



GOVERNMENT OF MALAWI

**MINISTRY OF AGRICULTURE, IRRIGATION AND
WATER DEVELOPMENT**

SHIRE VALLEY TRANSFORMATION PROGRAM

**Updated Environmental and Social
Impact Assessment (ESIA) for the**

Shire Valley Irrigation Project (SVIP)

Impact Assessment Report

Disclosed on May 24, 2017 (updated and redisclosed on August 8, 2017)

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) FOR THE SHIRE VALLEY IRRIGATION PROJECT (SVIP) IMPACT ASSESSMENT REPORT

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List of Acronyms

ADD	Agricultural Development Division
Ca	Calcium
CC	Construction contractor
CBOs	Community Based Organizations
CMIP	Common Management Information Protocol
COB	Coyne et Bellier Study
DNPW	Department of National Parks and Wildlife
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
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
JICA	Japan International Cooperation Agency
KRC	Korea Rural Corporation

LNP	Lengwe National Park
Masl	Meters above sea level
Mg	Magnesium
MWK	Malawian Kwacha (1\$ US equals +/-715 MWK)
MoAIWD	Ministry of Agriculture, Irrigation and Water Development
MWR	Majete Wildlife Reserve
N	Nitrogen
NWDP	National Water Development Project
P	Phosphorus
PAPs	project-affected people
PCCPLTRPF	Preparation and implementation of a Communications, Community Participation, Land Tenure and Resettlement Policy Framework
pH	Soil Reaction
PMP	Pest Management Plan
PPE	Protective Personal Equipment
PPP	Public Private Partnership
RoW	Right-of-Way
SRBMP	Shire River Basin Management Program
SVIP	Shire Valley Irrigation Project
SVTP	Shire Valley Transformation Program
TORs	Terms of Reference
UNESCO	United Nations Education Scientific and Cultural Organization
WASVIP	Water Availability for Shire Valley Irrigation Project
WESM	Wildlife and Environmental Society of Malawi
WRB	World Reference Base for Soil Resources

1. INTRODUCTION

This report is the updated Impact assessment (ESIA) report. The Impact assessment report and Environmental and Social Management Plan constitute the Environmental and Social Impact Assessment report (ESIA) for the Shire Valley Irrigation Project (SVIP), and are based on analysis of baseline and impacts. Baseline was included in Baseline report. In addition, an Executive Summary was produced as a standalone document.

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. In addition, two stand-alone reports, the Inception report (June 2015) and the Pest Management Plan (PMP, September 2016) were produced by the consultant.

The ESIA and PMP were developed by BRL, Nimes, France. This report is based on the Consultant’s final version, which has been publicly disclosed. However, the Government of Malawi will update this report (i) as new technical project information becomes available, particularly after the Detailed Design of the irrigation works has been completed and (ii) in response to further public and stakeholder comments.

OBJECTIVE OF THE PROJECT

The Project objective is to provide access to reliable gravity-fed irrigation and drainage services, secure land tenure for smallholder farmers, and strengthen management of wetlands and protected areas in the Shire Valley.

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 complies 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 are applicable, when relevant. Measures developed under this assignment has informed the Client and technical studies about ways to mitigate impacts and enhance positive effects of the Project. The ESIA is based on the FS description of the Project.

Mitigation measures are based on the BRLi experience in canals in Africa not only in designing canals but also in monitoring impacts during construction. Fieldwork and discussions with stakeholders have helped identifying risks and impacts.

This ESIA is not only intended for funding agencies who financed the ESIA but also for the construction contractor, the designer of the Project the future operator as well as national institutions and the SVIP.

SHIRE VALLEY TRANSFORMATION PROGRAM - I

The program development objective for the Shire Valley Transformation Program is to improve the management and utilization of natural resources in a sustainable way to increase agricultural productivity and commercialization for targeted households in the Shire Valley.

The SVTP-I Project Development Objective is to provide access to reliable gravity fed irrigation and drainage services, secure land tenure for smallholder farmers, and strengthen management of wetlands and protected areas in the Shire Valley.

The first project under the program (SVTP-I) will initiate the process of transformation of the Shire Valley and pave the way for agricultural commercialization and improved natural resource management at the landscape level. The indicative objectives for the second and third phases would be to increase agricultural productivity in targeted smallholder-owned commercial farm enterprises; support value chain and value addition; extend area supported with irrigation and farm development; and continue and expand efforts to address land degradation and sustainable management of forests, wetlands and protected areas.

The Program is directly aligned with Malawi's policy commitments to address climate change and build resilience, as set-out in Malawi's Nationally Determined Contribution (NDC) document submitted to the United Nations Framework Convention on Climate Change in 2015. NDC's top adaptation priorities are to address land and watershed degradation and specifically the loss and degradation of forests, improve the resilience of the agriculture sector to climate change through development of irrigation and climate smart agriculture and improved management of fisheries and natural ecosystems.

The SVTP is a 14-year program (2017-2031) structured around three coordinated pillars:

- (i) Providing reliable, professionally managed and sustainably financed irrigation service to a large number of irrigators in a phased construction of the Shire Valley Irrigation Project scheme and providing multiple services including water supply;
- (ii) Support farmer organization within a comprehensive land use plan; supporting land tenure strengthening and consolidation; as well as natural resources management; and
- (iii) Establishment of smallholder owned commercial farm enterprises transitioning into commercial agriculture from subsistence farming and integrating them into commercial value chains.

These pillars all contribute to the overarching goals of the program, and build on each other in a phased approach.

This project is the first of three sequential but partially overlapping phases (with different financiers entering at different times and in parallel financing arrangements). In general terms, SVTP-I initiates the process on all pillars with a major focus on irrigation service provision to the SVIP-I area, land tenure, farmer organization and natural resource management as these precede any downstream development. While not investing heavily yet in areas of agricultural commercialization and investment promotion, it incorporates the vision and principles of agricultural modernization and commercialization and prepares for downstream investments under SVTP-II, which shifts investment focus to agricultural investment, private sector and value chain support, as well as the investments in bulk infrastructure for the SVIP-II area. Finally, SVTP-III is the scale up phase of investments to the SVIP-II area. Additionally, the government of Malawi has allocated GEF-6 resources to support investments from the Biodiversity, Climate Change, and Sustainable Forest Management focal areas. Designed as a fully blended operation, GEF funds will provide support to Component 2 (natural resources management) of the Shire Valley Transformation Project (SVTP-1). Under SVTP-I there are four components:

Component 1: Irrigation Service Provision

This component will implement the works, goods and services necessary to develop irrigation and drainage infrastructure in the SVIP-I area. This includes preparation of detailed designs and construction supervision and quality assurance, construction of the physical bulk water conveyance and main distribution system, major drainage and service and access roads. Provisions will be made for SVIP-II area in terms of canal dimensions, right of way, and preparatory studies. In parallel, the component will support spatial planning in the wider project area to ensure the irrigation scheme is well integrated with other land uses and natural resources. Subcomponent 1.2 will support the establishment of a professional management, operation and maintenance system for the scheme.

Component 2: Preparing land-based investments and natural resources management support

Sub-component 2.1 will implement the works, goods and services in support of addressing security of land tenure and organizing farmers for commercial production – as a first step in developing commercially oriented agriculture. This subcomponent supports coordinated pilot implementation of the new legal framework for land administration. Subcomponent 2.2 is GEF funded and supports natural resources management to broaden the multi-sectoral benefits of the program and enhance environmental sustainability within the modernization program. Key activities focus upon national level strengthening of frameworks for biodiversity conservation, sustainable landscape management and building capacity for field level monitoring and management of information for enforcement. The program will invest in protected areas, the Elephant Marshes and associated activities that will support improved natural resource management and the development of a broader land use plan for the Shire Valley.

Component 3: Agriculture Development and Commercialization

This component will implement the works, goods and service in support of a program of activities to support inclusive commercialization in agriculture through smallholder owned commercial farm enterprises. Financial sustainability of the SVIP irrigation investment can only be achieved through profitable agricultural production. Farms will need to be linked to Commercial Value Chains for production and sale of their produce. Development of commercial value chains will be needed to enable farmers to gain access to markets and commercial services; this is essential to enable viable commercial agriculture. The process of identifying and capacitating farmers for commercial production will begin immediately after the project is commenced so that farmers will be ready for commercial operation when the irrigation infrastructure is completed. This component will pave the way for major scale up in SVTP-II.

Component 4: Project Management and Coordination

This component will finance the multiple coordination and management needs of a project of this scale and focus on the roll out of the communications strategy and manage grievance redress mechanisms, as well as day-to-day management, monitoring and evaluation of the project. The GRMs will provide a responsive ongoing mechanism to address PAP and other stakeholder concerns raised throughout the life of the project, including those arising from resettlement and compensation initiatives, and construction and operations phases. The sub-component will finance project management structures that have been established and in place throughout project preparation. The project will provide funding for professional and support staff to strengthen the PMT and facilitate its operations, coordination and communication, including procurement, financial management, environmental and social safeguards specialists.

The sub-component of the SVTP called “Sub-component 2.2 Natural Resources Management” will be supported largely with GEF-6 funding and will promote an inter-sectoral approach to the management of the Lower Shire landscape by addressing biodiversity conservation, protecting and enhancing the role that forests, woodlands, rangelands and wetlands play in mitigating climate change; and promoting sustainable approaches to forest management that protect forest resources and deliver benefits to local communities.

At landscape and park level, this sub-component would:

- (i) Invest in community-level natural resource management in areas adjacent to the irrigation and conservation areas (Lengwe National Park, Mwabvi and Majete Wildlife Reserves, Matandwe Forest Reserve and the Elephant Marsh proposed Community Conservation Area) and in wildlife corridors,

(ii) Provide targeted support to these conservation areas to strengthen conservation and community management and encourage private sector investments (e.g. by tourism concession investors) that could boost revenues for re-investment in local community development and conservation management,

(iii) Invest in establishment of the Elephant Marsh Community Conservation Wetland Area, with a strong emphasis on community-based natural resources management strategies, based on the wetland management plan currently being finalized with the support of the Shire Basin Management program (SRBMP) phase 1.

Activities that will be implemented as part of this sub-component are separate from, and additional to, the mitigation measures specified in this ESIA. Although by and large these activities have positive environmental impacts, a screening procedure is included in the ESMP to address any possible negative impacts that may arise from these community level activities.

2. MITIGATION WORKSHOPS

After the draft Impact Assessment report was produced, a mitigation workshop was carried out by the Consultant in November 2016. The objective was to present the mitigation measures to stakeholders and collect their opinions. In addition, a presentation to the Task Force, World Bank and the Feasibility Consultant was done to discuss about several key issues: the tiger fish, the impact on Majete Wildlife Reserve and on Lengwe National Park and impacts on Elephant marsh.

WORKSHOPS WITH LOCAL COMMUNITIES

Two workshops with communities in Nsanje (November 10th 2016) and Chickwawa (November 11th 2016) Districts were held and presented by the Consultant. The objective was to expose the main conclusions from the impact assessment and the set of mitigations. Opinions and questions raised are presented in annex of this report; some of them are dealt with in the main text whenever relevant. In Nsanje, 50 people attended the workshop and in Chickwawa 37.

Other meetings were held at several occasions, their outcomes are presented in relevant sections: meeting with African Parks, meeting with Jambo Africa (in charge of tourism in LNP), meeting with Wildlife and Environment Society of Malawi (WESM) and meeting with Escom.

Figure 1 Workshop at Nsanje (left) and Chickwawa (right)



Source: BRLi, 2016

WORKSHOP WITH TASK FORCE AT LILONGWE

A Workshop with Task Force (SVIP), the FS consultant team, with the World Bank and national stakeholders was held. It was the opportunity to exchange on the latest development of the FS, and on the key technical issues to address such as the tiger fish barrier and type of canal inside MWR.

OUTCOME OF DISCUSSIONS

In the draft impact assessment report, BRLi had developed several scenarios for the canal inside MWR (and estimated their cost). In parallel, the FS consultant had developed a new canal alignment that was not specifically presented in its report. The outcome of the discussion was that:

- The FS Study proposes a canal that is partially underground inside MWR and crosses the Mwembezi River using a siphon (more detail is provided in this report under section 4). The rationale for the latest canal alignment route and mix of open and buried canal is the presence of topographic and terrain constraints. The high cost for the buried sections do not leave much place for a completely buried canal.
- The FS Study did not have the correct boundaries of the reserve and confused the electric fences with MWR boundaries; in fact, the fences are not MWR boundaries.
- BRLi needs to take into account this new canal alignment, however the FS consultant (or Design consultant) also need to study the shortest possible way out of the reserve.

The Tiger fish issue had been given serious consideration by the World Bank. Discussion revolved under the most efficient location for a Tiger fish barrier which is on the Feeder canal and inside MWR (see section 8.7). The FS consultant has been required to incorporate in its design a fish weir at this location.

INCEPTION AND BASELINE CONSULTATIONS

The Consultant had carried out other consultations in the framework of this ESIA at inception and baseline, their outcomes are presented in the Inception and Baseline reports:

- Inception mission (June 2015)
- Baseline mission (January 2016)
- Public consultations (June 2016) two consultation with stakeholders: one in Chikwawa and one in Nsanje

PREVIOUS PUBLIC CONSULTATIONS

In the framework of the 2005 EIA, the consultant in charge of the EIA (Coda and Partners in association with Ninham Shand for the former Ministry of Irrigation and Water Development, 2005) carried out public and stakeholder consultations between September and October 2005.

3. RELATION BETWEEN THE IMPACT ASSESSMENT REPORT AND OTHER SVIP STUDIES

The ESIA/ESMP has many links with other studies. These links can be distinguished in three different categories:

- Relations with the Project technical studies (feasibility and design study);
- Relations with Shire River Basin Management Programme (SRBMP) funded by the World Bank;
- Relations with other studies under the SVIP.

The following table presents these relations.

Table 1 Relations between studies

Project technical studies	Relation
Feasibility Study reports (several versions were produced during the writing of the ESIA, the final version is dated December 2016)	The ESIA is based on FS project definition. The ESIA provides to the FS study the series of mitigations that need to be technically tested. These mitigations only relate to infrastructures or changes in the Project design that will be required to mitigate or avoid impacts.

Design Study (after the FS). This study has not started yet.	The ESIA proposes many measures for which the technical and economic feasibility will have to be assessed at the Detailed Design study phase. The Design has to make a final decision on the fate of mitigations presented in the ESIA. Tender documents after the Design phase have to include measures from the ESMP
SRBMP studies	Most of SRBMP studies were not available at time of Vol.1 Baseline report. Their conclusions are used in this final version of Vol.2
Component A – Shire Basin Planning Sub-components: A1-Basin planning framework A2-Institutional capacity A3-Water resources information systems A4-Program management monitoring & evaluation Component B – Catchment Management Sub-components: B1-Catchment planning, monitoring and learning B2-Rehabilitation targeted catchments B3-Alternative rural livelihoods B4-Ecological management Component C – Water related infrastructure Sub-components: C1- Kamuzu Barrage C2-Flood management C3-New water investment	The SVIP is included within the Shire River Basin Management Program (SRBMP) planning for the Basin and its longer-term basin modelling and water allocation. In the framework of SRBMP activities, several studies produced results that were used in this ESIA Report, most notably the Shire Basin Plan (which exists as a draft) and ecological, hydrological, and ecosystem management studies for the Elephant Marsh.
Implementation Service Provider (ISP) for Flood Risk Management (SRBMP-1)	This report deals with risk from floods. In some sections, it presents measures to minimize flood impacts on human safety from: • Ruo River • Thangadzi East River • Mwanza River • Lalanje River • Tombokamwa River
Lengwe National Park, General Management Plan 2016-2020 work document (Component B, Sub component B4)	The ESIA refers to this document as it defines new objectives for the LNP as well as identifies current issues with wildlife and infrastructures of the park.
Shire River Basin Management Program (Phase I) Project Final Environmental and Social Assessment Report (July, 2013)	The overall assessment of impact of SRBMP planned activities is dealt with in this report (except for the impact of Kamuzu barrage).
Independent Environmental Impact Assessment for the Upgraded Kamuzu Barrage (December 2011)	An ESIA was carried out under the Component C.1: upgrading of the Kamuzu Barrage. The barrage is a key element which has many interactions with SVIP as the current objective of the upgraded barrage is to raise the water level up to 40 cm in Lake Malawi.

Climate resilient livelihoods and sustainable natural resources management in the Elephant Marshes, Malawi. Ministry of Water Development and Irrigation. P117617. <u>Description of the livelihoods in the area of the Elephant Marsh Report</u> November 2016	This study addresses the following objectives (MRAG, 2016): • Describe local livelihoods, including spatial and temporal use of resources; • Assess the past, present and potential future influence of human livelihoods on the Elephant Marshes, and what effect these will have on the functional resilience of the Marshes in the future, and the implication for climate change; • Identify the socio-economic impacts of livelihoods and how climate change might affect these livelihoods; • Describe the risks to livelihoods (e.g. flooding or overfishing), and current strategies to increase resilience to these risks that will be exacerbated by climate change; and • Provide an assessment of the support mechanisms for community welfare in line with possible flood mitigation measures and disaster management strategies.
Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi <u>Management Plan for the Elephant marsh</u>	The management plan objectives are to: • To improve understanding of the functional ecology of the Elephant Marsh; • To assess the feasibility of designating the Elephant Marsh as a community-managed protected area and a Ramsar site; and • To identify strategies and development options that would build the resilience of local communities to environmental change At time of final Impact assessment writing, the management plan was not available (not published)
Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi <u>Hydromorphology study</u>	The hydromorphology study objectives are to: • To establish the current status and recent trends of the hydromorphology of the Elephant Marshes. • To establish a hydraulic model predicting flooding patterns in the Elephant Marshes since flow records began. • To evaluate historic land-use change (especially deforestation and agriculture) and its effect on sedimentation and siltation. • To map historic changes in the channel patterns in the marshes. This report was not available at time of the Baseline report (Vol.1) and at time of draft Impact Assessment report (Vol.2). However, main conclusions from it were used to update this Vol.2 final version.
Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi Sub-Study 4: <u>Biodiversity of the Elephant Marsh</u> (2016)	"This sub study forms part of a larger study on the Elephant Marsh which also includes studies of the hydrodynamics, local communities and ecosystem services, in order to provide key information for a management plan for the marshes, as well as to prepare an application for Ramsar status as a Wetland of International Importance" (Anchor, 2016).

	This sub-study aimed at describing (through surveys), biodiversity of Elephant marsh. Specialized surveys and studies of several taxonomic groups were carried: plants, aquatic invertebrates, dragonflies, butterflies, reptiles, amphibians, fish, birds and mammals. This report was not available at time of the Baseline report (Vol.1) and at time of draft Impact Assessment report (Vol.2). However, main conclusions from it were used to update this Vol.2 final version.
Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi Analysis of the potential effects of alternative future scenarios of flow and/or management on the ecological condition of the Elephant Marsh (<u>Ecosystem Functional Model (DRIFT)</u> (2016)	This sub study explores the potential effects of alternative future scenarios of flow and/or management on the ecological condition of the Elephant Marsh. This report was not available at time of the Baseline report (Vol.1) and at time of draft Impact Assessment report (Vol.2). However, main conclusions from it were used to update this Vol.2 final version.
Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi. Sub-Study 3. <u>Ecosystem Services of the Elephant Marsh.</u> (December 2016).	This study is a desktop study which: • Describes the ecosystem services provided by the Elephant Marsh in physical terms and provide desktop estimates of their economic and social value; • Draws comparisons with other wetlands in Africa of a similar nature; • Discusses how capacity of the system to deliver these services responds to hydro-morphology how this has changed over time; • Discusses the wetland's sensitivity and adaptive capacity to multiple pressures, with a description of those pressures. This report is relevant for Baseline information and this impact assessment report.
Shire River Basin Plan (draft December 2016)	This report is the result of the Shire Basin Planning Consultancy and a participatory multi-sector process. It includes information on a basis for planning; a Framework Plan; sectoral and thematic planning; Climate Change Adaptation Plan; sub-basin plans; Investment Plan; Strategic Environmental Assessment; Promulgation Plan; and Monitoring, Evaluation, and Reporting Plan. It describes the institutional, physical, environmental and socio-economic characteristics and outlook for the Basin, and identifies key management issues to achieve the Basin-wide vision and goals. It prioritizes sector and multi-sector actions and addresses the emerging environmental and social issues associated with the prioritized investment options, along with the management strategies for how to address them. The Shire Valley Irrigation Project ranks high on its list of recommended priority investments.

Other SVIP studies	
Public-Private Partnership (PPP Feasibility study) (on going)	The PPP study informed the ESIA about public-private partnership arrangements for irrigation services for SVIP. The ESIA also makes recommendations about what arrangement and what are the responsibility of the scheme operator in terms of maintenance and what is the relationship between parks management (Lengwe and Majete) and the scheme operator. The ESIA also helps to identify environmental and social risks regarding the scheme operator.
Hydraulic model study at the headpond of Kapichira dam	Although the title of the study is hydraulic modeling, the main objective of this study is to assess the impact of the Project on the reservoir sedimentation pattern. The study's objectives are also to avoid negative impact on sediment flushing operations at the power station and to minimize the entry of sediment into the proposed feeder canal system of SVIP. The ESIA will not rely on conclusion of this study, as the progress of the study is not as advanced as the ESIA. The ESIA is therefore referring to this study for these topics.
Preparation and implementation of a Communications, Community Participation, Land Tenure and Resettlement Policy Framework (PCCPLTRPF) (on going)	Many elements on socioeconomics are dealt with in the PCCPLTRPF. The ESIA make references to it. This assignment is divided in several studies: • Communications strategy: This study describes the main stakeholders and presents a SWOT analysis. It also presents the communication strategy toward stakeholders. • Gender and Youth Strategy Study: This study describes the current challenges that women and young people face. This report also recommends a series of measures and guidelines aiming at these two groups. In addition, roles of various stakeholders and monitoring actions are defined. • Grievance redress mechanism: This study describes the current method for grievance redress (revolving around traditional leaders). This study also implements the Grievance Redress Mechanism (GRM) and Grievance Redress Committee (GRC) to ensure that people's opinions and grievances regarding the project are documented and addressed. In addition, monitoring of complaints will be carried out under this mechanism. • Resettlement Policy Framework This document provides the basis for the Resettlement Action Plan (regulatory review, gap analysis, etc.). It deals with impact of resettlement but also the issue of access to sources of livelihood and to impact on cultural heritage. The ESIA refers to this study, especially when it comes to the number of affected villages and the number of bridges that shall be built to cross canals (and footpaths for people). • Stakeholders' views report This report presents the main conclusions from various stakeholder's consultation. It discusses stakeholders views on several topics: land tenure, access to irrigated land, resettlement, agricultural development, access to water for livestock and gender vulnerability. • Socio-economic baseline report This report presents the main socio-economic figures of the

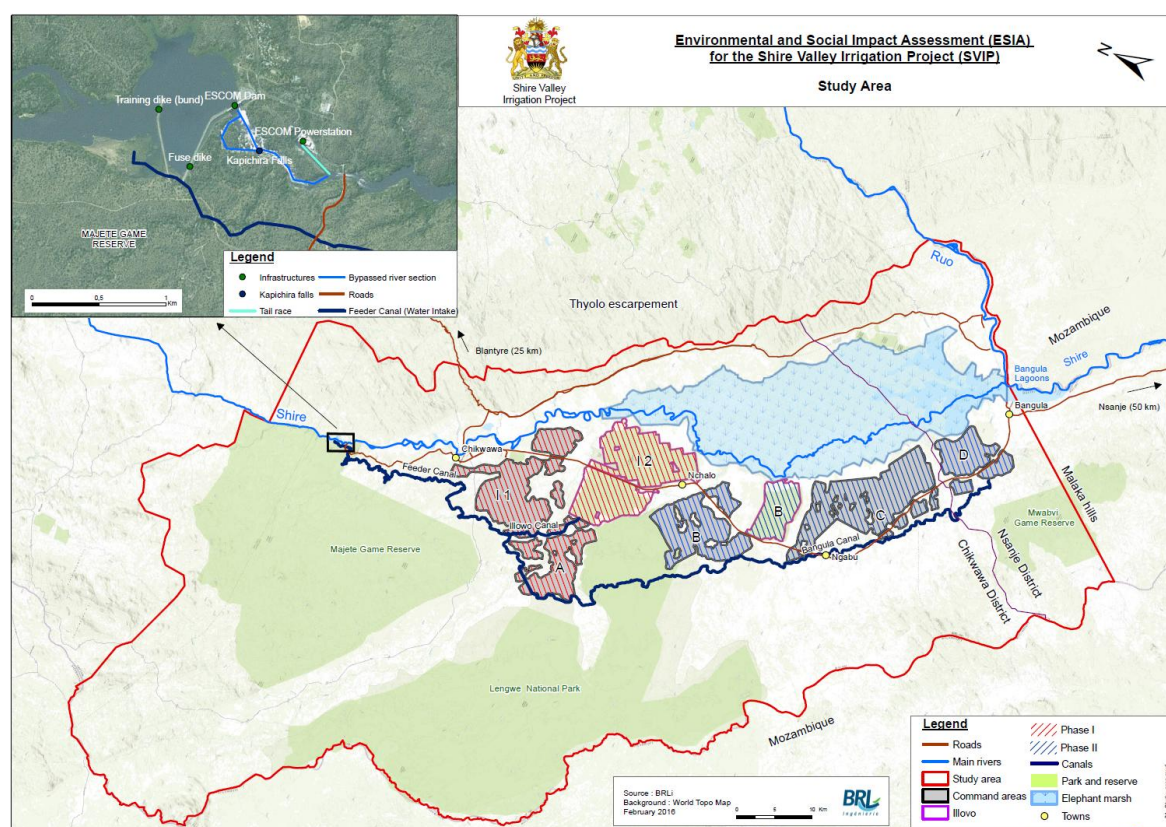
	SVIP area and discusses about health, land tenure, livestock, agriculture, etc. It also includes a chapter on communities' views of the Project.
Agricultural Development Planning Strategy (2016)	This study describes the crops of SVIP. Many elements related to agriculture and fisheries are dealt with in this report. It discusses about mitigation for smallholder livestock farmers and assesses the potential for fish farming. In addition, this study describes efficient organization of producers that shall be implemented
Pest Management Plan (2016)	The PMP identifies the main pest based on the type of crops and proposes measures to fight pests.
A Cultural Heritage Impact Assessment Report (2016)	This report provides information on cultural heritage sites based on surveys around Phase I of SVIP. Forty-six sites were identified by the MDoA in addition to those identified by the consultant.
Other report	
Majete Wildlife Reserve, 5 years business plan 2016-2020	This document, written by African Parks, describes the reserve's objectives and presents its zoning. It also describes the various infrastructures of the reserves.

