provisional soil legend based on own field observations. BRLi received copies of soil maps, which appear to be older existing soil maps of fairly small scale (in the order of 1:100.000) based on older FAO classification. The origin is unknown; there are indications that this map is also derived from CODA but from another source than SOGREAH. The map below shows an already existing soil pattern with notes on areas still under survey or completed by Illovo. This map (without source reference) is used by KRC to plot their pit and other observations.

Figure 66 Lower Shire Valley Composite Soil Map



All soil maps inspected in Malawi shows older FAO Soil Classification with use of only the highest level or adding only one qualifier. The FAO system of soil classification has been renamed World Reference Base for Soil Resources (IUSS Working Group WRB, 2006; published by FAO, Rome). The 2006 edition has already been updated by the 2015 edition. This is the system to be used in Malawi for all soil characterisation. A number of rules from WRB (IUSS Working Group WRB, 2015) to be observed read as follows:

- WRB comprises two levels of categorical detail: (1) the First Level having 32 **Reference Soil Groups** (RSGs) and (2) the Second Level, consisting of the name of the RSG combined with a set of **principal and supplementary qualifiers**. In the WRB, a distinction is made between principal qualifiers and supplementary qualifiers. Principal qualifiers are regarded as being most significant for a further characterization of soils of the particular RSG. They are given in a ranked order. Supplementary qualifiers give some further details about the soil. They are not ranked, but listed alphabetically.
- **Classification consists of three steps:**
  - **Step one – detecting diagnostic horizons**, properties and materials Guidelines for Soil Description (FAO, 2006) should be followed when describing the soil and its features. It is useful to compile a list of **the diagnostic horizons, properties and materials observed** (see Chapter 3). It is possible to make a preliminary classification of the soil in the field, etc....
  - **Step two – allocating the soil to a Reference Soil Group**
  - **Step three – allocating the qualifiers**
- Chapter 2 - 2.2 **Rules for classifying soils**: For the classification of a soil (or strictly, the allocation of a soil according to the WRB classification) at the second level, **all the principal and supplementary qualifiers that apply must be added to the name of the RSG**. Example of a WRB soil classification: Albic Endostagnic Luvisol (Cutanic, Differentic)
- The **rules for creating map legends**: For larger map scales: **the RSG plus the first three applicable principal qualifiers are used**: a. the principal qualifiers are placed first, and of them, the first applicable qualifier is placed first, and b. the sequence of any supplementary qualifiers added is decided by the soil scientist who makes the map.

5) Irrigability Assessment and 6) Drainability Assessment (Inception report section 4.2.4)

The KRC Inception Reports continues with land classification for irrigation: .... *And shall be implemented an assessment of the irrigation and the draining situation and potential of land units by a standard land classification system.*

On the same subject, The Options Assessment Report (Draft) of 31 January 2016 (SVIP Feasibility Study; Govt. Malawi and Korea RC, 2016) lists only one soils related requirement in the selection procedure for irrigated land: “Land which has suitable soil properties for agriculture after the soil survey”. In the same Option report, Table 3.2.2 entitled “Selection Criteria of Irrigable Land” highlights only one soil-based criterion, one for slope and one for flooding frequency:

Table 25 Physical Criteria (Slope, Soil and Flooding) for Rating of Irrigable Land (Table 3.2-2 of KRC)

Criteria/Rating	Very Good	Good	Normal	Poor	Non Suitable
Geographic	< 2% slope	< 3% slope	< 5% slope	> 5% slope	No description
Soil Characteristic	Loam, sandy loam, siltloam	Clayloam, silty clay, sandy clay	Loamy sand, clay	Sand, gravel	No description
Flooding	-	1 in 3 years	1 every year	>1 per year	No description

Comments BRLi: The ‘*standard land classification system*‘is not specified. The potential of land units should be established using FAO Land Evaluation methodology as has been standard practise in Malawi.

Comment on the Table 3.2-2 entitled “Selection Criteria of Irrigable Land”: apparently the (average or topsoil?) texture of the soil is the only soil criterion, with two other physical criteria relating to slope and flooding (all others relate to non-physical factors). A class of non-suitable is actually not given; floods every 4 or 5 years are allowed in the class of Very Good. If this set of criteria is going to be used in SVIP, with only texture as a soils factor, there seems to be no need for any further detailed soil survey.