4. PROJECT LOCATION AND DESCRIPTION

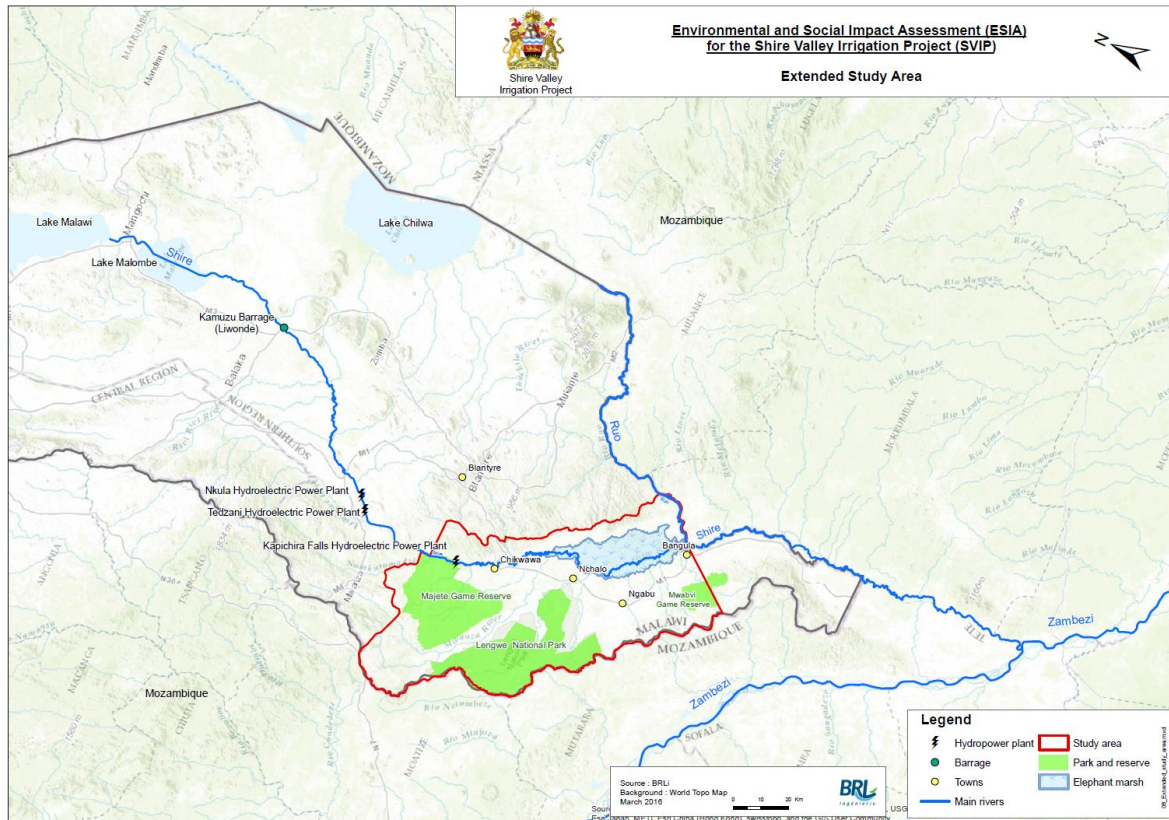
The impact assessment is based on the actual description of the Program and field visits in this area were carried out during the preparation of this study. The Study area is a geographical area that includes all the Project components as well as the boundaries of potentially affected geographical areas.

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. From a hydrological perspective, 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 as the area that 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 on the next page shows the Extended Study area.



Construction work of the SVIP is expected to start in 2018 after a tendering process for a designer, a construction contractor and a scheme operator. The water will start to flow inside the water intake at Kapichira Dam towards the end of year 2022. The total cost of SVIP taking into account direct and indirect construction costs is estimated at 519,250,000 USD. (KRC final report, 2016). This excludes the mitigation measures recommended in this Impact assessment report and detailed in the ESMP.



As mentioned in the latest version of the FS (Korea Rural Corporation, 2016), the Project consists of several key infrastructures as presented in the following sections. The Project design and construction will be phased according to the phases of the Project (Phase I will be designed and built separately from Phase II). Phase I is supposed to start in 2018. Phase II will start at an unknown date, most likely after Phase I.

In addition to these infrastructures, based on the latest information, this ESIA takes into account that dams of tributary rivers were not retained as options to increase available water for SVIP.

The Feasibility Study (FS) was finalized in December 2016. It was undertaken by Korea Rural Corporation in Joint Venture with Dasan Consultants co., LTD., GK Works Civil and Structural Engineers.

4.1 WATER INTAKE

A water intake will be built at Kapichira reservoir, the highest topographic point of the scheme (145.5~146.5masl), on the right bank of the Shire River, upstream from Escom training dike and the fuse dike, on the opposite side of the water intake of Escom hydropower station.

The SVIP water intake will extract a certain amount of water from the Shire River (the reservoir) to distribute water by gravity to the scheme. The value will be between 20.5 and 51.3 m³/s depending on the season. Based on the Hydraulic Modeling study, a bathymetric survey was carried out to select the adequate location which is shown in the following figure.

Figure 2 Water intake location inside MWR



Source: KRC, 2016

The SVIP intake structure will comprise a 46.5 m long intake sill, with 12 sluice gates each 3 m wide.

The Escom power plant has a capacity of 132 MW. The by-passed section between the reservoir dam and the power plant is very short (900 meters). An informal environmental flow of 30-50 m³/s is currently released from the dam spillway, which helps to maintain a strong flow over the Kapichira Falls during the rainy season. Although not a primary reason for visitors to come to the Majete Wildlife Reserve, the Kapichira Falls serve as a seasonally valuable tourist attraction. During much of the dry season, this environmental flow is not guaranteed and the Kapichira Falls sometimes dwindle to a trickle.

4.1.1 Construction and characteristics

No information regarding the construction of the intake is available (quantity of material needed, location of quarries, RoW, duration of work, etc.), most of these details will be provided at Design stage. One element can be highlighted: in order to prepare the passage for the water intake, part of the reservoir may be dredged to deepen the channel (using a dredger), if not already fully implemented by the planned reservoir dredging by EGENCO. The ESIA and ESMP will be updated with specific information as it becomes available after detailed design, and will also need to be included in the contractor's ESMP, based on principles of this ESIA avoiding impacts within the Reserve..

4.1.2 Operation

The gates will be operated by an automatic control system. When the operator inputs the required amount of water into the system, the system will automatically operate the gates based on the relation between the flow rate, gate opening and water level variation. The 12 sluice gates will be installed into two partitions, the first one comprising 8 gates and the second one 4 gates. The second partition will allow abstraction of 18 m³/s, and will be operated when the water requirements at the scheme are less than 18 m³/s. The first partition will allow abstraction of up to 32 m³/s and will be operated when the water requirements at the scheme are between 18 m³/s and 32 m³/s. Both partitions will be operated for scheme water requirements above 32 m³/s to the maximum requirement of 50 m³/s (KRC, 2016).

The SVIP water demand per month is presented in section 6.5 (hydrology impact assessment).

The water intake is not a pumping station as water enters the intake passively (gravity).

4.2 CANALS

There will be three main canals:

- A Feeder canal, also called Main canal 1, with a total length of 33.8 km (conveying water from the water intake),
- The Supini canal, also called Main canal 3, with a total length of 10.7 km (previously called Illovo canal) mainly irrigating Phase I,
- The Bangula canal, also called Main canal 2, with a total length of 88.0 km mainly irrigating Phase II but also some Zone in Phase I (before Lengwe National Park).

Each main canal will be lined with concrete. Bangula canal could potentially be an earth canal (not lined) in the 14 km stretch along Lengwe National Park. However, feasibility of an earth canal still needs to be assessed at Phase II.

The following are the main characteristics of the canals based on the feasibility study (lined canal). RoWs are estimated.

Table 2 Main canals characteristics

	Slope	Length (km)	Depth (m)	Average Velocity (m/sec) at max. capacity	Peak flow (m ³ /s)	Bed width (m)	Upper width (m)	Total Right of Way (RoW) (m)
Feeder Canal (also called Main Canal 1)	1H/1.5V	33.7	2.5	1.51	50	12.7	22.6	40-45
Supini Canal (also called Main canal 3 and Illovo Canal)	1H/1.5V	10.6	1.3	1.35	14	6.7	13.0	+/-40
Bangula Canal (also called Main canal 2)	1H/1.5V	78.7	1.9	1.13	29	9.1	17.2	30-45

Source: KRC TF final version, 2016

Each of these canals separate into Branch canals.

Siphons are planned to cross large valleys and rivers with important floods. In total, 11 siphons are planned for a total length of about 4 km. Culverts are planned where topographic changes are high but floods are small. Culverts are also planned to cross small-scale rivers and roads.

INSIDE MAJETE WILDLIFE RESERVE

Due to topographic constraints, the Feeder canal inside MWR is going to be partially underground along 1.25 km inside MWR boundaries. It will be open (open lined canal) along 1.20 km inside MWR.

The following are the characteristics of the underground canal (siphon) in MWR.

Table 3 Siphons of MWR

Chainage location of siphons	Length (m)	Length in MWR (m)	Size (m)	Name
0+64 to 0+817 (entirely in MWR)	755.40	755.40	8.0 x 3.0	Intake and #1 Siphon
1+237 to 1+430 (entirely in MWR)	195.40	195.40		#2 Siphon
2+710 to 2+890 (partially in MWR)	181.70	100		#3 Siphon
3+400 to 3+800 (partially in MWR)	406.80	200		#4 Siphon
Total length of buried canal inside MWR		1250.8		

Source: adapted from KRC TFS Final (2016)

According to the FS, the thickness of concrete will be sufficient to allow large wildlife to pass (50 cm). This thickness shall not be compromised at Design phase.

This report takes into account that the buried canal is fully buried and does not represent an impassable obstacle for wildlife. In case if the canal is not fully buried than 3 wildlife overpasses shall be installed inside MWR as presented in the Draft Impact assessment report.

NIGHT WATER STORAGE

In addition, night water storages will be built, their locations are not provided in the FS. Their size is as follows: between 90 and 270 meters long and 40 to 180 meters wide with a depth of 3.5 meters.

4.2.1 Construction and characteristics

Not much information is provided in the FS reports about the construction of canals. Usually canal construction is done with an excavator to remove earth which is then either stored or transported by trucks. Important elements for ESIA are lacking such as quarries location and duration of work (except for work in LNP which are mentioned in the Option report to last 2 years). The FS report provides with name of 8 borrow pits and quarries, but does not provide with location nor does mentioned whether these are existing or not. Sometimes the name reveals an existing pit: borrow pits are Tomali, Nyaika, Sibale old pit, Nyamithuthu old pit, Chikhama, Moroko, Chikalumpha and Namiche. Quarry sites investigated are Kajawo, Thabwa existing quarry, Nzongwe and Ngabu (KRC, 2016). Detailed information will be provided in the Design study and potential impacts will be assessed in the updated ESIA and specific measures provided in the updated ESMP.

4.2.2 Operation

All canals are gravity canals bringing water from the Feeder canal to the Supini and Bangula canals, each of which will lead to Branch canals. In some area, canals may be replaced by siphons (when crossing large rivers such as Mwanza River).

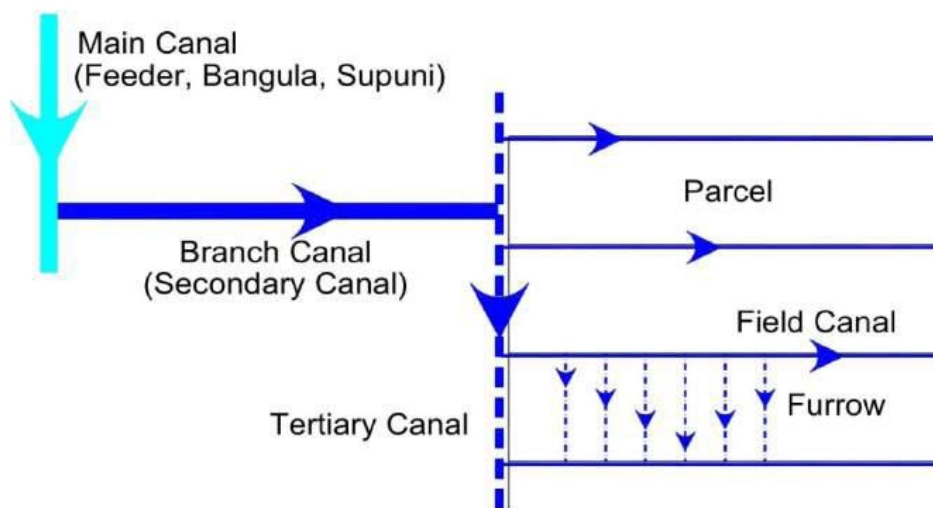
The daily time for irrigation depends on the irrigation methods. For pivot irrigation system, irrigation time is 24 hours, a whole day. For furrow irrigation, water application is normally 12 hours, during the daytime. Therefore, Branch canals shall be used only for 12 hours based on furrow irrigation methods. The main canals are designed for 24-hour continuous supply, for the whole year. Therefore, there is an operating time gap between the main canals and the Branch canals. Night storages will allow to store water (KRC, 2016).

Regarding drainage, the FS report considers using existing rivers and streams as drainage channels. However, it does not provide much information except channelizing some minor rivers to become drains and connecting them to larger rivers (KRC, 2016).

In addition, the FS foresees to modify Mwanza and Nkombedzi Wa Fodya Rivers to reduce the impact of floods. According to the FS report, river training works should be done on these two river channels (KRC, 2016).

The following figure summarizes the system.

Figure 3 Diagram of irrigation canal



4.3 COMMAND AREAS

The project is made of several irrigated areas as shown in the figure next page: Phase 1 of the Government Program consists of three zones:

- Zone I-1: 9,631ha (total area, including access roads and right of ways)
- Zone I-2: 11,250ha (total area, which is made of Illovo estate)
- Zone A: 5,199ha (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)

The total area is 50,830ha of land. The irrigation land covers 43,370ha (without road, canals and infrastructures).

With current layout, the Feeder canal will cross about 2450m of Majete Wildlife Reserve (most of it inside the reserve fences) and about 14km of Lengwe National Park.

The Shire Valley Transformation Program – I finances the development of the Phase I area only. The ESIA covers full scope of the program and the ESMP covers activities under SVTP-I. Future investments on SVTP-II area will be subject to updated and expanded ESIA and ESMP as designs are developed.

4.3.1 Construction and characteristics

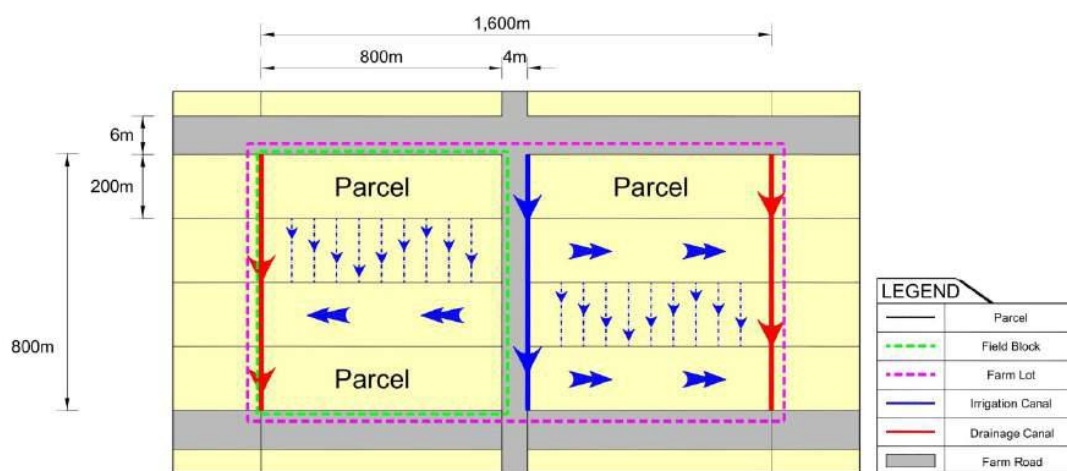
The command area will be made of parcels, drainage channels and farm roads (between 4 and 6m wide). Work will involve land leveling and major earthwork.

4.3.2 Operation

The irrigation and drainage system and roads in a unit parcel of land shall be based on its size. Typically, roads inside the farmland have been planned to be spaced at every 1.5 km distance. In this regard, several parcels comprise a single block around which roads have been planned. A field block shall comprise 6 parcels, and a farm lot shall comprise 2 field blocks (KRC, 2016).

A farm lot=2 field blocks, 1 field block=6 parcels.

Figure 4 Farm Land Composition and Irrigation and Drainage Canals



Source: KRC, 2016

The field canal will supply irrigation water directly to the parcel through furrows.

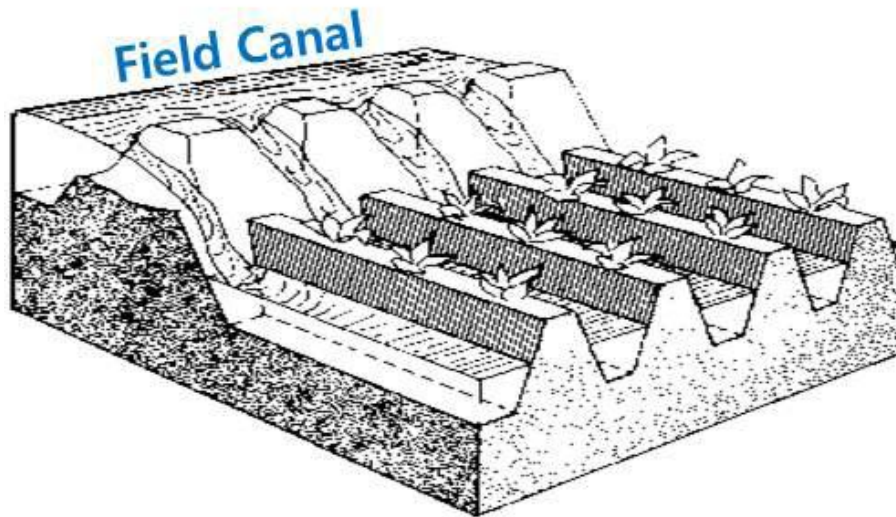
APPLICATION EFFICIENCY

The various efficiency coefficients are:

- Application Efficiency E_a (furrow irrigation): 64%
- Distribution Efficiency E_d : 90%
- Conveyance Efficiency E_c : 90%

Multiplying the three coefficient shows how much irrigation water will return to the system either to the water table, to drain canals or evaporates. The overall Application efficiency is 52%, which means that about half of the water is returned to the natural environment (or evaporates).

Figure 5 Furrow irrigation



Source: KRC, 2016

DOMESTIC WATER SUPPLY

From the Feeder canal at Chikwawa, a pipeline for Chikwawa town (as described in the latest FS report) will divert up to 1,240 m³ per day to supply drinking water to Chikwawa.

4.4 NATURAL RESOURCES MANAGEMENT (NRM) COMPONENT

The Sub-component 2.2 Natural Resources Management will include site level support for Conservation Areas of the Lower Shire Landscape aiming at :

- **Mwabvi Wildlife Reserve and Matandwe Forest Reserve:** Support will strengthen inter-agency planning and implementation between DNPW, DoF and develop nature-based tourism to deliver livelihood benefits for local communities and revenues to sustain landscape management. Support would also extend ongoing participatory forest management and linkages to wider tourism packages for the Lower Shire that includes a selection of sites. At Matandwe Forest Reserve, The project will support village-level income generating activities, (such as beekeeping, livestock production, timber/firewood harvest and sale, tree seedling production and sale), the establishment of woodlots and tree-based systems on customary land, and the establishment and management of Village Savings and Loan Schemes.

- **Elephant Marsh:** Government of Malawi is planning to establish the Elephant marsh as Malawi's first 'Community Conservation Wetland Area' with the intention of balancing local livelihood needs with the longer-term, sustainable management of the marsh ecosystem. The Project will support start-up management of the wetland management plan for the Elephant Marsh with a strong focus on building resilience of local livelihoods given the impacts of climate variability. This will include the establishment and implementation of a monitoring program covering marsh hydrology, biodiversity and livelihoods. In the context of the park management plan, support would also enable the implementation of the first phase of the Community-based Management Plan for the Elephant Marsh. The project will support conservation measures for the remaining fish biodiversity and wildlife populations through support for participatory planning and identification of areas of usage and non-usage zones, the introduction of community fisheries management regimes and development of community-based ecotourism.
- **New Lengwe** (the Lengwe "Extension" in the Western par of LNP): the Project will support for the extension of the park management plan to cover New Lengwe, including the development of co-management arrangements with local communities – building on an existing platform of Community-based Organizations around the Park, support for measures to reduce Human Wildlife Conflicts, development of access routes and support for day-to-day Park management, including survey, monitoring and patrolling activities. Support will also be provided to prepare a feasibility for a possible landscape corridor that could protect ecological linkages between New Lengwe and Majete Wildlife Reserve, perhaps through the introduction of a community conservancy-based approach.
- **Majete Wildlife Reserve:** The Project will provide additional support to expand and consolidate existing community livelihood initiatives from African Parks as well as for investments in Park management – for example, maintenance and management of parts of the perimeter fence by local to prevent and reduce Human Wildlife Conflicts within the surrounding communities.

4.5 ASSESSMENT OF ALTERNATIVES CONSIDERED

A number of alternatives have been considered during program design, including the without-project scenarios. This section presents the assessment of alternatives to achieve the program objectives in Malawi:

The parameters of the scheme are convincing in addressing the critical water-agriculture-nexus in Malawi and the scheme features highly in investment prioritization matrices. This is due to:

- (i) Its unique location for agriculture. Agro-ecological potential is very high if water is brought to this area as demonstrated by existing pumped irrigation in the valley. Any intensification for commercial agriculture in Malawi requires investment in irrigation; this area suffers most from lack of precipitation making even subsistence rain fed agriculture very precarious. Finally, the area is close to Blantyre, the country's largest market and transportation hub and the Nacala railway for exports;
- (ii) Its impact on the water balance. When fully developed the scheme will abstract in the critical month of September about 12 percent of the long term Q80 Shire River flow for that month at Kapichira. This corresponds to an 8 percent net abstraction (taking into account substitution for existing pumping by gravity-fed irrigation) and is determined to have limited appreciable harm on downstream marshes or other uses, as has been confirmed by a hydromorphological study on the marshes and modelling under the SRBMP. The potential trade-off with power production at Kapichira hydro-electric plant is obvious given the scheme's intake location, yet is determined to be limited and restricted to dry months in dry years (full supply is guaranteed in 4 out of 5 years for both hydropower and irrigation in the critical month of September – this is common practice). Virtually all other irrigation in the country would be upstream and affect the entire hydropower cascade and other uses and possibly future upstream hydropower development as well, so this is a least harm alternative, and economically justified. The scheme is designed and technically limited within sustainable resource use parameters and this was confirmed in the national water resources investment strategy as well as the Shire River Basin Management Program planning where alternative sites/developments have been analyzed; and

-
- (iii) Its impact on the energy balance. With Malawi's severely constrained energy situation, pump-based irrigation is unfeasible and undesirable. This scheme enables the expansion of irrigated area in the country by 40 percent, only relying on gravity, while enabling the release of power to the currently underserved national grid through converting current large scale pump based irrigation to gravity.

The technical design studies have been optimized from earlier versions that have been developed over the years, and alternatives have been considered, including options that would bypass Majete Wildlife Reserve altogether, and smaller pump-based versions. These designs would have prohibitive cost in construction and long term operation, rendering them non-viable. The current design is robust, has reduced environmental impacts by rejecting the alternative original design with an intake at Hamilton Rapids (9km upstream) and is better addressing current technology and farming models, optimizing resource utilization rather than low equilibrium agriculture. It has prioritized commercial agriculture instead of low value crops and better integrated multiple uses including livestock, drinking water and the environment. The design parameters are conservative and robust to reduce operation and maintenance costs, while allowing for gradual water efficiency improvements. The phasing has been optimized within available funding. It is technically, financially and socially undesirable to "pilot" with a smaller command area as costs per hectare would dramatically increase, future expansions would be significantly compromised, and short term benefits would be skewed towards existing commercial enterprises.

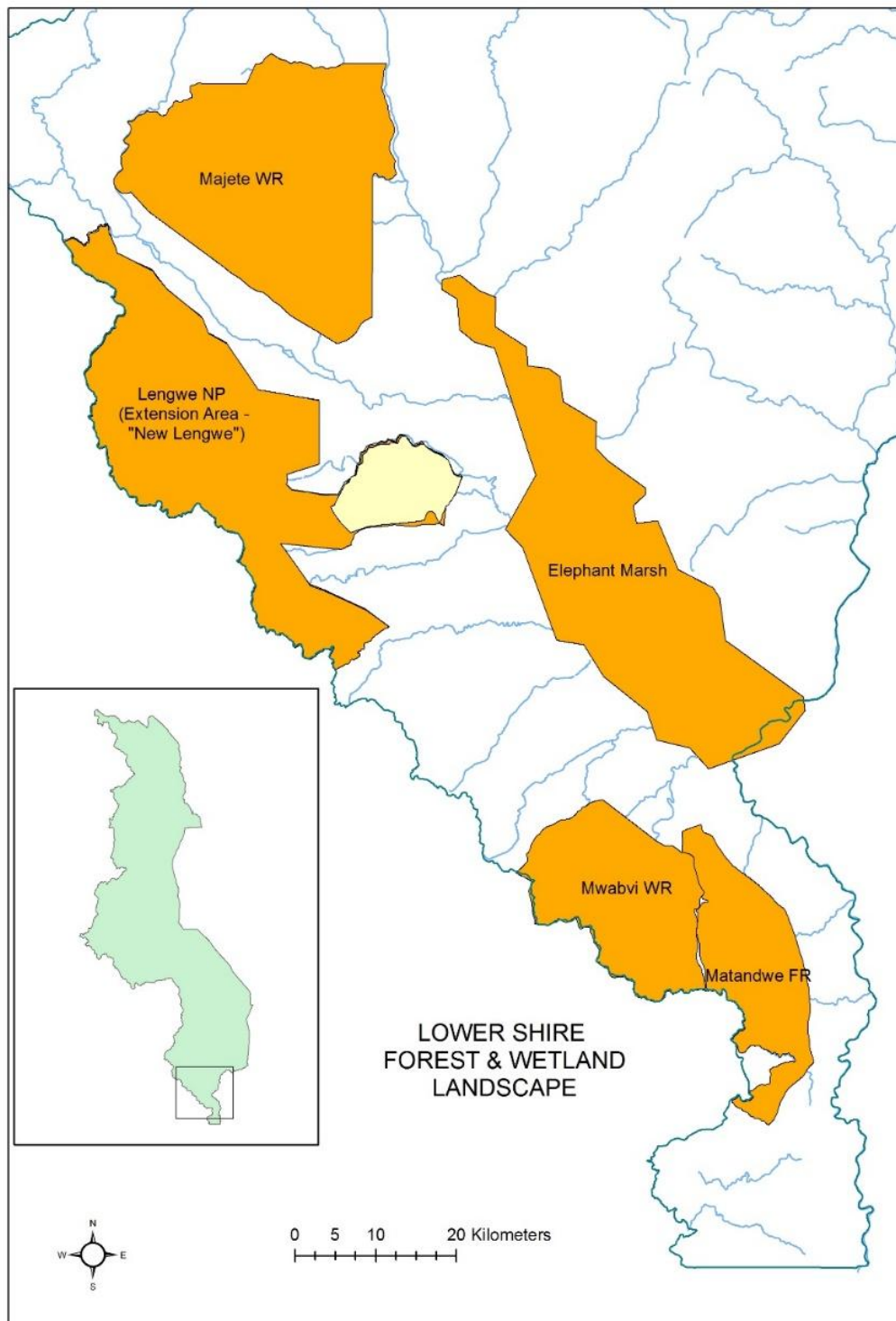
Several options have been considered in the ESIA/ESMP:

- **Canal options:** Apart from the choice of route inside vs. outside Majete Wildlife Reserve (MWR) as mentioned above, several technical options within Majete have been considered to minimize impacts during construction and operation. An option was considered to bury most of the length of canal, which will not function as a barrier or trap for animal movement as an open canal would. Much of this stretch will be within a siphon which reduces the length of canal and physical footprint in the canal as compared with the alternative where the canal follows the contours. Various lining options have been considered for the open sections. Final selection for the stretch in Lengwe National Park is to be made, but there is a strong preference for a technical design option that avoids slippery slopes and allows safe access and passing of wildlife.
- **Wildlife protection within MWR:** Various work schedules have been discussed and the selected option limits disturbance to wildlife and tourism. For the open canal section alternative barriers have been considered and a masonry wall with local rocks has been selected as the most robust and most visually attractive scenario.
- **Tiger fish invasion at Lake Malawi and Shire River:** Various alternatives have been considered and discussed with technical experts. While an independent panel is to verify final design, the choice was made for the design of a fish barrier that uses a high vertical drop with proven effectiveness and very low maintenance requirements, as compared with the two alternatives: use of fish screens (which would have had less head loss but which would be very difficult to maintain in good working condition and a construction with a lower drop and screen, which was considered less desirable.
- **Environmental flows:** Various scheme sizes, cropping patterns, scenarios with/without Illovo estate have been considered; and alternatives were considered for expanding hydropower rather than irrigation, and other developments and climate change scenarios were incorporated in this multi-criteria analysis under the Shire river Basin Program. Consideration has been given for various flow scenarios for downstream impacts from Kapichira Falls to Elephant Marshes. The technical design considered limits overall abstraction to within sustainable resources use and it has been decided to include environmental considerations into the operating rules at Kapichira Dam and at the basin level for releases at Kamuzu Barrage, keeping in mind overall water security and lake levels. While this will be an ongoing process of optimization and scenario development, the alternative would have been not coordinating water resource utilization with obvious detrimental effects.

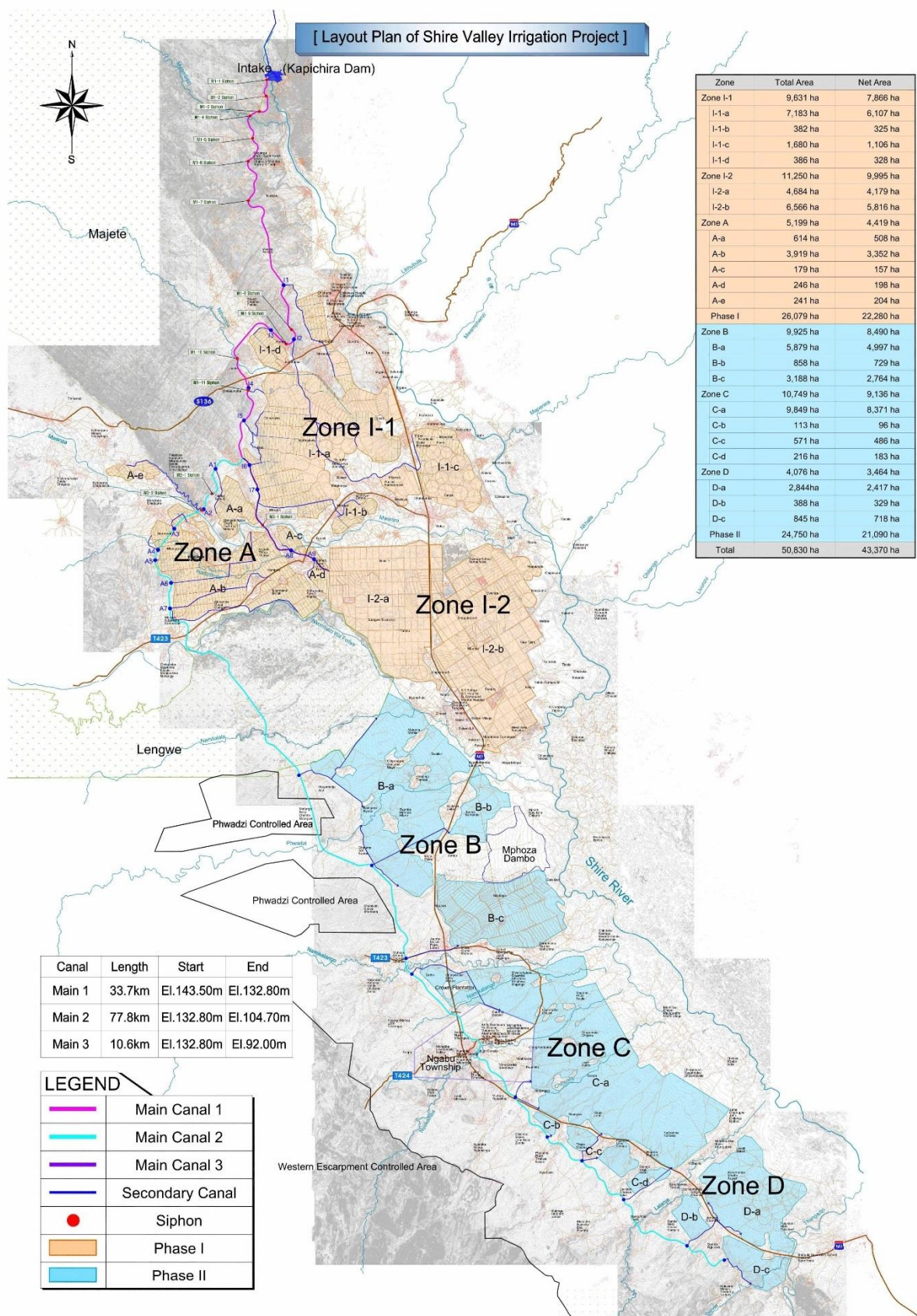
- **Flood risk management:** It has been considered that the scheme should generally only be constructed in areas outside the 10 year floodplain. The alternative would have opened up more area, but would have necessitated construction of significant stretches of embankments which has been discarded for environmental reasons, for hydrological reasons (it transfers flooding elsewhere) and economic reasons. The project area now provides a livelihood outside the immediate floodplain and reduces risk to production significantly.

A without project scenario would perpetuate the unsustainable livelihood scenario and poverty levels in the lower Shire, with long term negative impacts on household food security, natural resource utilization, and would not provide much needed economic impetus in the Shire Valley and beyond. From an safeguards perspective certain potential impacts associated with canal infrastructure and intensive agriculture would be avoided, but also opportunities for addressing these and other challenges in an integrated landscape approach would not be seized. On balance, with robust mitigation measures in place, it is anticipated that the program can deliver net social and environmental benefits over the baseline scenario. The no project scenario would also entail no leveraging of resources for the NRM component on natural resources management, which includes critical protection for protected areas and wetlands (Elephant Marsh protection and support for RAMSAR status). It is a safe assumption that without the project, continuous unregulated use and exploitation of the marsh will continue that will contribute to its degradation in the long run. Majete WR might not be negatively impacted most likely as it is managed well, but the other reserves and natural habitats might continue to be degraded and lose biodiversity.

Figure 6 Areas concerned by the Natural Resources Management component



Layout Plan of SVIP



5. POLICY AND LEGAL FRAMEWORK

5.1 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.

5.1.1 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.

5.1.2 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.

5.1.3 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.

5.1.4 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 analyze 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.

5.1.5 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.

5.1.6 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 will rely on several experts 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.

5.1.7 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.

5.1.8 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. Realizing 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 SVIP will have minimal impact on forests, as it takes place within a predominantly agricultural area. The ESMP recommends establishing Set-aside Lands within the proposed irrigation areas for a variety of reasons, including to avoid clearing remnant forest patches and other environmentally sensitive areas such as wetlands and riverbanks.

5.1.9 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 aims at creating and providing enabling framework for the establishment of a comprehensive disaster risk management system in Malawi. The priority areas of the policy focus on including 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.

5.1.10 National Water Resources Policy 2005

The 2005 National Water Resources Policy whose aim is to ensure sustainable management and utilization 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 meter 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 lying areas and flood prone areas.

5.1.11 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.

5.1.12 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 experts to be used by the SVIP will prepare interventions to help ensure that women and other vulnerable groups will have access to land and water under SVIP and that women as well as men will 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.

5.1.13 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.

5.1.14 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.

5.1.15 Shire River Basin Management Program (SRBMP)

The Shire River Basin Management Program (SRBMP) is a long-term program with the objective of increasing sustainable social, economic and environmental benefits by effectively and collaboratively planning, developing, and managing the Shire River Basin's natural resources. As such, the SRBMP is the Government of Malawi's chief tool for managing the cumulative impacts of multiple investments within the Shire River Basin, as well as the multiple demands upon the Shire River's water resources. Since its inception in 2012, the SRBMP has (i) supported inter-sectoral development planning and coordination mechanisms ; (ii) undertaken high-priority water-related infrastructure investments ; and (iii) developed up-scalable systems and methods to rehabilitate sub-catchments and protect existing natural forests, wetlands, and biodiversity. This approach seeks to provide a balance between building capacity for strategic planning and on-the-ground investments to address immediate needs. The SRBMP has thus made a promising start towards addressing many of the most critical issues facing the Shire Basin. Future phases of SRBMP will seek to scale-up and broaden existing activities, based on the lessons learned from implementation of the current first phase. The SRBMP is intended to serve as an integrating framework to synergize the work of all key institutions in the Basin.

5.2 LEGAL FRAMEWORK

5.2.1 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 for the SVIP is consistent with the provisions of this Act, as detailed in Sections 24 and 26.

5.2.2 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.

5.2.3 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.

5.2.4 New Legal Framework for Land Tenure (2017)

In 2002, the GoM adopted a new Land Policy designed to promote a more economically efficient, environmentally sustainable and socially equitable land tenure framework that supports poverty reduction and increased food security. In late 2016, the Malawian Parliament passed 8 new laws¹ to implement this policy and its effectiveness is anticipated before Project Effectiveness. These laws fundamentally modify the status and registration of land rights in the country. The new framework introduces a decentralized land administration and registration system and provides for the formalization and registration of previously unrecognized customary rights. The Ministry of Lands, Housing & Urban Development will be responsible for overseeing the further development of subsidiary regulations and the overall implementation of this new framework.

¹ The Land Act, The Physical Planning Act, The Forestry (Amendment) Act, The Land Survey Act, The Registered Land (Amendment) Act, The Customary Land Act, The Land Acquisition (Amendment) Act and the Local Government (Amendment) Act

The new Customary Land Act (CLA) proposes the creation and registration of customary estates based on current, legitimate, customary land occupation within Traditional Land Management Areas (TLMAs) and transforms these holdings into private land, capable of being transacted (with certain limitations) and encumbered. It envisages identification and formalization processes that incorporate international best-practice principles and lays the legal foundation for transparent and decentralized administration of these estates.

Arrangements for local governance of land rights envisage formal approval and dispute resolution roles for the Traditional Authorities (TAs), and for new institutions to be established at Group Village Level. These comprise of Customary Land Committees (CLCs), established in terms of s3 of the CLA, which will have powers to make grants of customary estates. In addition, the current regional land registry will be decentralised to district level.

Each TLMA will also have a Customary Land Tribunal (CLT) with responsibilities for hearing appeals and resolving disputes as a forum of first instance, and to be chaired by the Traditional Authority. The establishment of these Group Village CLCs and TLMA CLTs is a conscious attempt to institute greater legitimacy in decisions regarding the application of customary norms to land management. Whilst formalizing the roles of the TAs in this regard, the CLA introduces a level of democratization; the CLCs will be chaired by the Group Village Headperson, ex officio, but an additional six members shall be elected by people in the TLMA, three of whom must be women.

The recent reforms provide a solid legal platform for securing the current tenure rights of customary occupants within the SVIP area through transparent and locally-legitimate processes and institutions. The opportunity to undertake the systematic adjudication and formalisation of customary land rights, in areas defined by the development plans of the irrigation infrastructure, along with the introduction of customary estates as a form of legal land-holding, available to individuals, groups and corporate entities, allows the SVTP to provide safeguards for current occupants and affected persons, as well as mechanisms for making land available to the intended beneficiaries.

5.2.5 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.

5.2.6 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. It also sets out the coordination, allocation and delegation of responsibilities. It enforces use of water resources for domestic uses, livestock watering, irrigation and agriculture, industrial, commercial and mining, recreation, hydro-electric power generation, and other uses, in ways that minimize harmful effects to the environment, control pollution, and 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.

5.2.7 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.

5.2.8 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.

5.2.9 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 maintenance of buffer zones along riverbanks, it prohibits any actions that are destructive to the catchment. Issues of livestock, fire management, and catchment protection are very pertinent to SVIP and therefore this Act is very relevant.

Various experts engaged by the SVIP have proposed measures to control livestock grazing and bush fires, enhance riverbank protection, stabilize water dams, and properly construct water delivery and storage systems. This includes the stabilization of embankments and protection of water intake points..

5.2.10 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 regards 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 labor 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.

5.2.11 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 and is compliant with this legislation.

5.2.12 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.

5.3 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 Operational Policies and the IFC Performance Standards. AfDB policies are not detailed below because they are either similar or less demanding than those of the WB and IFC.

5.3.1 Environmental Assessment (Operational Policy 4.01)

World Bank's Environmental Assessment (EA) Operational Policy 4.01 requires that all projects proposed for Bank financing be 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.

Under 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.

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 the 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 the 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 this ESIA 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 on its Web site. In commissioning the formulation of the ESIA and by making the document available to the public, the proposed project will also be in compliance with the World Bank's Information Disclosure Policy, BP 17.50.

5.3.2 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. 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. 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.

5.3.3 Involuntary Resettlement (OP 4.12)

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 as needed.

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.

5.3.4 Cultural Heritage (OP 4.11)

The WB's safeguard policy on cultural heritage is OP 4.11 on Physical Cultural Resources. 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 of OP 4.11, which states: "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 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

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”.

5.3.5 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.

5.4 INSTITUTIONAL RESPONSIBILITIES FOR ESIA MONITORING AND ESMP IMPLEMENTATION

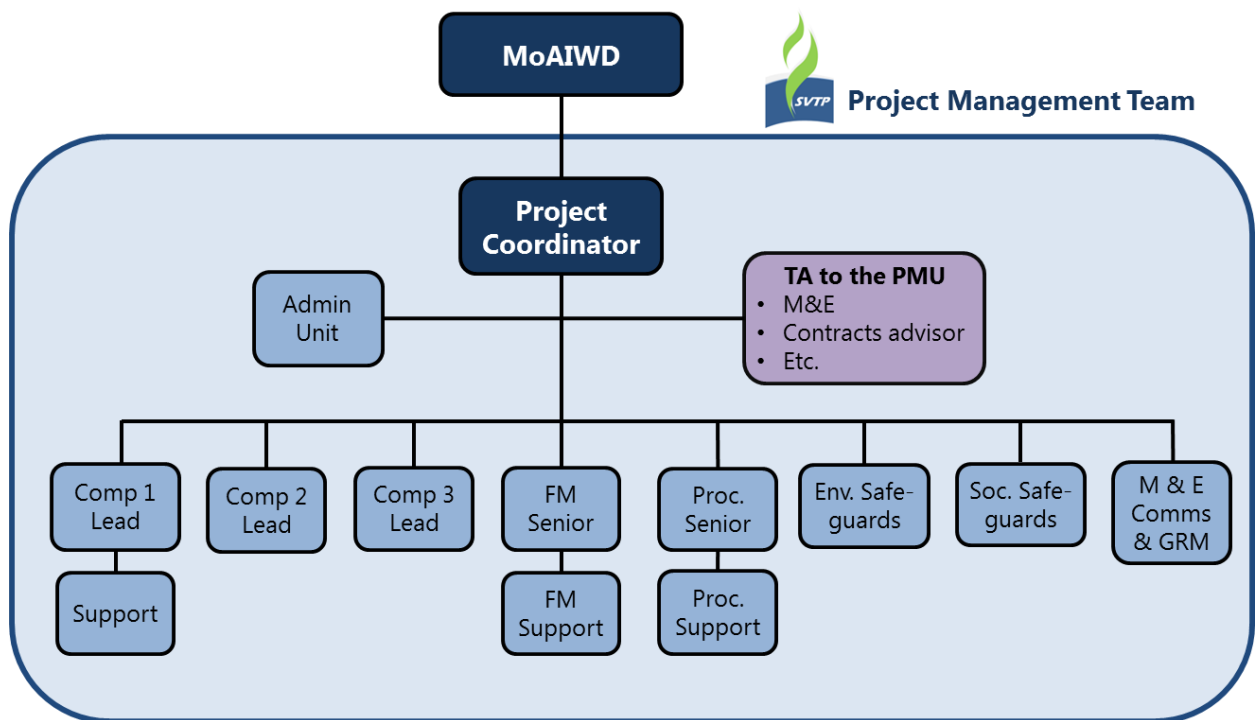
This Section identifies the institutional needs to ensure the effective implementation of the social and environmental management and monitoring program as outlined in the ESIA and ESMP so that the Project’s benefits are maximised and that the Project is implemented on a sustainable basis. It is important that the institutional arrangement provides the capacity to implement social management plans. Recommendations are also included for staff on environmental monitoring and management aspects. The ESMP provides project specific arrangements for monitoring. The ESMP is based on MoAIWD having the overall responsibility for the coordination, planning and implementation of the Project as well as the actual implementation of the environmental monitoring and management and land acquisition and resettlement components. It is also based on the appointment of a construction Supervision (Management) Consultant with responsibilities under the direction of MoAIWD of directly supervising the Contractors implementing the works.