Comment on the matter of **possible impact of the project on soils, such as soil salinisation**: this can be linked here with the above mentioned physical selection criteria, or rather the lack of it. A selection procedure without full attention to all relevant soil characteristics may easily lead to an unsustainable Project as important factors such as risk of salinisation of certain sensitive soils are ignored or overlooked under poorly defined management systems.

It is recommended not to adopt the KRC proposed criteria of Table 3.2-2 but to continue applying FAO Land Evaluation Procedures, as has been proposed in earlier SVIP reports. The following text summarises what can be expected from the FAO methodology and how the land suitability should be rated.

Short Summary of FAO Land Evaluation Methodology

The assessment of the production potential of the land, named land evaluation (FAO, 1985), requires a systematically designed land resource data base. The suitability for irrigated agriculture in the study area is established on the basis of the findings and interpretation of the soil survey of the area, including a variety of land qualities or factors such as slope, soil depth, soil toxicity and drainage.

The Agro-ecological zones (AEZ) methodology as developed by FAO (1978, 1996) provides a framework to organize, present and evaluate land resource data. The AEZ approach is used in the land evaluation process following soil surveys and other land inventories. The AEZ definition is based on sets of basic resource data, including climate, crop requirements, physiography and soils.

The land evaluation models consider the soil and land characteristics together with climatic conditions of each land unit. This information is matched against the requirement of the crop in question and a class is given depending on how the land characteristics conform to the crop requirements. Four physical land suitability classes are distinguished:

- Class S1 (Very Suitable) applies to land having no significant limitation to sustained application of a given use.
- Class S2 (Suitable) applies to land having limitations which in aggregate are moderately severe for sustained application of a given use.
- Class S3 (Marginally Suitable) applies to land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefit.
- Class N (Not Suitable) applies to land having limitations which appear so severe as to preclude any possibilities of successful sustained use of the land in the given manner.

In the land evaluation, land suitability subclasses indicate the following land constraints:

- Thermal conditions (te). These are found incorporated in Agro-ecological Zoning (AEZ) analysis.
- Slope gradient (sl). The slope factor is found incorporated in the physical soil mapping approach; there are basically two main classes: 0-15% suitable, and >15% not suitable for irrigation.
- Effective soil depth (de). Normally expressed in standard soil depth classes (0-30cm, 30-50cm, 50-100cm, 100-150cm and >150cm); however for practical evaluation reasons some soil types may be defined in more detail.
- Drainage (dr). Most soils of the survey area fall in two drainage classes, namely moderately well drained and well drained, both of which do not lead to limitations for reasons of drainage. However, several low lying areas have impeded drainage, and most crops are prohibited when drainage conditions are poor or very poor.

- Soil fertility/toxicity (fe). Soil fertility/toxicity classification is determined using the pH (averaged value over the root zone), the electric conductivity (ECe) (highest value in the root zone), and organic carbon content of the topsoil. These parameters are normally considered sufficiently indicative of soil fertility and toxicity.
- Available water holding capacity (w). This does not play an important role when soils are irrigated, however in extreme cases, as with a very light texture, a limitation can be applied.

Estimates can be made for the percentage reduction of each of the suitability classes reflecting expected yield reduction. Table 26 presents an example of a realistic framework indicating the relationship between the suitability class and expected reduction from the optimum yield of irrigated sugarcane under an optimum commercial management level. This example from Swaziland (LUSIP II) uses adapted % optimum yield classes (*Class S1 Dependable yield more than 80% of the optimum yield, Class S2 60-80% etc*), with average yields around 110mt/ha (in Class 2) and break-even point around 80mt/ha (in Class 3). Yield values can be modified according to local conditions and linked with local land qualities.

Table 26 Relationship Land Suitability Class and Expected Reduction from Optimum Yield of Sugarcane

Suitability Class	**Percentage of Optimum Yield**	**Minimal Yield (mt/ha)**	**Median value**	**Maximal Yield (mt/ha)**
Class S1 (Very Suitable)	80-100%	144	162	180
Class S2 (Suitable)	60-80%	108	126	144
Class S3 (Marginally Suitable)	40-60%	72	90	108
Class N (Non suitable)	<40%			<72

7) Soil Mapping (Inception report section 4.2.4)

Soil types would be first delineated on the printed topography map (1:20,000) and digitized to build a database on a GIS. In terms of land mapping, the current land use and land suitability maps by crop could be also prepared along with other thematic maps.......

Comments BRLi: No indication is given with respect to the relationship between the number of observations and the mapping scale. The scale mentioned here is 1:20,000 but further in the Option report (section 3.2 *Irrigable Areas to be Developed*....) a detailed scale of 1:10,000 is mentioned for project area maps to reflect soil data. The intention is probably just to enlarge the soil maps to detailed scale 1:10.000.