5.4.1 National Level

By nature, this Project will be multi-sectoral and will involve a number of key government agencies, and consultation and coordination mechanisms. The main implementing agency is the Ministry of Agriculture, Water Development and Irrigation, and it coordinates overall implementation together with the Ministry of Finance, Economic Planning and Development (MoFEPD). Other agencies involved in the program are the Ministry of Natural Resources, Energy and Mining (MNREM); the Department of National Relief and Disaster Management (DNRDM); the Ministry of Lands and Housing (MLH); Ministry of Local Government and Rural Development (MLGRD); the Ministry of Transport and Public Works (MTPW); the Ministry of Tourism and Culture (MTC); Malawi Investment and Trade Center (MITC), EGenco; the PPP Commission; the Southern Region Water Board (SRWB); and the Shire River Basin Agency/National Water Resources Authority.

The Program will have a steering and technical committee at national level, a consultative committee and a technical team at local level. The Project Management Team (PMT) comprises of civil servants and recruited professionals for project management, coordination and monitoring. This team is housed in the MoAIWD.

The Ministry also has experience in implementing safeguards instruments and documenting compliance. It has regularly trained staff in ministry and districts on safeguards compliance, with support of MoNREM. The PMT assumes responsibility for all day to day management and coordination needs under the project, including fiduciary, safeguards, M&E, safeguards, citizen engagement and grievance redress mechanism. As is the case for the preparation period, the PMT will be comprised of competitively recruited experts and will be complemented with technical assistance on quality assurance, planning and M&E. The PMT is a fully integrated project team. Besides the recruited component leads, fiduciary staff and safeguards, M&E/GRM staff, it may include professional staff from the main government agencies involved in the SVTP-I who are assigned to work on this project. All project operational modalities are detailed in the Project Implementation Manual, with gantt charts, flow charts, responsibilities. A component Lead will be responsible for comprehensive management, liaison and coordination of the respective pillar, under the guidance of the project coordinator. The safeguards coordinators will lead all implementation, monitoring and compliance documentation of the safeguards instruments and will liaise frequently with the service providers on issues related to safeguards, health and safety, etc. The same applies to the M&E, Communications and GRM officer, who will be responsible for maintaining the project Management Information System, lead communications and manage the Grievance Redress Mechanism with relevant committees.



The responsible Implementing Agency, here the Ministry of Agriculture, Irrigation and Water Development has the overall responsibility for coordinating and monitoring implementation of the ESIA recommendations, as well as its required updates. SVTP works through representatives of key government ministries and stakeholders under a taskforce governed by a joint MoU.

The SVTP will recruit an appropriate Consultant to update the ESIA and ESMP once the detailed designs are available. Once the study is completed, the SVTP will consult the Director of Environmental Affairs who will be responsible for reviewing the ESIA through the Technical Committee on the Environment (TCE).

The Environmental Affairs Department, coordinates and facilitates sustainable management of the environment and natural resources in Malawi. As such it is responsible for harmonization of national environmental policies and legislation, enforcement of legislation, capacity building, and compliance monitoring. The Director of Environmental Affairs may arrange for public consultations as part of the EIA process, in order to sensitise the communities and to create awareness. The TCE may require to carry out their own site and works assessment before making the appropriate recommendations to the National Council on the Environment (NCE), through the Director of Environmental Affairs (DEA). The NCE will evaluate the recommendations of the TCE and make appropriate recommendations for approval.

The Department of National Parks and Wildlife is mandated to protect and conserve wildlife in protected areas such as National Parks and Wildlife Reserves in collaboration with other stakeholders especially boarder zone communities. It has concessionaires in some parks, notably in Majete Wildlife Reserve while maintaining overall responsibility.

5.4.2 Project Level

The MoAIWD shall be responsible for the implementation of the ESMP and for compliance auditing. The Supervising Engineer consulting firm (SE) will include in its team an environmental specialist and be responsible for the day to day monitoring of environmental performance of the Construction Contractor and for monthly reporting of environmental performance which is to be submitted to the MoAIWD.

Malawi's Environmental Affairs Department (EAD) will participate in the supervision of civil works construction. The Department of National Parks and Wildlife and African Parks (the concessionaire that manages Majete) will also participate in the supervision of canal construction and operation within the Majete Wildlife Reserve.

The Ministry of Local Government established is responsible for local government and its linkages with traditional authorities. It has a role in community participation in the formulation and implementation of developmental and environmental programmes through Districts. The country is divided into three regions Northern, Central and Southern regions. Malawi has 28 districts. The Phase I project is entirely located within Chikwawa District in the Southern Region, whereas phase II extends into Nsanje District. Within each of these districts there are formal and traditional institutions. Formal institutions include the District Councils, headed by District Commissioners. The traditional institutions are headed by Traditional Authorities whose areas of jurisdiction are known as Area Development Committees, headed by chiefs. Each of these traditional authorities is composed of villages which are the smallest administrative units, and the villages are presided over by village headmen. Traditional Authorities are important interlocutors for social and environmental issues at local level. The District Councils, under the general direction of the District Commissioner, will work closely with project staff to take stock of the progress for each project activity in their respective areas of jurisdiction. The Council will hear the views of the communities on the progress, expected benefits and challenges being faced during the implementation period of the projects and the anticipated challenges during time of exit. The District Commissioner will also be the moderator between conflicting views and interests of both the communities on one hand; and the implementing and executing agencies on the other.

Where the Environmental staff of the PMT or Supervising Engineer observe activities or conditions at Project construction sites or on adjoining sites which do not comply with the requirements of the ESMP, as incorporated under the construction contract documents, they shall forthwith make a written report. On no account shall the Environmental staff give directions to any contractor, employed under a Contract with the MoWDI, in relation to any non-compliance. The report shall define the non-compliance with the ESMP and shall note the time and date of the non-compliance. Based on the report, the Supervising Engineer can issue instructions to the Contractor to forthwith instigate procedures to correct the non-compliance and to avoid any recurrence of such non-compliance or to stop work until compliance is achieved. The Supervising Engineer shall confirm in writing to the Project Manager as soon as practicable after correction of the non-compliance. Where non-compliance is not related to the contractor's contract, a report shall be drawn up and submitted to the Project Manager and EAD for remediation.

The ESMP provides action plans and implementation schedules for the monitoring and mitigation measures. This schedule will be reviewed and revised at least every 6 months during the construction period and on an annual basis for other activities.

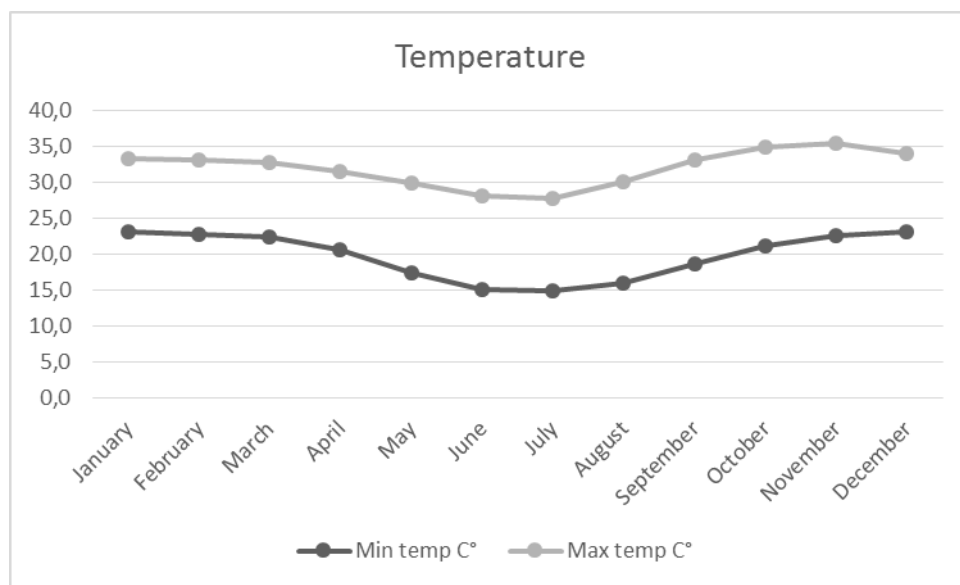
6. PHYSICAL ENVIRONMENT

6.1 CLIMATE

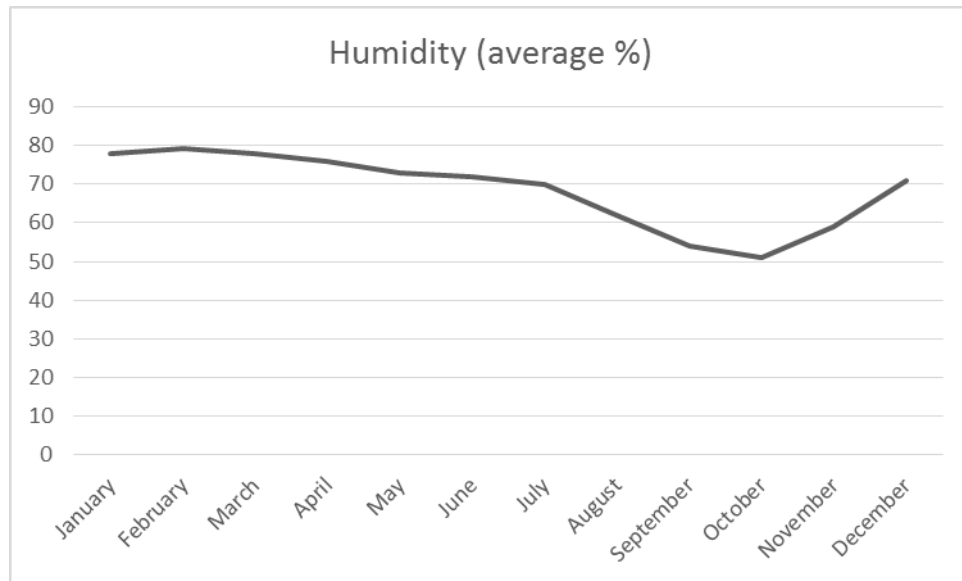
The study area has a tropical climate marked by hot temperatures and two distinctive seasons: the dry and the rainy seasons.

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

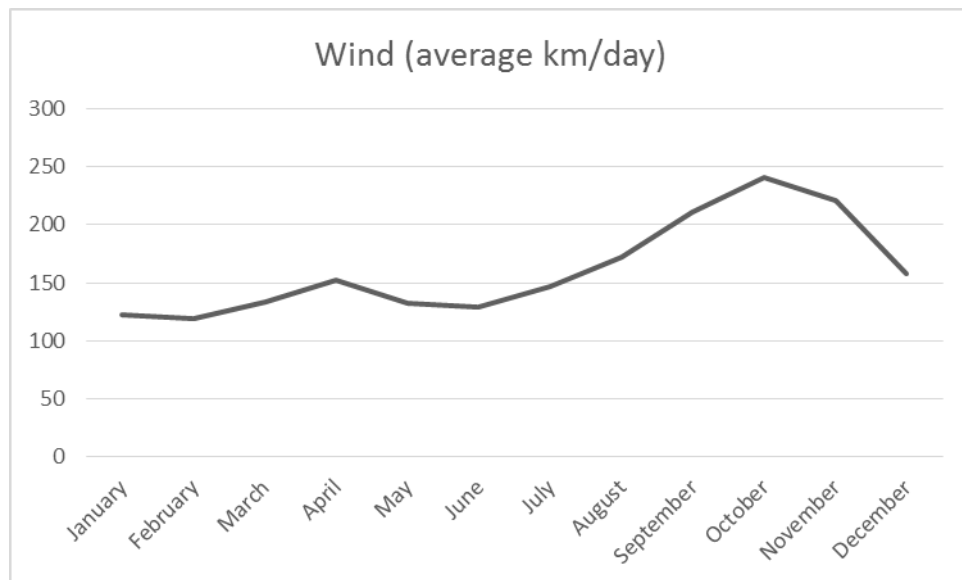
The following graphs show the main figures related to climate: temperature, humidity, rainfall and sunshine duration. Data are taken from Nchalo Illovo, Makanga Station (from 1971 to 2014).



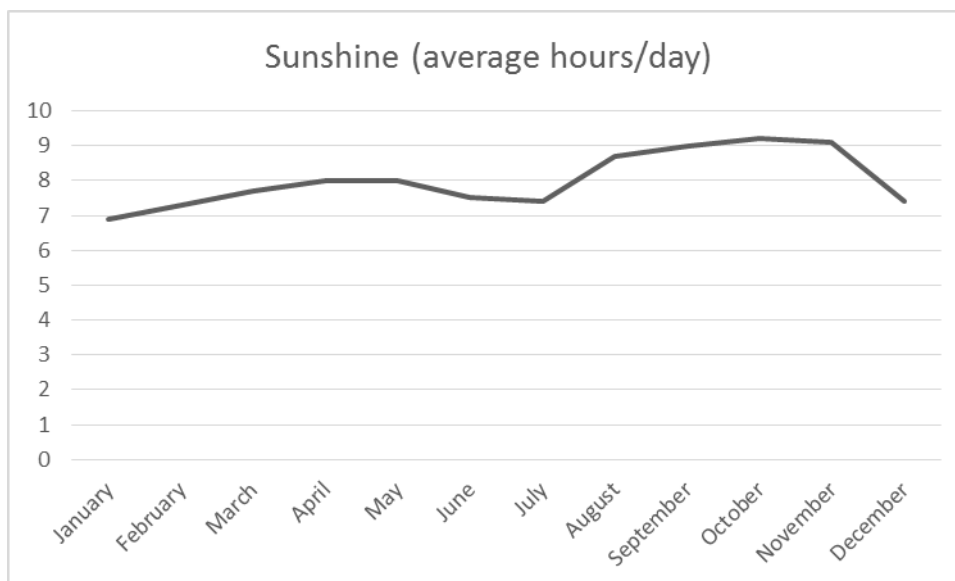
Source: Nchalo Illovo, Makanga Station (1971-2014)



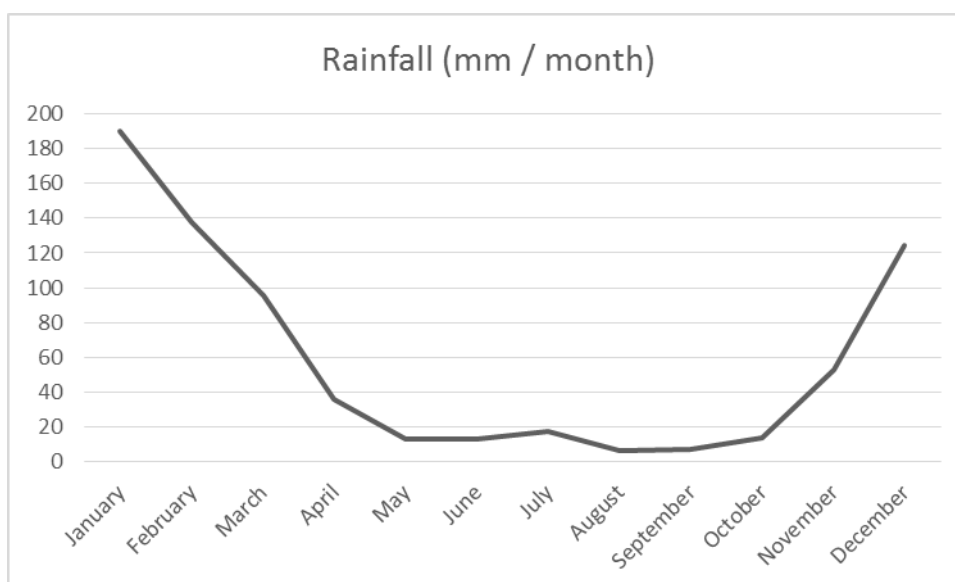
Source: Nchalo Illovo, Makanga Station (1971-2014)



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).

6.2 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 Kapichira falls. At this point, where the water intake will be located, the altitude is 144 masl.

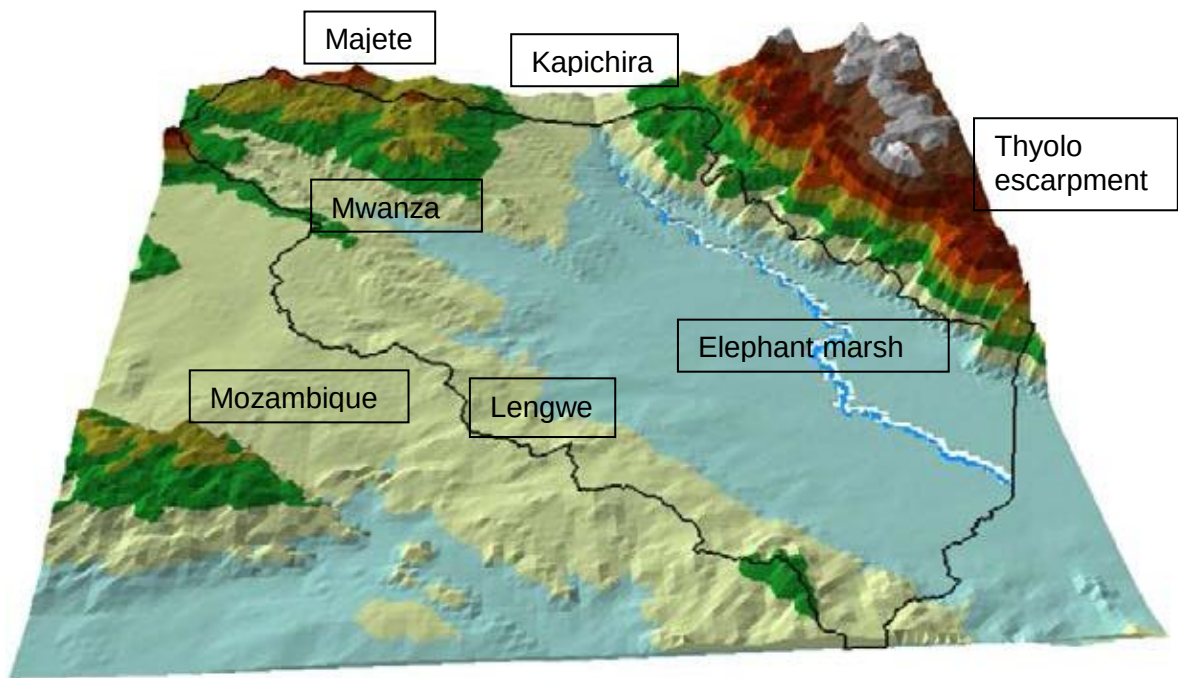
After the reservoir, the Shire River flows down the dam spillway and Kapichira falls, the altitude drops about 50 meters and the Shire is incised in a gorge 10 additional meters below ground level. The Lower Shire plain is the only area in Malawi where the elevation is below 150 masl.

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 1,500 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 sparsely 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 masl 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 7 Topography of Chikwawa district



Source: Montjerezi, 2012

6.3 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 Xalacongwe 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.

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 8 River Bed Split in the Nkombedzi Wa Fodya River



Photo Credit ©2016 BRLi

Figure 9 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 (km ²)	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

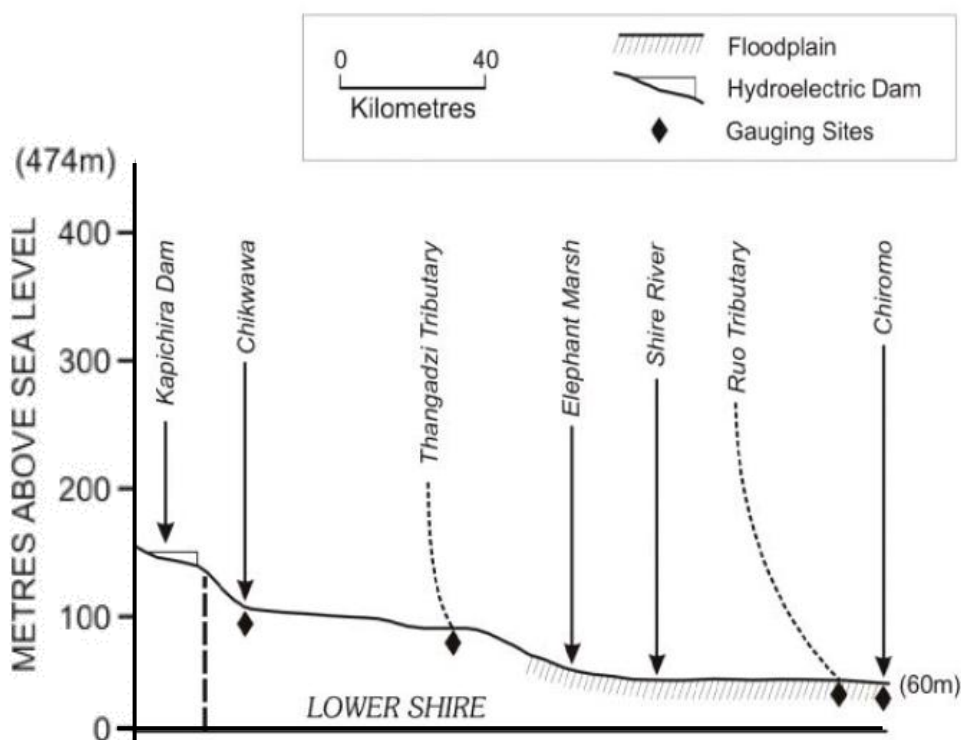
With the exception of the Likhubula, Mwamphanzi and Ruu, the left-bank tributaries of the Shire River are smaller than the right-bank ones.

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 10 Lower Shire River Profile from Kapichira Dam to Chiromo Bridge

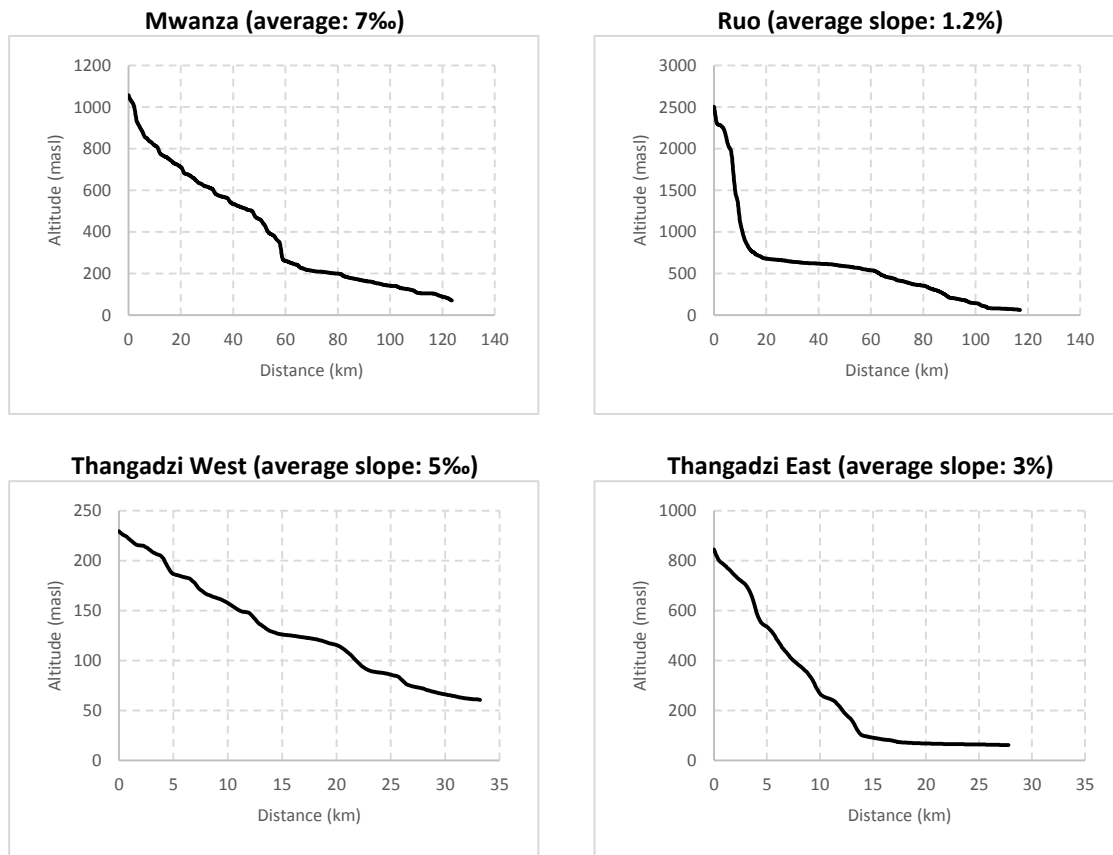


Source: NWRMP, 1986

The Figure 5 shows the profile delineations based on Shuttle Radar Topography Mission, SRTM² of 4 representative tributaries: Mwanza, Ruwoti, 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.

² 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 11 River Profiles of Mwanza, Ruu, Thangadzi West and East

Source: BRLi, 2016

6.4 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 flow 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):

- NORPLAN (2013) and NIRAS/DHI (2017) 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 River³.

Water Resources data are covered in the chapter on hydrology.

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.

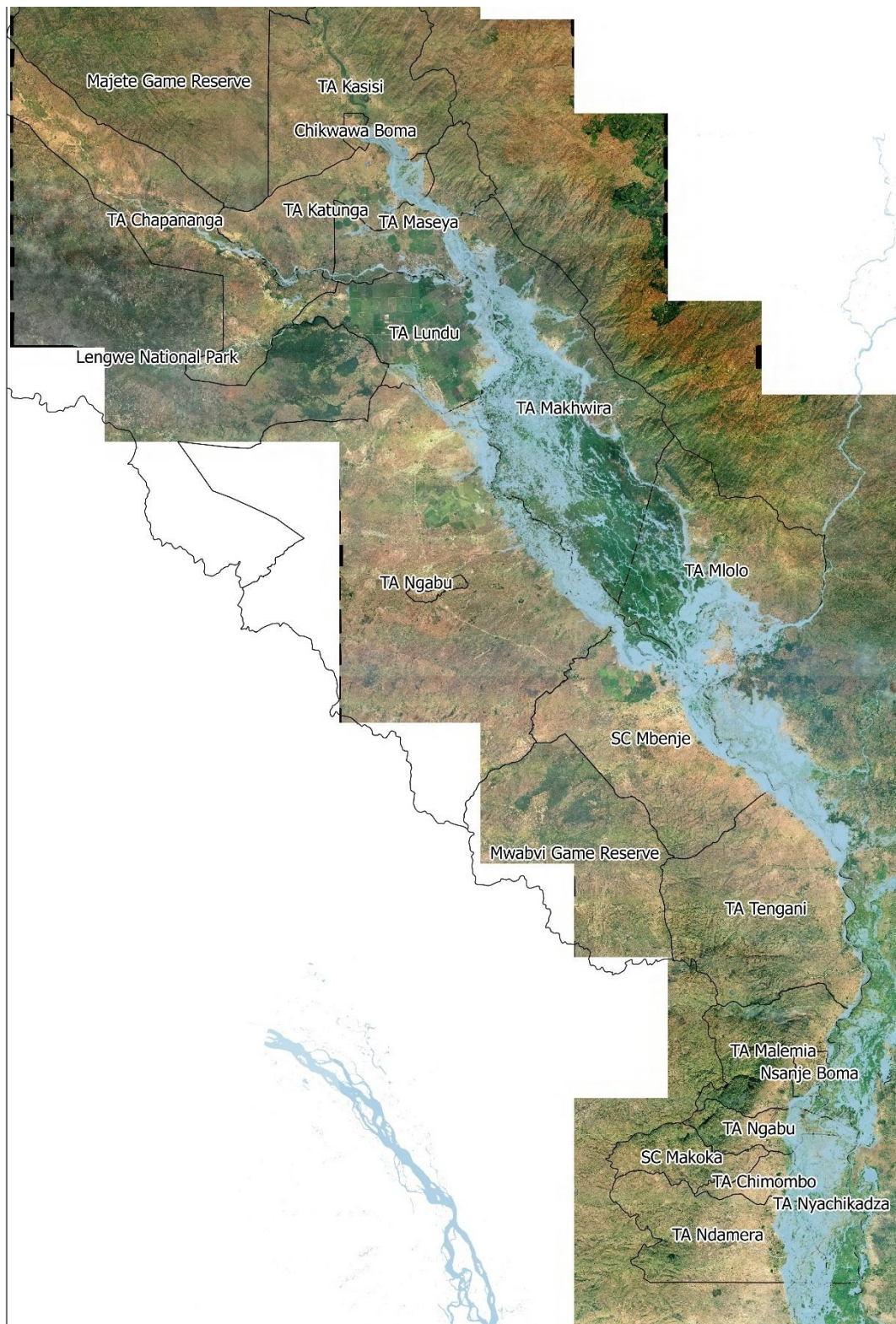
³ A GR2M hydrological model was implemented (Mouehli, 2003). The calibration was made with the historical time series discharge for the Ruo River at Sinoya South (4721 km²). The statistic calculations were made for the reference period from 1979-2009 as in (JICA, 2014) and (SMEC, 2014).

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 12 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 13 *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.

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



Photo Credit ©2016 BRLi

Figure 15 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 Report⁴ 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 RCP4.5⁵ emission scenario characterized by:

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

Table 2 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

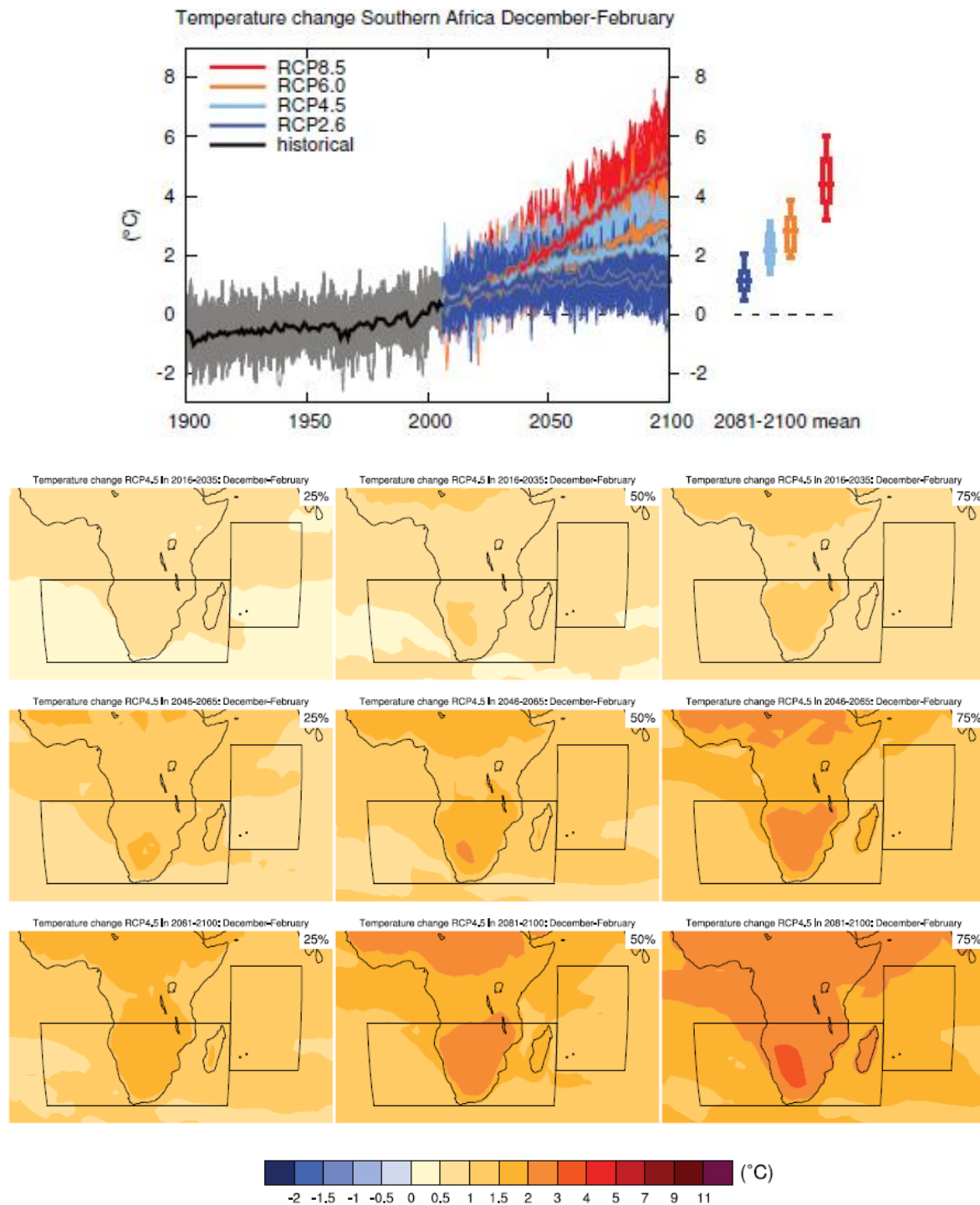
The figures shown are averages over the South Africa region (Seneviratne et al., 2012) of the projections by a set of 42 global models for the RCP4.5 scenario. The area-mean temperature and precipitation responses are first averaged for each model over the 1986–2005 period from the historical simulations 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. This variation will be more directly felt in the tributaries since the Lake will act as a buffer for most upstream variations.

⁴ 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.

⁵ 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 16 Time Series and Maps of Temperature Change Southern Africa December-February

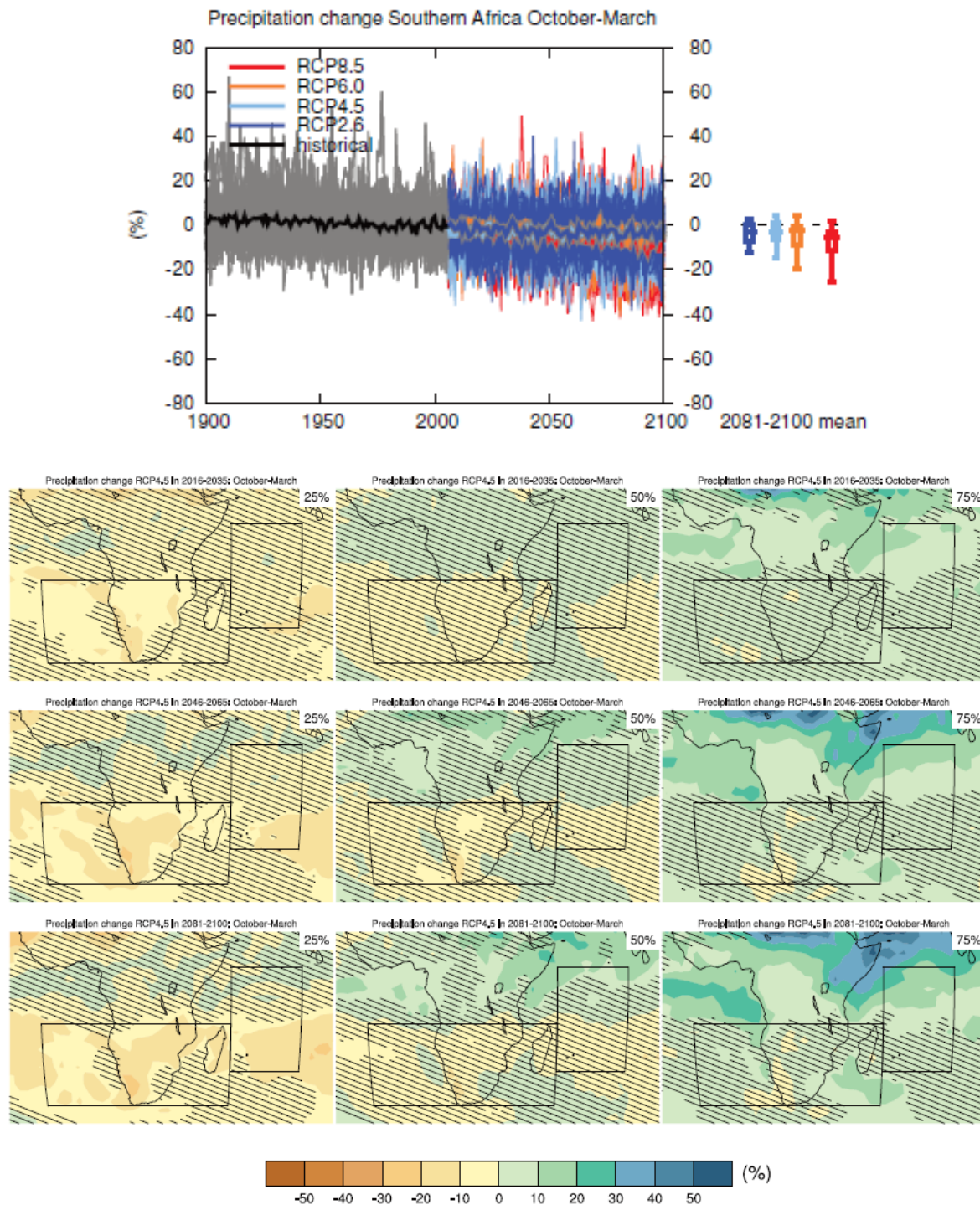
(Top left) Time series of temperature change relative to 1986–2005 averaged over land grid points in Southern Africa (35°S to 11.4°S, 10°W to 52°E) in December to February. (Top right) Same for sea grid points in the West Indian Ocean (25°S to 5°N, 52°E to 75°E). Thin lines denote one ensemble member per model, thick lines the CMIP5 multi-model mean. On the right-hand side the 5th, 25th (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

Temperature change Southern Africa June-August



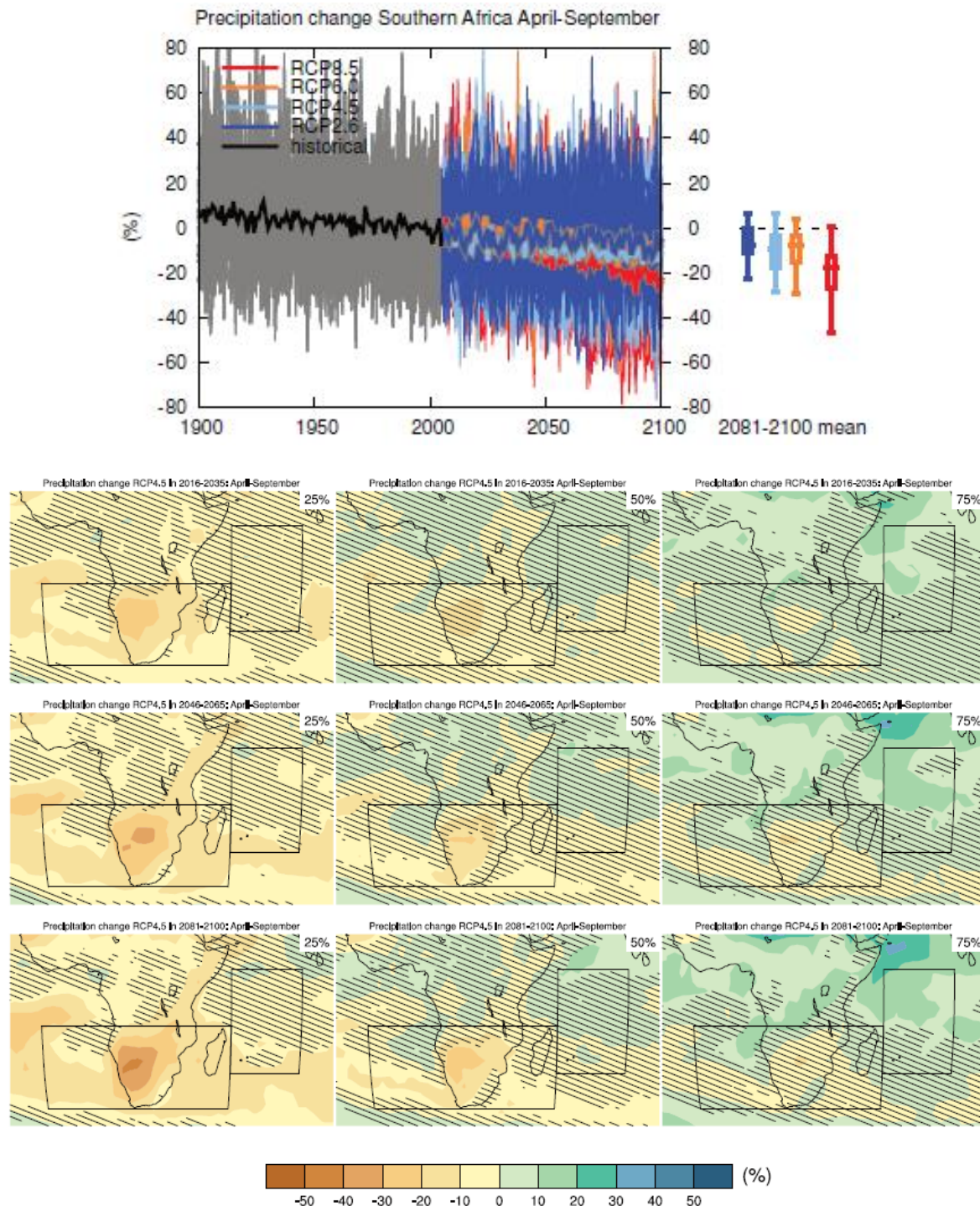
Figure 18 Time Series and Maps of Precipitation Change Southern Africa October-March

(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 19 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

6.5 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 3 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 4 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

	Parameter (mg/l)				
	Sulfate SO_4^{2-}	Nitrate NO_3^-	Phosphate PO_4^{3-}	Lead (Pb)	Mercury (Hg)
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 5 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 6 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	5 - 25 mg/l Mesotrophic	25 - 250 mg/l Eutrophic	> 250 mg/l Hypertrophic

	conditions	conditions	conditions	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.

6.6 SOIL, EROSION, SEDIMENT TRANSPORT AND GEOLOGY

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.

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

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

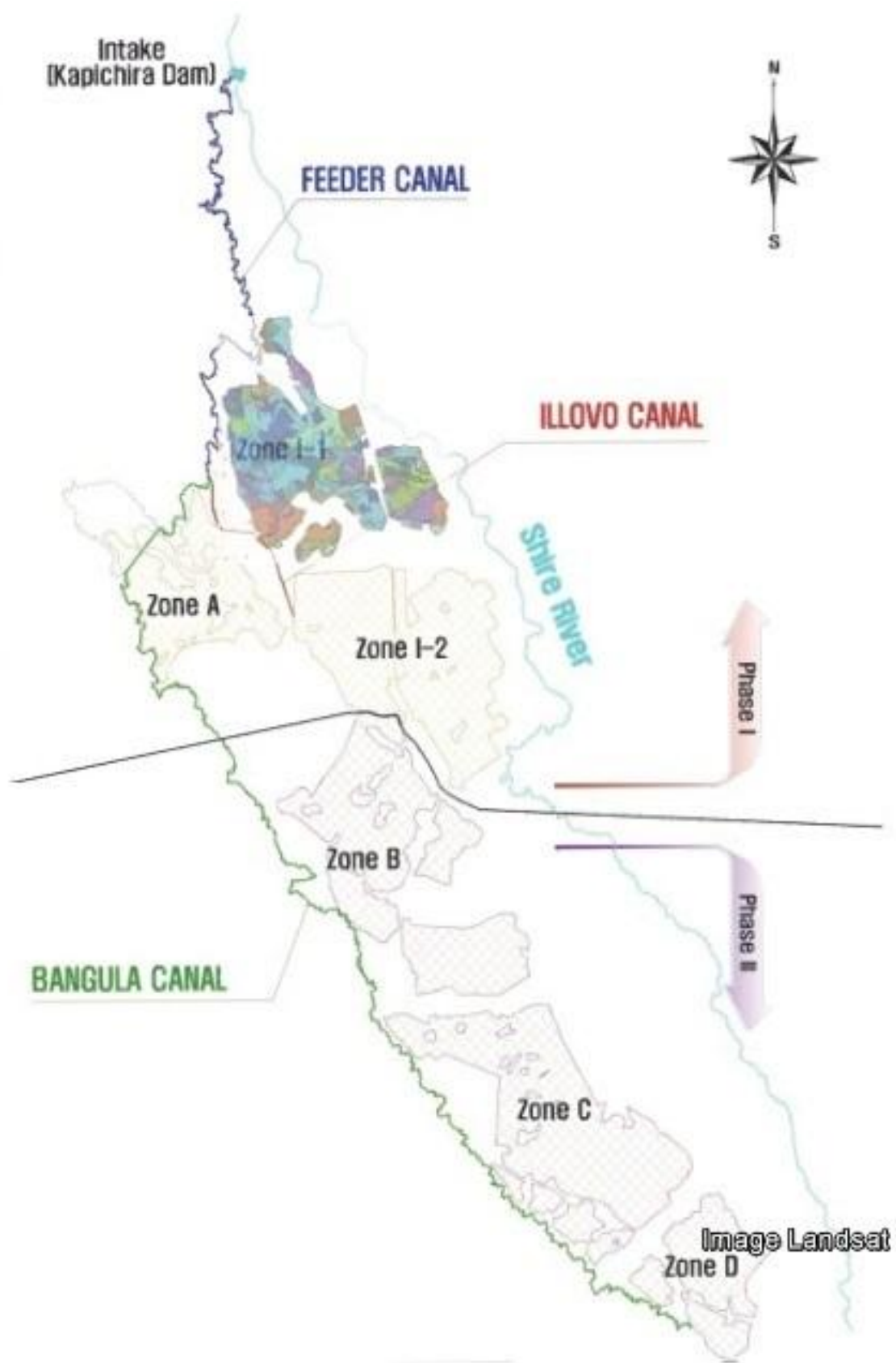
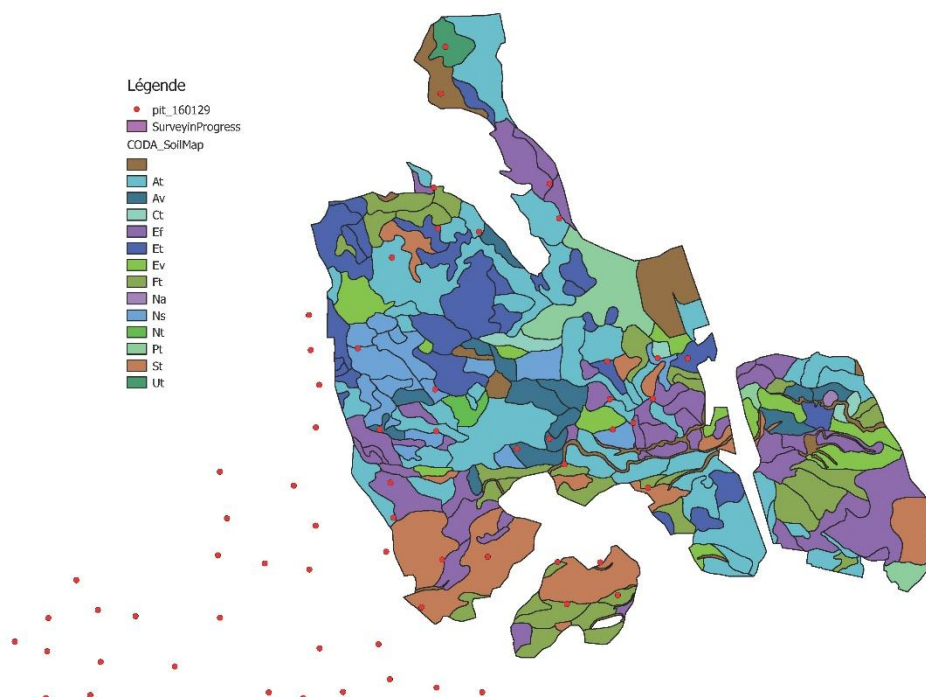


Figure 21 Zone I-1 Soil Map by CODA (2006)

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

Table 7 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	Et
			Fluventic	Ef
			Vertic	Ev
Alfisols	Ustalf	Haplustalf	Typic	At
			Arenic	Ar
			Vertic	Av
		Natrustalf	Typic	Nt
Vertisol	Ustert	Chromustert	Salorthidic	Ns
			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 Ustochrepts 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 phosphorus 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.