It is probably sufficient for the Project to have 1:20,000 semi-detailed soil maps to define the areas of different land suitability. The following

Table 27 with mapping scale relationships is useful for calculating the required number of observations for a certain map scale (a mean to guarantee observation density and map accuracy).

Table 27 Soil Mapping Scales and Related Number of Field Observations

Kind of Survey (Elsevier)	**Very Detailed**	**Detailed**	**Semi-detailed**	**Detailed-reconnaissance**	**Reconnaissance**
Kind of Survey (US Soil Survey Manual)	**Very Intensive**	**Intensive**	**Intensive to Extensive**	**Extensive**	**Extensive (Broad)**
Scale	>1:10,000	1:10-20,000	1:20-35,000	1:35-70,000	<1:70,000
Purpose	Experimental agric, farms	General agric, farms	Projects	Projects	Large projects
Minimal density of observations without API (Aerial Photograph Interpretation)	1 per 4ha (at 1:10,000)	1 per 8ha (at 1:20,000)	1 per 12.5ha (at 1:25,000)	1 per 100ha (at 1:50,000)	1 per 400ha (at 1:100,000)
Minimal density of observations **with API**	Not given (at 1:10,000)	1 per 50ha (at 1:20,000)	1 per 100ha (at 1:25,000)	1 per 500ha (at 1:50,000)	1 per 2000ha (at 1:100,000)
Minimal number of observations in area of 40.000 ha without API	10,000 (at 1:10,000)	5000 (at 1:20,000)	3200 (at 1:25,000)	400 (at 1:50,000)	100 (at 1:100,000)
Minimal number of observations in area of 40.000 ha **with API**	Not given (at 1:10,000)	800 (at 1:20,000)	400 (at 1:25,000)	80 (at 1:50,000)	20 (at 1:100,000)

Modified from Elsevier, 1989: API = Air Photo Interpretation

Comments BRLi: The relevant number of observations for an area of 40,000ha (approximate gross area corrected for Illovo) without aerial photo interpretation would be 5000 (1 per 8ha); 1 per 8ha is also the opinion held in Project's Technical Committee (Mr A. Nigussie, SVIP, PTT Irrigation Specialist). The current shortfall needs to be discussed. Additional numbers of reliable observations from other surveys may be available and added to the total, and/or the map accuracy should be improved by Aerial Photograph Interpretation (API) or Satellite imagery interpretation to compensate for shortfall in the number of observations (e.g. aiming at 1600-2000 with further imagery interpretation).

Annex D: Minutes of consultation

APPENDIX D.1 GOVERNMENT AND NGOS OFFICIALS

The following table is a summary of discussion held with various stakeholders.

Person Consulted	Designation	Issues consulted for	Comments/Suggestions/Recommendations Made
D. Magwira	DADO, Chikwawa	Types of Crops	• High value crops such as beans, spices, onions and vegetables should be considered as major crops to be planted in irrigation schemes. Maize can be considered for off season planting. • There is also need for crop diversification for enhanced productivity • There is need to minimise the heavy use of chemical fertilisers and pesticides during irrigation farming to reduce pollution of air, water and soils • The schemes should consider organising the farmers into cooperatives for easy bargaining of produce prices and access of better markets. However, group dynamics will need to be handled properly for the sustainability of the cooperatives and the irrigation scheme structures • Agroforestry using short-term species such as *gliricidia sepium* should be considered for planted with the irrigation farms. These will be useful for short-term and immediate results in terms of soil fertilisation and enhanced crop productivity
Mr. A. M Bulirani 0884225132 Dr. F. Njaya 0999278088	Director of Fisheries Assistant Director of Fisheries	River and fish management	• There is need to consider integration of fisheries in the proposed irrigation schemes during the planning phase. Part of the water abstracted from the river for irrigation can be diverted into fish ponds. Fisheries integration is a low cost option but with multiple benefits • Fish ponds and abstraction of water should not disturb the natural river flow to minimise loss of fish species as a result of loss of important habitats. • Limit the use of heavy chemicals and fertilisers when cultivating to minimise soil and water contamination which might result into loss of available fish stocks in the rivers • Local communities will need to be sensitised on sustainable farming and land management practices proper management of the buffer zone to limit soil erosion that might be detrimental to the survival of aquatic fauna
Ms Botha	Deputy Director,	Land management	• The client should consider preparation of resettlement action plans (RAPS) in case of loss of property and assets such as houses, temporary shelters and fruit trees. Proper land and