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):

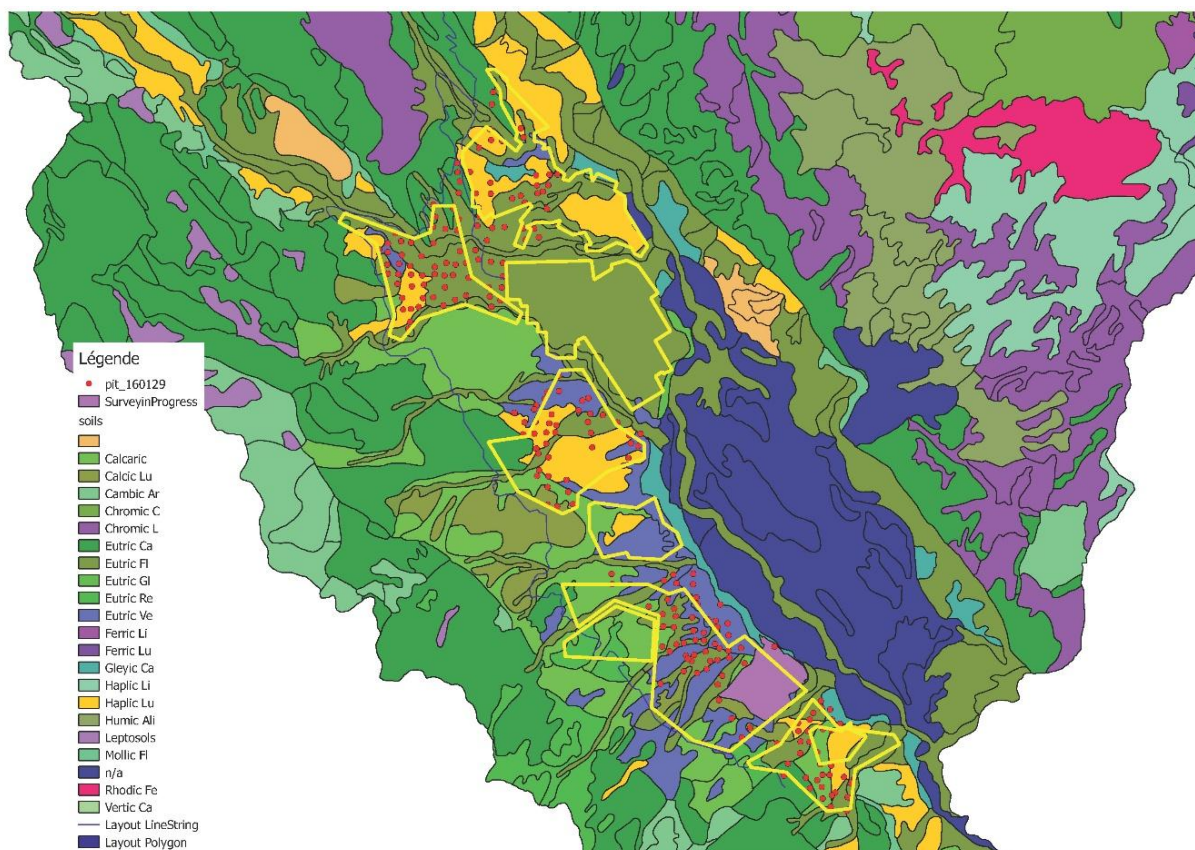
1. Well drained youthful soils (Cambisols, soil association A) constituting 59% of Estates
2. Black cracking clays (Vertisols, soil association H) comprising 22% of Estates
3. Duplex soils (Luvisols, soil association C) comprising 6% of Estates

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.

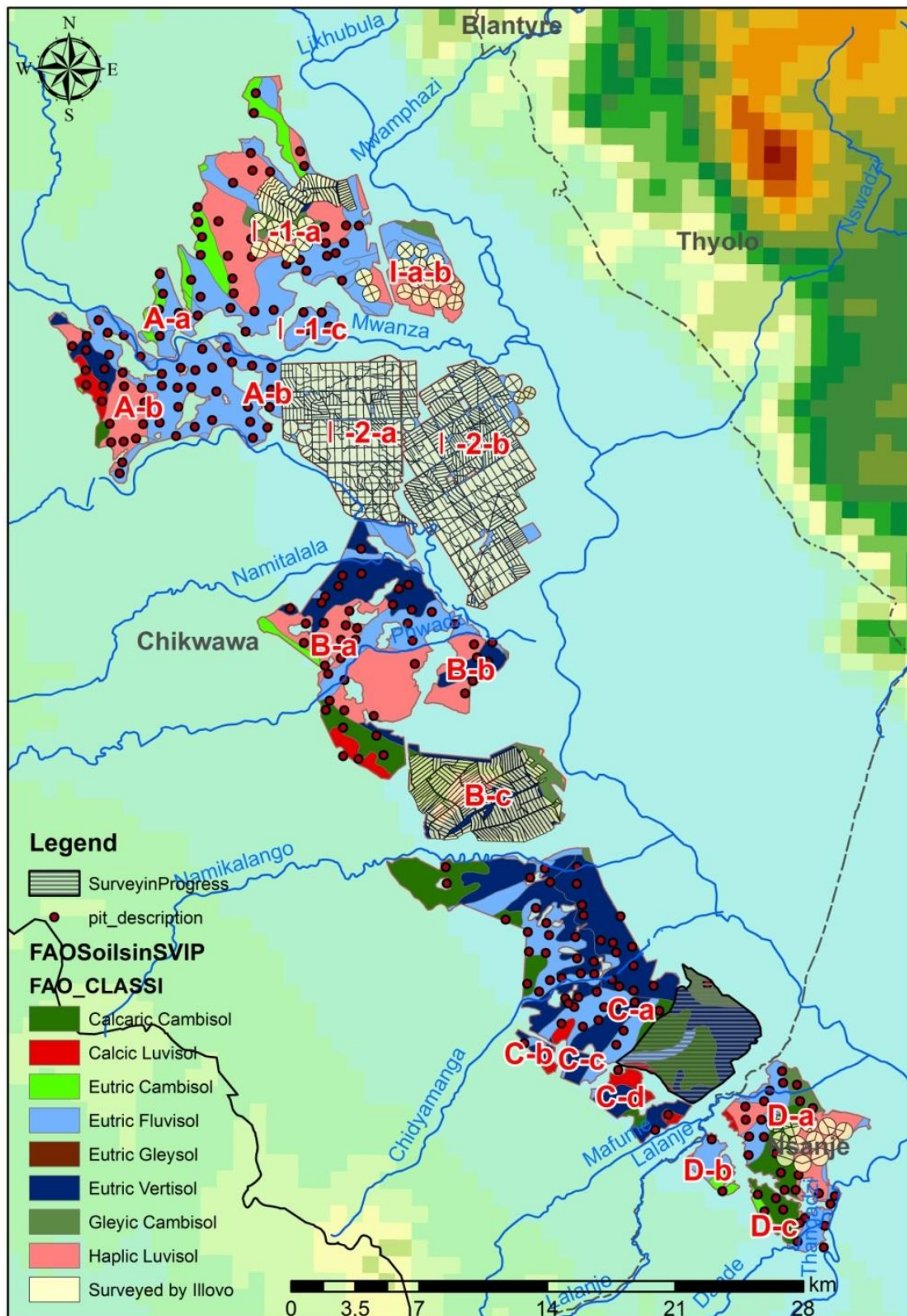
Figure 22 Soil map used by KRC (based on FAO classification)



The map below shows an already existing soil pattern with notes on areas still under survey or completed by Illovo.

The soil expert of the ESIA consultant has estimated the surface of heavy Vertisol to be 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 and recommended that Vertisols need special management or in cases cannot be used. 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. KRC subsequently mapped identified Vertisols and during detailed design special measures will be developed for these areas or they will be included in set-aside lands. .

Figure 23 Soil map used by KRC (Unpublished, 2016)



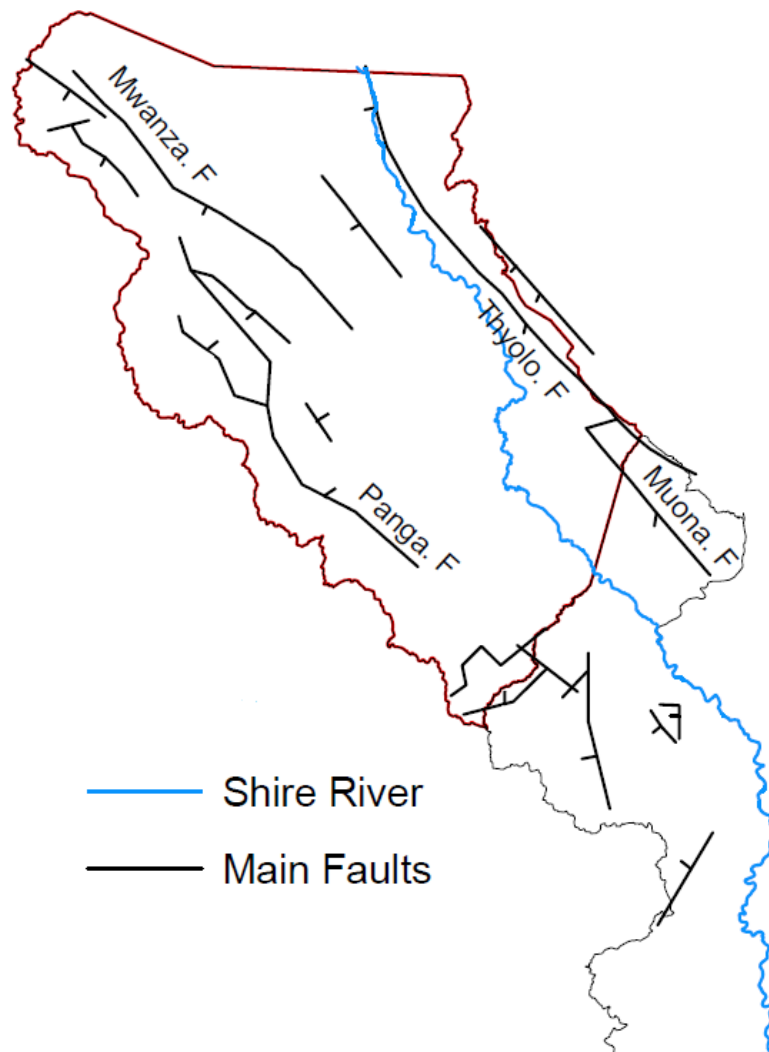
6.7 AQUIFER AND GROUNDWATER

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 24 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 $\mu\text{S cm}^{-1}$, 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_4^{2-} 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).

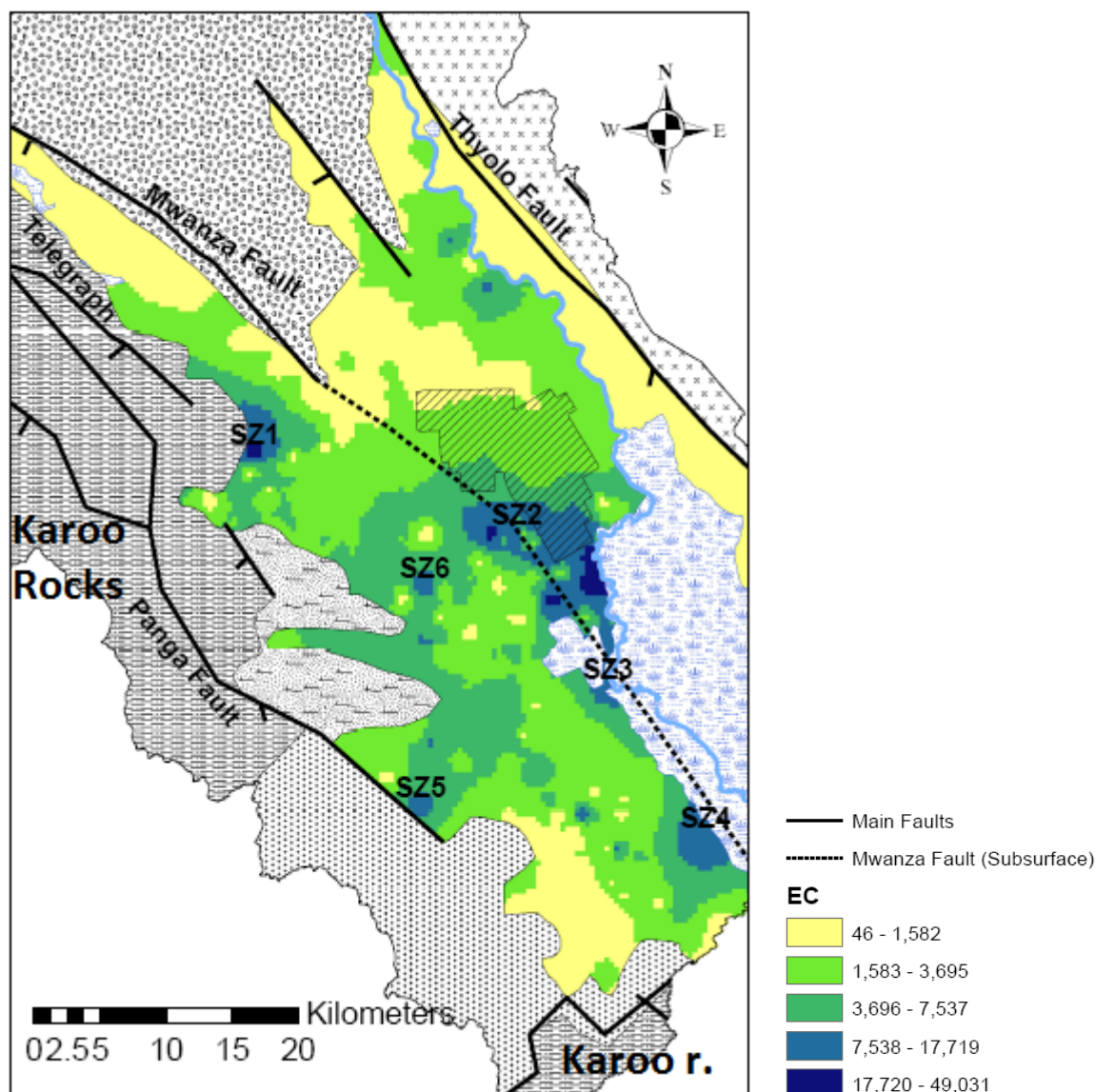
In general, the salinity in groundwater increases gradually as it flows towards Shire River. In the region, there is a spatial variation in groundwater salinity with extreme gradients in chemical composition over short distances; however there is not a significant variation with depth of groundwater (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 $\mu\text{S/cm}$) 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 25 Electrical Conductivity (EC) of groundwater



Source: Adapted from Monjerezi et al. (2012)

7. SOCIOECONOMIC BASELINE

7.1 INTRODUCTION

This chapter includes baseline assessment of the current socioeconomic features of the Study 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.

7.2 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 and in coordination with the social and economic assessments carried out under the COWI assignment on Communication, Community Participation and Resettlement Policy Framework (COWI, 2016).

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).

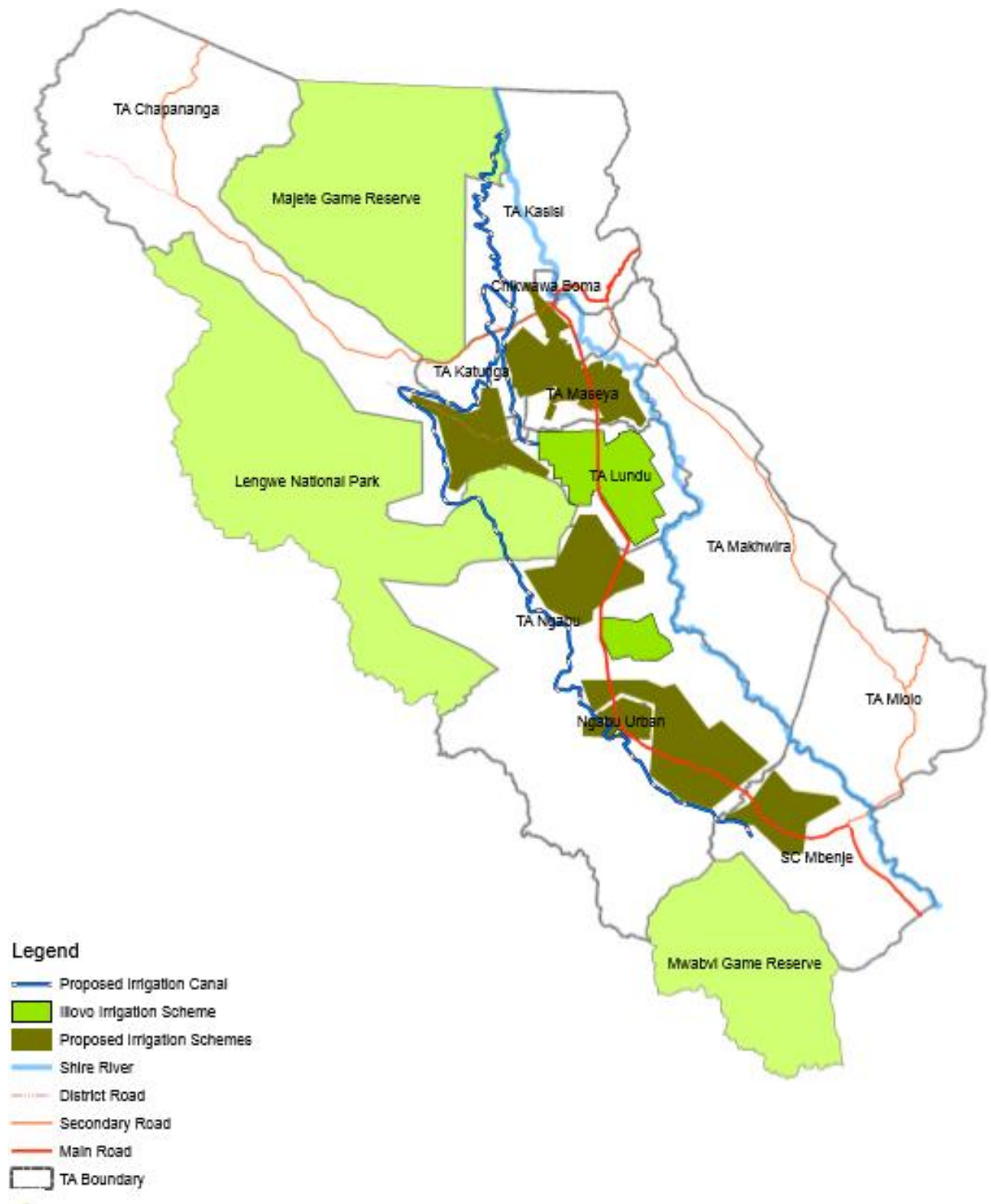
Traditional leaders concern by the Project are as follow:

- 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 26 Traditional Authorities



7.3 EARLY PROCESS 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 follows:

- 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?

These issues have been considered during subsequent project design and where relevant are incorporated below in specific measures or covered by the Resettlement Policy Framework.

7.4 SOCIAL INDICATORS

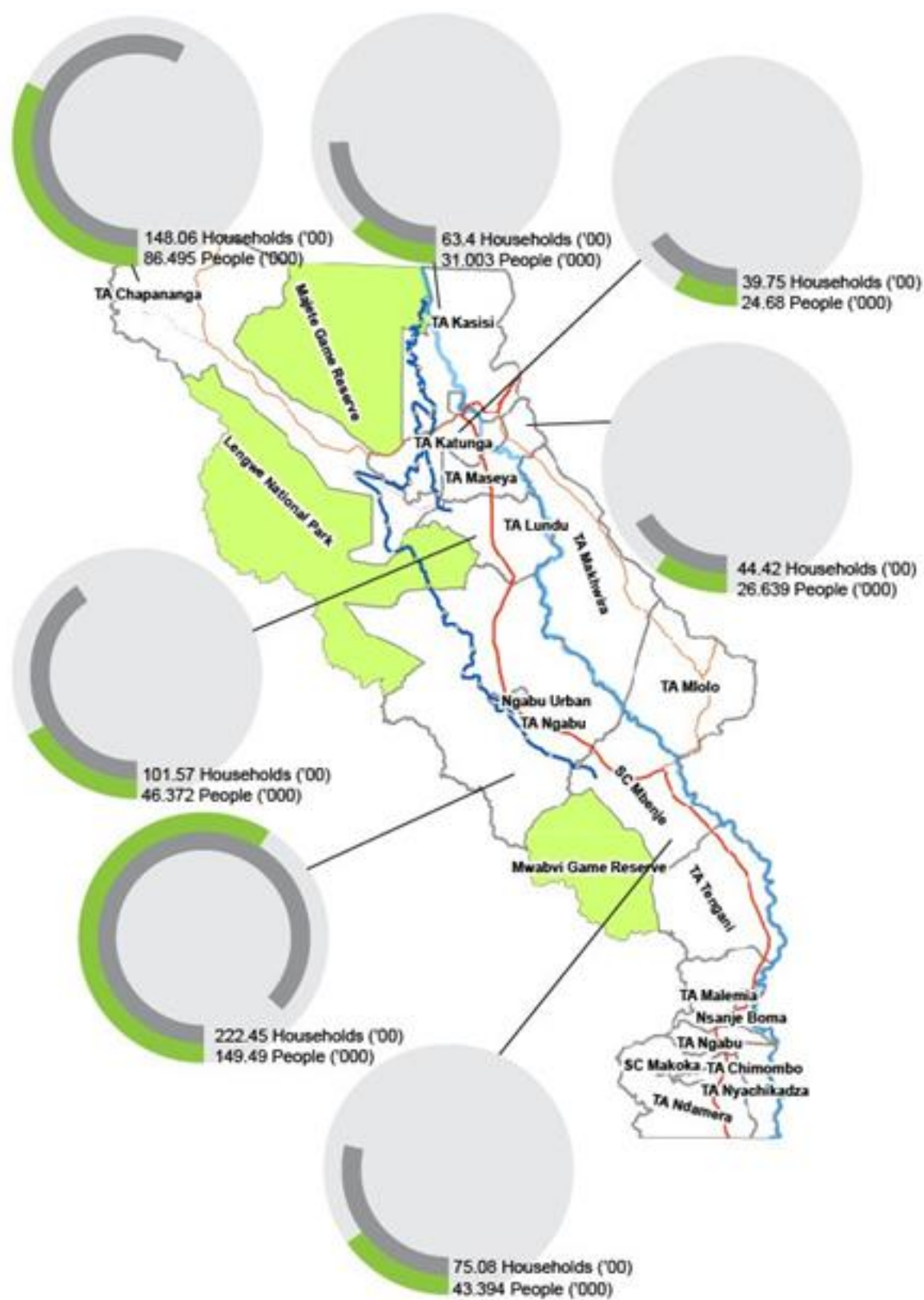
7.4.1 Population and demographics

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 27 Population



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

7.4.2 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.