0993444518	Department of Lands		property assessment will be required to determine the amount of loss for compensation. The RAPS will need to be reviewed by the department of lands and surveys • Local community leaders will need thorough consultation if there will be need for relocation or change of ownership from customary to public land • Department of lands should be involved during awareness and sensitisation meetings on land and environmental management issues
Mr. R. Njewa 0888441201	Principal Community Development Officer – Community Mobilisation and Capacity Building	Community mobilisation, awareness and sensitisation	• The role of the department of community development is to facilitate community mobilisation, sensitisation and awareness on various projects that requires such activities. • The department needs to be involved at all stages of the project cycle, more especially during the planning stage where issues of mobilisation, project awareness and sensitisation is requires in the development of the irrigation schemes. Mobilisation, awareness and sensitisation of local communities on the project will ensure a good understanding of the purpose of the project and its associated benefits to the local communities which will result into buy-in and ownership of the project by the local communities. • The project should make use of the existing committees and community structures when it comes to management of some of the project components • The project should consider involvement of the community development officers and other relevant stakeholders when it comes to mobilisation of community's contribution to the project to minimise conflicts. • There should be involvement of local communities in managing the project so as to bring forth the element of self-help for the sake of sustainability. In this regard, people should be involved in the choice of crops and identification of markets • Both upstream and downstream communities should be made aware of the project and involved in the planning of the project to minimise conflicts during project implementation and ensure sustainability • The project should set aside enough resources for mobilisation and awareness activities to be conducted by community development assistants
Mr. Z.A.K Mwandira 0888355910	Principal Community Development Officer		
Peter Elesani 0881267202	Chief Gender and Development Officer	Gender mainstreaming	• There is need to conduct as gender issues assessment in all the project areas in order to understand local specific gender issues that the project must strive to address during its lifetime • Women should particularly be targeted by the project if the project is to adequately address their needs. This should happen at all stages of the project cycle.

			• Arrangements should be made that the project should ensure co-ownership of project resources between men and women to ensure the project benefits everyone
Mrs J. P. Mabangwe 0888891402	Chief Disability Awareness and Equalisation Officer	Equity and Involvement of people with disabilities in the project	• There is need for the involvement of people with disabilities during the planning and design and implementation stages of the proposed project • There is need for the project to consider development of settlement schemes to ensure that people with disabilities are adequately involved in the project activities • The whole value chain should be disability friendly to make sure that the projects benefits every part of the communities • The project should make sure that people with disabilities should have equal access to project resources, opportunities and benefits
Mr. Thomu	Project Coordinator, Evangelical Association of Malawi (EAM)	Smallholder farmers empowerment and gender equity	• The project should provide start up input to farmers and ensure that women farmers are empowered
Mr. W. Msowoya	Project Coordinator, Concern Universal	Smallholder farmers empowerment and gender equity	• Women farmers should be given training on good farming practices, entrepreneurship, financial management

APPENDIX D.2 MEETING WITH TA CHAPANANGA

Present

- TA Chapananga – Chairman
- VDC Committee
- C. Chibwana - District Council Representative
- R. Matengula -- Key Expert

Discussions

The TA welcomed the research team to the meeting.

Introductions were made and the key expert outlined the objectives of the consultation meeting

He explained that the objective of public consultation was to review the implementation of the Shire Valley Irrigation Project and assess its impact on the project affected people (PAPs).

Specific aims are:

- To enlist views and opinions, reflections and aspirations, expectations and community involvement and participation of the affected community and other stakeholders in the development process for sustainable implementation of the project.
- To ensure that the relationship between project development and stakeholders should ideally be managed to achieve public acceptance and ownership.

This is being achieved through Meetings conducted with key stakeholders to obtain their views and concerns with respect to the likely impacts of the project.

TA Chapananga welcomes the Shire Valley Irrigation Project. He explained that people in the area believe that irrigation can bring in changes to their livelihoods. He cited the example of Illovo which is using irrigation to grow crops such as sugar canes and even maize throughout the year.

He pointed out that people in the area are eagerly waiting for the irrigation project which will enable them to produce food and cash crops a number of times in a year even in the absence of rains. The concern is that the starting of the project has been on and off for a number of years to the extent that people have lost hope even with the present consultations. They are not sure whether this will continue or stop as has been the case before.

However with the current climatic conditions which have ushered in droughts leading to food insecurity, people are hoping that the current resumption of consultations will lead to implementation of the project.

He personally has been involved in a number of consultation meetings and has noted that there is political, donor and community will to move forward with the new project.

Generally there were a number of concerns by communities in the area which include:

- The coming of the canal will bring crocodile menace close to the homes;
- The canal will worsen flood situation in areas which are already suffering from floods;
- The canal may interfere with movement of animals in the park

These issues were however clarified and communities are now satisfied that the new project will not interfere with their normal day to day life.

Economic Benefits of Game Parks

TA Chapananga says Majete Wildlife Reserve has proved economically beneficial to surrounding communities in his area. He pointed out that a number of young men have been employed in the Park and earns incomes to improve the welfare of their families.

He explained that Majete Park is viewed as a National Asset. Tourists who visit the park bring in forex which is essential for the development of the country. In addition the park is viewed as an important catchment area for rivers in surrounding areas.

At the community level there is collaborative management of the Park to enhance community ownership and commitment to conserve the Park. Community members are allowed to harvest some of the products in the park such as grass and herbs. They are also allowed to place bee hives to harvest honey as an income generating activity.

Community Based Organizations (CBOs) have also been established in villages around the Park through which funds for community based development activities are channeled. The CBOs implement environmental and income generating activities. Profits from such activities are shared by committee members to improve their livelihoods and excess funds assist needy communities and projects. For example Park Management have donated four maize mills to four CBOs as part of income generating activity.

In terms of corporate responsibility Majete Wildlife Reserve have managed to construct a number of school blocks and teachers houses in the area and have been paying school fees for some needy students.

Main Livelihood Challenges

The main livelihood challenge which the people in the area of TA Chapananga face is lack of food. Rainfall is erratic in Chikwawa more especially in the western bank of the Shire River. This has a big impact on food security in TA Chapananga. He was optimistic that the Shire Valley Irrigation Project will tackle this problem.

APPENDIX D.3 MEETING WITH TA KASISI

Present

- TA Kasisi – Chairman
- VDC Committee
- C. Chibwana - District Council Representative
- R. Matengula -- Key Expert

Discussion

The TA welcomed the research team to the meeting.

Introductions were made and the key expert outlined the objectives of the consultation meeting

He explained that the objective of public consultation was to review the implementation of the Shire Valley Irrigation Project and assess its impact on the project affected people (PAPs).

Specific aims are:

- To enlist views and opinions, reflections and aspirations, expectations and community involvement and participation of the affected community and other stakeholders in the development process for sustainable implementation of the project.
- To ensure that the relationship between project development and stakeholders should ideally be managed to achieve public acceptance and ownership.
- This is being achieved through Meetings conducted with key stakeholders to obtain their views and concerns with respect to the likely impacts of the project.

TA Kasisi welcomes the Shire Valley Irrigation Project. He explained that people in the area believe that irrigation can bring in changes to their livelihoods. The only concern is that the project is delaying considering that people are experiencing food shortages as a result of the dry spells.

Economic Benefits of Game Parks

TA Kasisi says Majete Wildlife Reserve has proved economically not beneficial to surrounding communities in his area. He cited as example that only two people are employed in the Park from his area whereas people from other TAs are employed in large numbers. He pointed out that sometimes more young men are given piece works such as cutting grass around fire breaks but this has proved not to be sustainable to the communities.

Communities in his area do not harvest any forestry products in the Wildlife Reserve which is securely fenced. They are not allowed to deploy bee hives on the reserve land.

In terms of corporate responsibility Majete Wildlife Reserve have managed to construct a number of school blocks and teachers houses in the area and have been paying school fees for some needy students.

Main Livelihood Challenges

The main livelihood challenge which the people in the area of TA Kasisi face is lack of food. Rainfall is erratic in Chikwawa more especially in the western bank of the Shire River. This has a big impact on food security in TA Kasisi. He was optimistic that the Shire Valley Irrigation Project will solve this problem.

Conflict between Livestock and crop farming

Once the new project is implemented TA Kasisi does not expect any conflict between livestock and crop farmers. Sometimes it is errors made by herdsmen which may result in livestock destroying crops. There are by laws which bind livestock owners to make sure that their livestock do not destroy crops.

APPENDIX D.4 MEETING WITH TA KATUNGA

Present

- TA Katunga – Chairman
- VH Mpatsa
- VDC Commitee
- Chibwana - District Council Representative
- R.Matengula -- Key Expert

Discussion

The TA welcomed the research team to the meeting.