7.4.3 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 challenge 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 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.

7.4.4 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, Chapanganga, 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.

7.4.5 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.

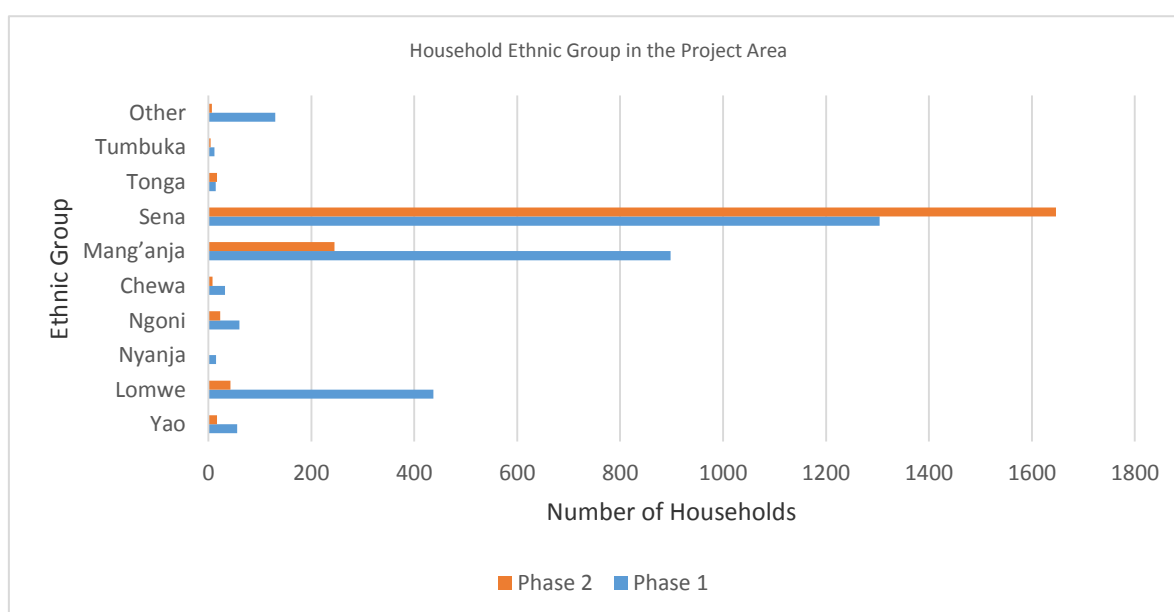
The number of dropouts in primary school was higher for girls than boys except in T/A Chapananga and Katunga.

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.

7.4.6 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 28 Household ethnic groups



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

7.5 INFRASTRUCTURE

7.5.1 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 levels.

Table 8 Population and housing for Chikwawa and Nsanje against regional and national conditions

	Chikwawa	Nsanje	National average	Southern region	Observations
Levels and trends in urbanization					
Population (people)	434,648	238,103	13,077,160	5,858,035	Lower than average density and growth rate.
Annual growth rate (%)	2.0	2.1	2.8	2.4	
Population density (persons/km ²)	91	123	139	184	
Urbanisation centres > 5,000 inhabitants	1.6	8.5	15.3	15.9	
Housing conditions					
Household size (people)			4.6	4.4	
Occupancy tenure (%)					Owner occupancy dominant, rented dwellings is an urban phenomenon only.
-owned			87		
-rented			11		
-other			3		
Size of dwelling (%)					Smaller size dwelling prevalent.
- one room for sleeping	45.6	47.8	41.3	40.3	
- two rooms for sleeping	38.2	34.7	38.5	40.7	
State of permanency (%)					Majority lives in dwellings using traditional materials and construction techniques. However, some improvements in durability since 1998.
-traditional dwelling	43.0	45.1	44.4	34.9	
-semi-permanent	34.8	40.8	34.2	41.5	
-permanent	22.3	14.0	21.4	23.6	
Construction materials (%)					Majority of dwellings are susceptible to flood damage. Flood proofing of individual dwellings may not be feasible.
Floor					
-earth, sand, dung	85.6	87.0	78.5	77.1	
-cement, bricks, etc.	14.1	12.8	21.2	14.1	
Walls					
-mud	19.2	13.5	19.9	4.3	
-unburnt bricks	35.9	36.6	38.3	50.7	
-burnt bricks	38.2	44.3	38.5	42.2	
Roof					
-grass thatch	74.6	76.3	70.6	66.9	
-corrugated iron	24.9	23.0	28.4	32.1	

Figure 29 Permanent dwelling and traditional dwelling in the study area



7.5.2 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.

7.5.3 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%.

7.5.4 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 30 Main sources of drinking water

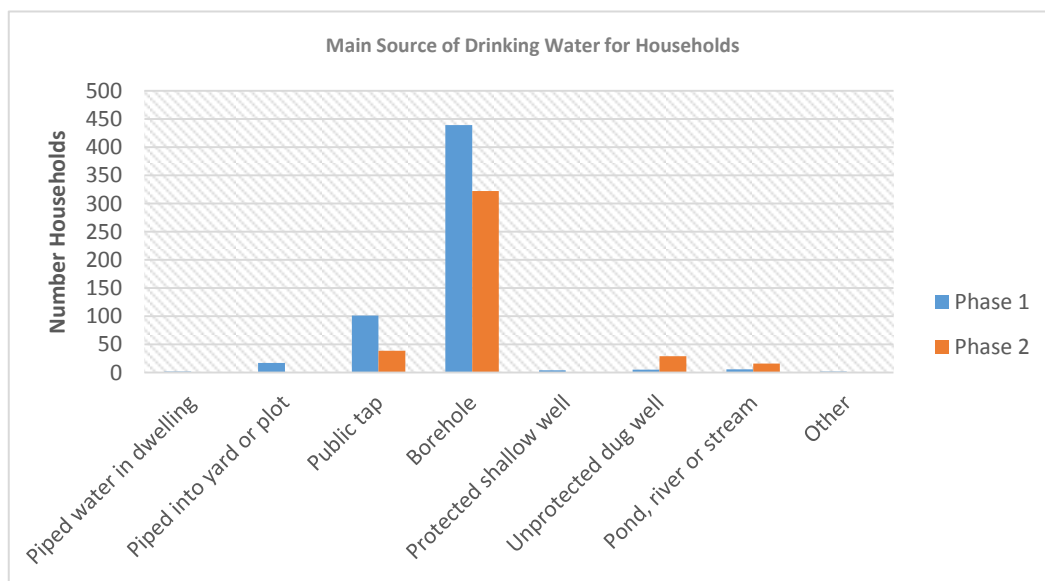


Figure 31 Unprotected well from river bed



7.5.5 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).

7.5.6 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.

7.5.7 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.

7.6 LAND

7.6.1 Land tenure

For more details on land tenure this report refers to the Resettlement Policy Framework Document. 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 uxrilocal (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.

7.6.2 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).

7.6.3 Land use

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

7.6.3.1 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 (more details in the Pest Management Plan):

- 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.

7.6.3.2 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.

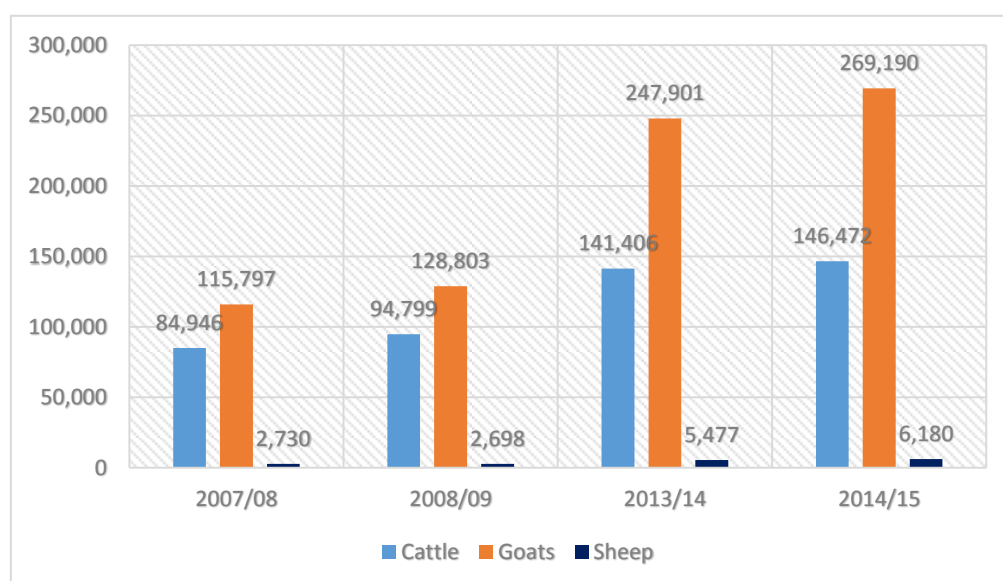
The shrub originates from South America and has been introduced to Malawi for life fencing for maize garden (Shackleton, 2014). Although it is invasive, it is considered a valuable shrub for several reasons : it is a source of fuelwood, a source of pole, timber and fencing for maize garden. However, 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).

7.6.3.3 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 32 Livestock Population in Chikwawa District

7.6.3.4 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.

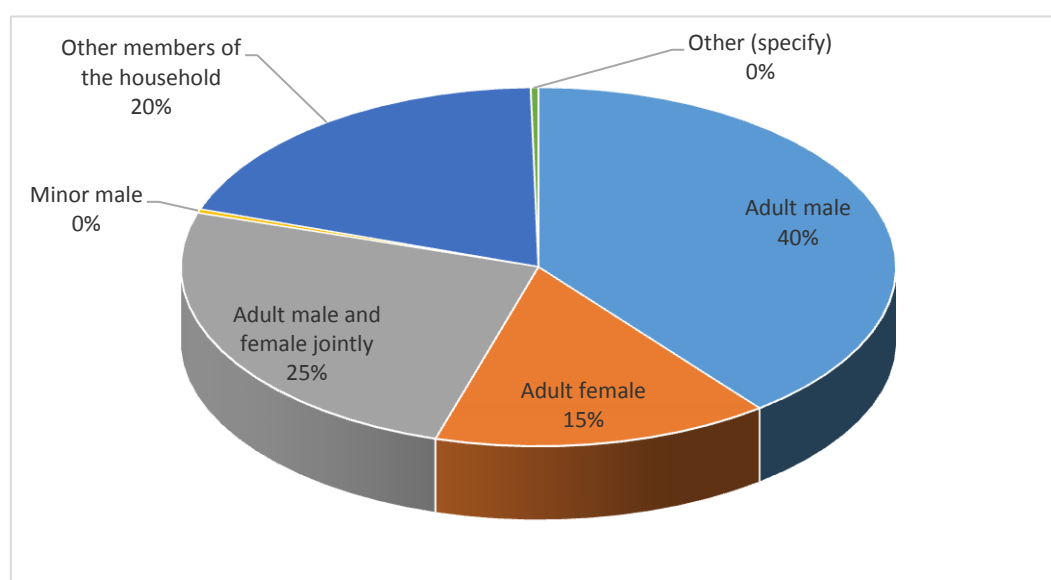
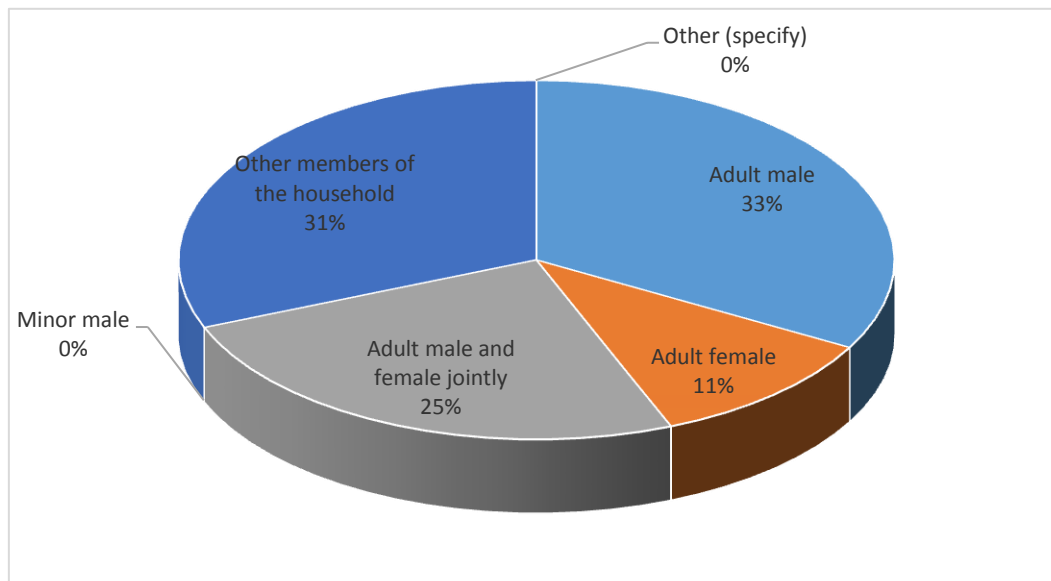
Figure 33 Gender and Decision Making on landuse at Household Level: Phase 1

Figure 34 Gender and Decision Making on landuse at Household Level: Phase 2

7.6.3.5 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 because 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.

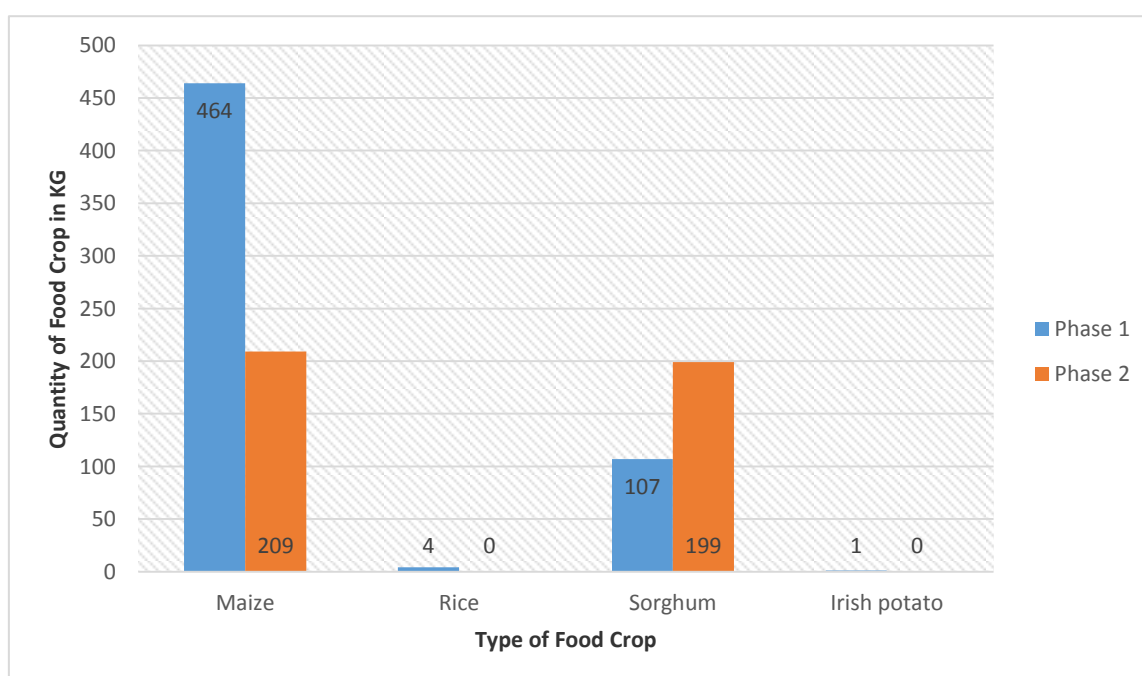
7.6.4 Economics

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.

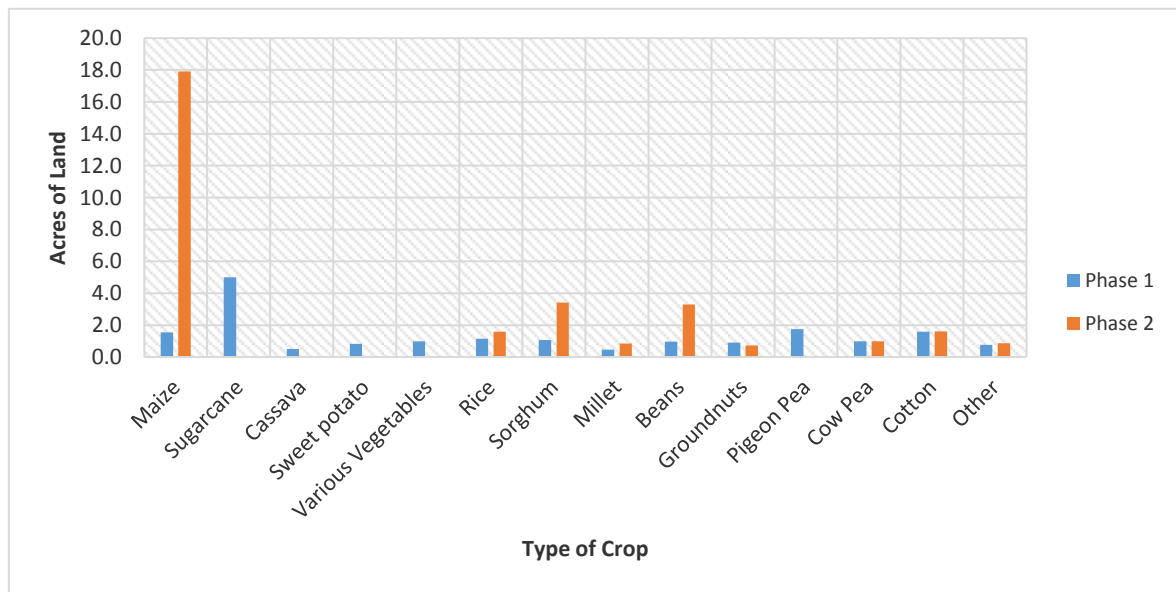
7.6.4.1 Crop Production

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.

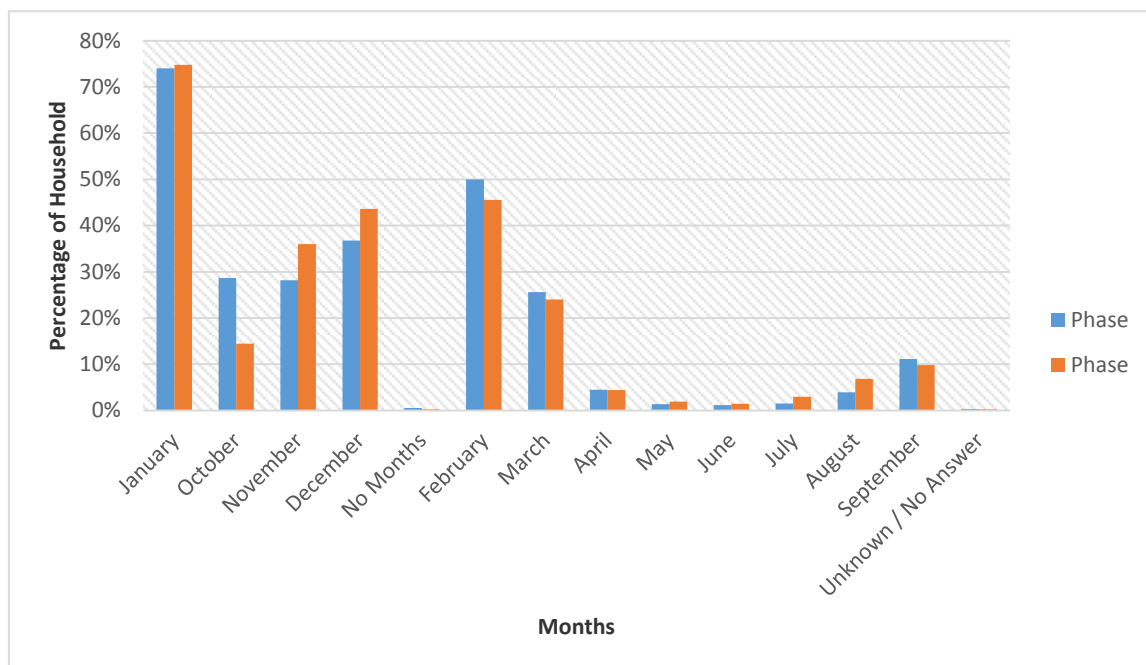
Figure 35 Main food crops



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 36 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 exacerbated this food security problem in this area and Malawi at large.

Figure 37 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.

7.6.4.2 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.

7.6.4.3 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 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.