Introductions were made and the key expert outlined the objectives of the consultation meeting

He explained that the objective of public consultation was to review the implementation of the Shire Valley Irrigation Project and assess its impact on the project affected people (PAPs).

Specific aims are:

- To enlist views and opinions, reflections and aspirations, expectations and community involvement and participation of the affected community and other stakeholders in the development process for sustainable implementation of the project.
- To ensure that the relationship between project development and stakeholders should ideally be managed to achieve public acceptance and ownership.
- This is being achieved through Meetings conducted with key stakeholders to obtain their views and concerns with respect to the likely impacts of the project.

TA Katunga welcomes the Shire Valley Irrigation Project. He explained that there great expectations by people in the area was that once the project is implemented it will solve their food security and economic problems. The only set back has been that the project has taken long time to be implemented shattering hopes which the people had to improve their livelihoods.

He is optimistic however that the new project will bring many benefits which includes increased food security; job opportunities for young people

Economic Benefits of Game Parks

TA Katunga says Majete Wildlife Reserve has not proved economically beneficial to surrounding communities in his area as opposed to communities in other TAs. He cited as example that none of the people from his area are employed in the Park. Communities in his area do not harvest any forestry products in the Wildlife Reserve which is securely fenced. They are not allowed to deploy bee hives on the reserve land.

In terms of corporate responsibility Majete Wildlife Reserve have managed to pay school fees for some needy students.

Organizations such as Press Cane and Kasinthula Cane Growers have shown no corporate responsibility. They have not assisted in the development of communities in the area through projects to provide potable water supply, construction of health facilities or improvements to existing school infrastructure.

Main Livelihood Challenges

The main livelihood challenge which the people in the area of TA Katunga face is lack of food. Rainfall is erratic in Chikwawa more especially in the western bank of the Shire River. This has a big impact on food security in TA Katunga. He was optimistic that the Shire Valley Irrigation Project will solve this problem.

APPENDIX D.5 MEETING WITH TA NGABU

Present

- TA Ngabu – Chairman
- C. Chibwana - Chikwawa District Council Representative
- R. Matengula -- Key Expert

Discussion

The TA welcomed the research team to the meeting.

Introductions were made and the key expert outlined the objectives of the consultation meeting

He explained that the objective of public consultation was to review the implementation of the Shire Valley Irrigation Project and assess its impact on the project affected people (PAPs).

Specific aims are:

- To enlist views and opinions, reflections and aspirations, expectations and community involvement and participation of the affected community and other stakeholders in the development process for sustainable implementation of the project.
- To ensure that the relationship between project development and stakeholders should ideally be managed to achieve public acceptance and ownership.
- This is being achieved through Meetings conducted with key stakeholders to obtain their views and concerns with respect to the likely impacts of the project.

TA Ngabu welcomes the Shire Valley Irrigation Project. He explained that the project dates back to the period of Dr. Hastings Kamuzu Banda. However after Traditional leaders and communities were sensitized the project did not materialize. Consultations were restarted in 2008 but did not continue. Since last year Traditional Leaders have been invited to a number of meetings where they were informed that there was now commitment by both the Malawi Government and donors to implement this project.

However there is still concern among Traditional leaders and communities in the project area that these consultations may not be different from the previous ones which ended without the project being implemented.

He pointed out that this project is very important to the people in the Lower Shire more so now that the effects of Climate Change are affecting the people in a hard way. It will be sad if the new consultations will have the same fate as the previous ones with the project not being implemented.

People in the Lower Shire have great expectations that once it is implemented it will solve their economic and food security problems. The only set back has been that the project has taken long time to be implemented shattering hopes which the people had to improve their livelihoods.

He is optimistic however that the new project will bring many benefits which includes increased food security; job opportunities for young people

Economic Benefits of Game Parks

TA Ngabu says Lengwe Wildlife Reserve has proved economically beneficial to surrounding communities in his area. He explained that at the national level the Park is a Tourist Resort and brings in Foreign Currency.

At the community level Joint Management structure was established to ensure co-management of the Park and foster community commitment to conserve the Park.

Community Based Organizations (CBOs) were established in all villages which surround the Park through which Park Management support various community level development projects.

Main Livelihood Challenges

The main livelihood challenge which the people in the area of TA Ngabu face is lack of food. Rainfall is eratic in Chikwawa more especially in the western bank of the Shire River. This has a big impact on food security in TA Ngabu. He was optimistic that the Shire Valley Irrigation Project will tackle this problem