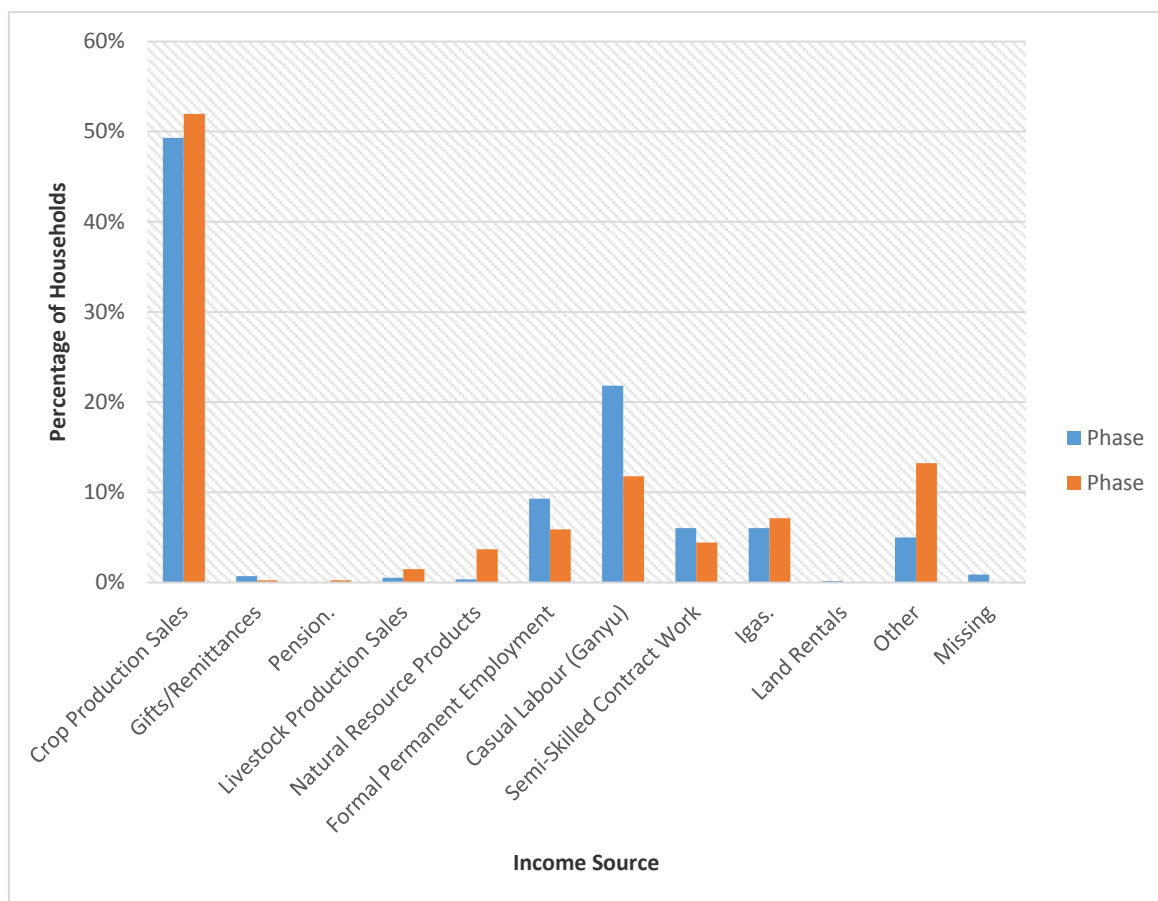
7.6.4.4 Employment

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.

7.6.4.5 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 38 Main income sources



7.6.4.6 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.

7.7 HEALTH ISSUES

7.7.1 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.

7.7.2 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).

7.7.2.1 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.

7.7.2.2 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 through 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.

7.7.2.3 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.

7.7.2.4 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).

7.7.2.5 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.

7.7.2.6 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.

7.7.3 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.

8. CULTURAL HERITAGE

8.1 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.

8.2 METHODOLOGY AND APPROACH OF THE STUDY

The methodology of this study consisted of three distinctive components:

- Desktop assessment
- Fieldwork assessment
- Meeting with relevant stakeholders

8.2.1 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.

8.2.2 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).

8.3 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.

8.3.1 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 Chagalumbe 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 39 Examples of Nkope Pottery, Early Iron Age



Source: Rachel Warren, unknown date

Figure 40 Examples of Kapeni Pottery, Terminal Early Iron Age



Source: Rachel Warren, unknown date

Figure 41 Examples of Mawudzu (or Maudzu) Pottery, Late Iron Age



Source: Rachel Warren, unknown date

Figure 42 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 43 Grinding stone and "Livingston" Baobab



Source: BRLi (2015)

8.3.2 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).

8.3.2.1 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 20m². 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.

8.3.2.2 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 44 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.

8.3.3 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 9 Site prioritization

Old Age	Primary context	High 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.

8.4 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.

9. 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 degazetted in 1922 (Dudley, 1997). There is no touristic activity in the marsh.

9.1 MAJETE WILDLIFE RESERVE

9.1.1 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 km².

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.

9.1.2 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 in the rainy season (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 45 Kapichira falls and Shire River from Majete



Source: BRLi (2015)

9.1.3 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 by the canal.

9.2 LENGWE NATIONAL PARK

9.2.1 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 where Nyala antelope occurred. In 1928 its size was 520 km². 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 km². 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).

9.2.2 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 Western 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).

9.2.3 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. This river is heavily silted due to deforestation in the catchment (some illegal deforestation take place in the Eastern Salient), this has consequences in the Old Lengwe as it creates floods.

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 income 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.

9.3 MWABVI WILDLIFE RESERVE

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

9.3.1 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 km² and is managed by the same staff as Lengwe National Park.

9.3.2 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.

9.3.3 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.

9.4 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). A number of studies have been carried out specifically on the elephant Marshes and their recommendations have been incorporated where relevant in the remainder of this ESIA document.

10. ECOLOGY

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

10.1 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 10 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 (TREG)	40.1	Open Woodland with Herbaceous Layer (TREG)	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 savanna (HBCL)	8.1	Closed Herbaceous Vegetation with Sparse Trees - Trees and shrubs savanna (HBCL)	1.5
Post Flooding Cultivation Of Small Sized	6.4	Post Flooding Cultivation Of Small Sized	3.2

Percentage of land cover in Chikwawa District (%)		Percentage in land cover in Nsanje District (%)	
Field(s) Of Herbaceous Crop(s) Cultivated Dambo (AGFL)		Field(s) Of Herbaceous Crop(s) Cultivated Dambo (AGFL)	
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 where human activities do not intervene with ecological processes.

- Open Woodland with Herbaceous Layer (TREC): 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 shrubs.
- 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.

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).

10.2 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 changes 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 doing dimba agriculture (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.

10.3 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.

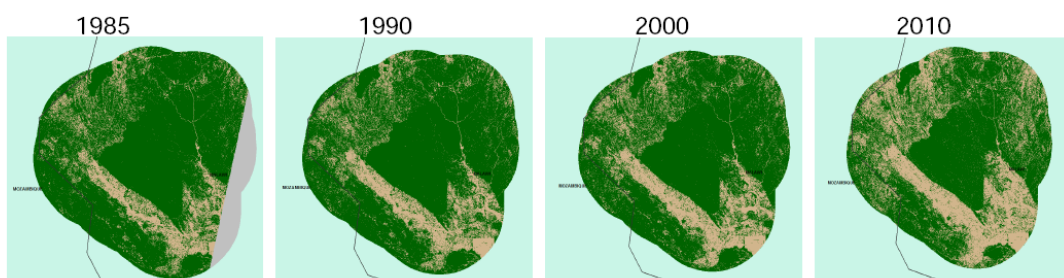
10.3.1 Majete Wildlife Reserve

10.3.1.1 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 46 Evolution of deforestation around Majete Wildlife Reserve



Source: Geoterralmage, 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.

10.3.1.2 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 47 Majete at Feeder canal location



Source: BRLi (2015)

10.3.1.3 Ecological Continuity

The reserve is fenced therefore there is 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.

10.3.2 Lengwe National Park

10.3.2.1 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. In addition, fragmentation of Old Lengwe because the natural path to the Shire River was cut by sugar plantation decades ago created a dry place where wildlife can no longer fetch for natural water. Water has been a limiting factor for wildlife since.

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) where 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 48 LNP in 2001 (Northern part of the Uplands Unit)



Figure 49 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 fragmented 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.

10.3.2.2 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 50 Area where the Bangula Canal crosses the park (tree savanna)



10.3.2.3 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 continuity. 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. According to Max Del Bufalo, Managing Director of Jambo Africa (in charge of Nyala Lodge), some animal do migrate from Old Lengwe to the Eastern Salient and to Mozambique to fetch for water in the dry season, this water driven migration is however not documented (personnal communication, 2016).

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.

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).

10.4 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.

10.4.1 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 Ruvo River junction with Shire (at the destroyed bridge) where the wetland is constricted by the alluvial fans of the Ruvo. After the junction with Ruvo, 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 km² (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 Ruvo 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 Ruvo River. Ruvo River feeds an important pool in the marsh named "Tomaninjobi Pool" where fishing activities take place. Ruvo 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.

10.4.2 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 are dominated 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 have been carried out in the marsh in the framework of the SRBMP (Sub-study n°4: Biodiversity surveys carried out by MRAG) provide valuable and up-to-date information on biodiversity..

- 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.
- Herpetofauna (reptile and amphibian). Based on biodiversity surveys done by MRAG Ltd (2016), it is considered that amphibian diversity and populations numbers still reflect in great part that originally existing in the Elephant Marsh. However, reptiles are considered to show reductions in the numbers, and possibly even local extirpation, of arboreal snakes (Boomslang and Twig Snake), larger terrestrial species (Puffadder), and specialised aquatic species (Zambezi Flap-Shelled Terrapin and Floodplain Viper).
-
- 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.

10.4.3 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. This is because a wetland is defined as a system where hygrophilous plants thrive rather than an inundated system. 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, on an ecological point of view, wetland surface does not vary with season.

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 selected month to produce the following map is 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 km²), 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 km²) 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.

10.4.4 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 degazetted 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 51 Original situation with a meander of the Shire in the marsh (2010)



Figure 52 Manmade dyke to increase flow to the Shire



Figure 53 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 54 Original situation in the marsh (2006)

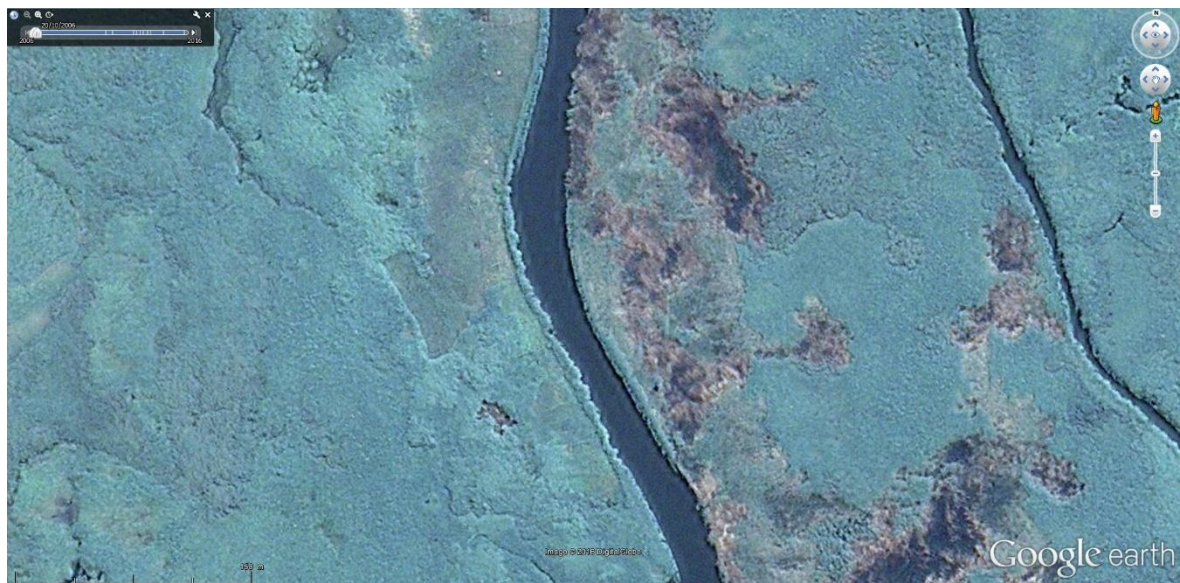


Figure 55 Beginning of encroachment (2011)

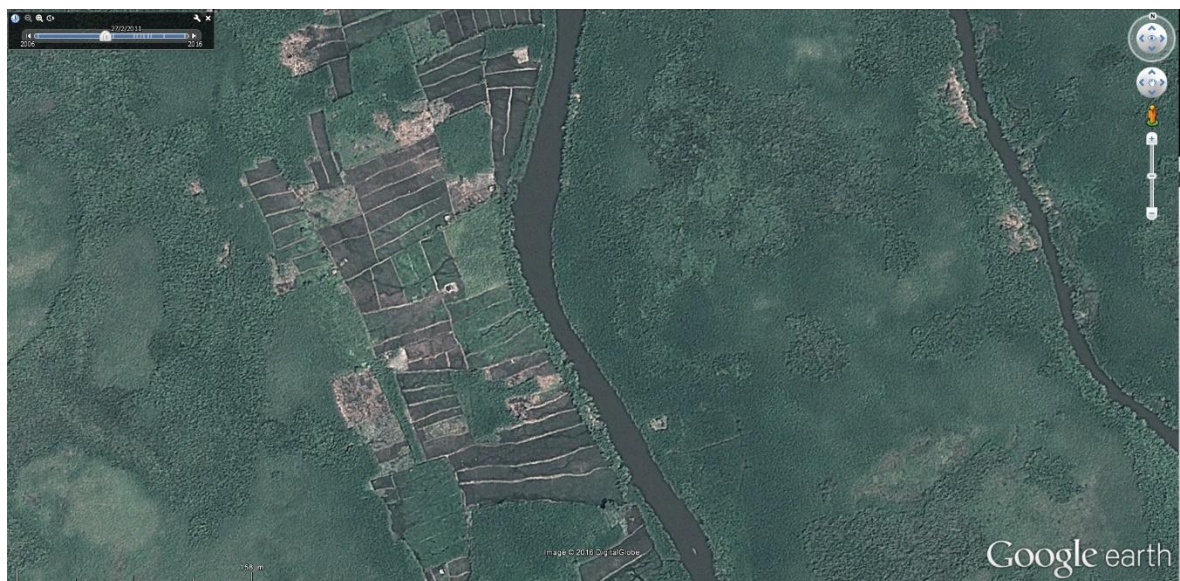
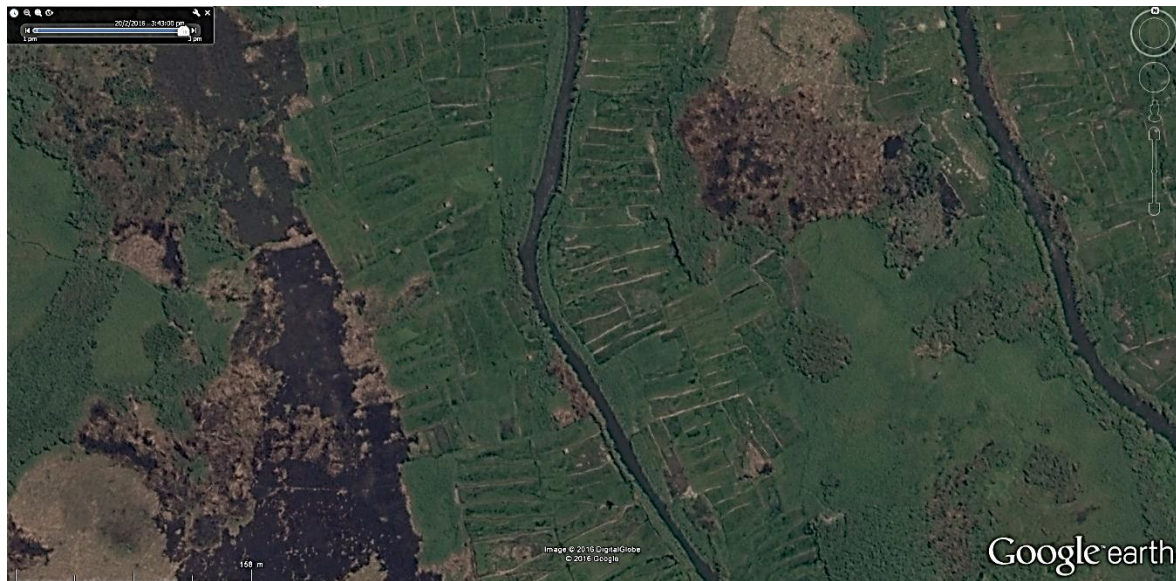


Figure 56 Ongoing encroachment (2016)



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 fodder 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.

10.4.5 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.

10.5 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 11 Common mammals in LNP

Common name	Latin name	IUCN status and world population trend	Habitat
Nyala	<i>Tragelaphus angasi</i>	Least concern, population trend : stable	Thicket
Impala	<i>Aepyceros melampus</i>	Least concern, population trend : stable	Grassland, thicket
Warthog	<i>Phacochoerus africanus</i>	Least concern, population trend : stable	Woodland
Greater Kudu	<i>Tragelaphus strepsiceros</i>	Least concern, population trend : stable	Woodland
Suni	<i>Neotragus moschatus livingstoni</i>	For N. moschatus: Least concern, population trend : stable For N. moschatus livingstoni: not studied by IUCN	Very restricted range, thickets
Buffalo	<i>Syncerus caffer</i>	Least concern, population trend : decreasing	Acacia and <i>Brachystegia</i> woodlands of Old Lengwe
Bushbuck	<i>Tragelaphus scriptus</i>	Least concern, population trend : stable	Thicket and riparian habitat
Reedbuck	<i>Redunca arundinum</i>	Least concern, population trend : stable	Grassland

Common name	Latin name	IUCN status and world population trend	Habitat
		trend : stable Rare in the Park	
Nchima monkey	<i>Cercopithecus albogularis</i>	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 12 DNPW versus WSM animal census

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Warhog DNPW	927	1003		727	1332	1326			390	901	
Warhog 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
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	

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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 found 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 13 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 14 Common mammals in the three parks

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

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

Ol :Old LEngwe 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).

10.6 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 15 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	<i>Aquila nipalensis</i>	Hills and mountains	Endangered
Basra Reed-warbler	<i>Acrocephalus griseldis</i>	Marshland	Endangered
Southern Ground-hornbill	<i>Bucorvus leadbeateri</i>	Woodland and savanna	Vulnerable
Stierling's	<i>Dendropicos</i>	Brachystegia woodland	Near Threatened

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	
Woodpecker	<i>stierlingi</i>		
White-backed Vulture	<i>Gyps africanus</i>	Open wooded savanna (Acacia)	Critically Endangered
Olive-headed Weaver	<i>Ploceus olivaceiceps</i>	Brachystegia woodland	Near Threatened
Martial Eagle	<i>Polemaetus bellicosus</i>	Open woodland, wooded savanna, bushy grassland	Vulnerable
Secretary bird	<i>Sagittarius serpentarius</i>	Grasslands, lightly wooded savanna	Near Threatened
Temminck's Ground Pangolin	<i>Smutsia temminckii</i>	Savanna woodland	Vulnerable
Crowned Eagle	<i>Stephanoaetus coronatus</i>	Forest, woodland, savanna and shrubland	Near Threatened
Bateleur	<i>Terathopius ecaudatus</i>	Grasslands, savanna	Near Threatened
Lappet-faced Vulture	<i>Torgos tracheliotos</i>	Dry savanna	Endangered
African Straw-coloured Fruit-bat	<i>Eidolon helvum</i>	Riverine forest, savanna	Near Threatened
Commerson's Leafnosed Bat	<i>Hipposideros vittatus</i>	Savanna woodland habitats	Near Threatened
Elephant shrew	<i>Rhynchocyon cirnei shirensis</i>	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	<i>Diceros bicornis</i>	Woodland, savanna and shrubland	Critically Endangered
Leopard	<i>Panthera pardus</i>	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 16 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	<i>Ardeola idae</i>	Swallow wetlands fringed with vegetation and adjacent trees	Endangered
Grey Crowned-crane	<i>Balearica regulorum</i>	wetlands such as marshes, pans and dams with tall	Endangered

Taxonomy	Location system &	Habitat	Assessment
Chordata (vertebrate)	Malawi, Freshwater	Wetlands (inland)	Extinct, Critically Endangered, Endangered, Vulnerable, Near Threatened
Common name	Latin name	Habitat	
		emergent vegetation	
Blue Swallow	<i>Hirundo atrocaerulea</i>	Montane grassland	Vulnerable
African Clawless Otter	<i>Aonyx capensis</i>	Permanent river	Near Threatened
Hippopotamus	<i>Hippopotamus amphibius</i>	Wetland and permanent river	Vulnerable
Spotted-necked Otter	<i>Hydricis maculicollis</i>	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 veronii*, Woodward's 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 *Spermacoce* (Rubiaceae) 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.

10.7 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.

10.7.1 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 *Clariidae*.

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 ECOSYSTEM

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 obstacles to the upstream migration of the Lower Shire fish fauna into the Lake Malawi basin, however the only absolute barrier to upstream fish migration is the Kapichira falls (Tweddle, Lewis, Willoughby, 1979). Thus, fish cannot migrate from the Lower Shire to the Middle Shire.

Regarding downstream migration, some fishes from Upper Shire 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. In addition, the tiger fish from the Lower Shire and Zambezi River is such an aggressive predator that scientifics believe that it is the reason why endemic fish species from upper Shire have not succeeded in colonizing Lower Shire (and not only because of the the dangerous falls of Kapichira) (Tweddle, Lewis, Willoughby, 1979).

Figure 57 Spillway

10.7.2 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.

10.7.3 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:

- Straightfin Barb, “Matemba” (*Barbus paludinosus*);
- “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 or 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 endemism 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.

10.7.3.1 *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 19°C and for reproduction is above 22°C (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 10°C.

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°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 breeding 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 (Courtenay, 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*.

10.7.3.2 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 anguillaris*, *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 al 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.

10.7.3.3 Straightfin Barb (*Barbus paludinosus*)

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.

10.7.3.4 *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 28°C (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.

10.7.3.5 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 28°C, 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. However, the fish can jump out of the water to catch low flying birds.

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 invasive but is a predatory species. Kapichira falls is a barrier that has kept the Tiger fish from moving upstream the Lower Shire and preying on Lake Malawi fish fauna. Hence, the tiger fish is confined to the Lower Shire area in Malawi.

10.7.3.6 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°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 (Tweddle 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 Lower 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. Its 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.

10.7.3.7 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°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.

10.7.3.8 *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 28°C 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 ripens 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.

10.7.3.9 *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 28°C 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 (Froese and Pauly 2006). Hence, there is a need to maintain adequate water levels in the Lower Shire.

ABILITY TO PASS OBSTACLES

The *B. johnstonii* 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 (Froese 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.

10.7.3.10 *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°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.

10.7.3.11 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 brienii***, inhabits muddy areas. Spawns in roots of aquatic vegetation;
- ***Megalops cyprinoides***, inhabits the Shire, lagoons and swampy area. Spawns offshore;
- ***Anguilla bicolor*** 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 macrotania***, 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;
- ***Pseudocrenilabrus 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.

10.7.4 Herpetofauna

(this section is based on MRAG, 2016: substudy 4, biodiversity of the Elephant Marsh).

Amphibians are well represented in sub-Saharan Africa, where approximately 600 species have been recorded. Amphibians are of increasing scientific concern as global reports of declining amphibian populations continue to increase. Although there is no consensus on a single cause for this phenomenon, there is general agreement that the declines in many areas, even in pristine protected parks, are significant and do not represent simple cyclic events. Frogs have been aptly called bio-indicator species, whose abundance and diversity is a reflection of the general health and well-being of aquatic ecosystems. They are important components of wetland systems, particularly ephemeral systems in which fish are either excluded or of minor importance. In these habitats, they can be dominant predators of invertebrates, many of which may impact significantly on humans (e.g. as vectors of disease, such as mosquitoes and bilharzias snails) or their livestock and/or crops.

Reptiles also form a significant component of vertebrate faunas in Africa. With the exception of land tortoises, all terrestrial reptiles are carnivorous, although some larger lizards do supplement their diet with vegetable matter in certain seasons. Reptiles therefore play an important role in nutrient cycling within ecosystems, and in population control of their prey items. Most snakes are specialist feeders, taking specific and limited food classes, and this is often reflected in their common names, i.e. egg-eaters, slug-eaters, centipede eaters, etc. They are usually habitat generalists, occupying a wide range of habitats and vegetation types, provided their primary prey is present. In contrast, most lizards take a wide-range of insect prey, and niche separation between sympatric species usually occurs via habitat selection and/or diel activity (e.g. most geckos are nocturnal). Congeneric species especially occupy different habitats that are determined more by the habitat physical and substrate characteristics rather than the presence of specific plants and/or soil.

The herpetofauna of Malawi in general is not well-known, and has not been recently reviewed. Mercurio (2011), in his review of Malawi amphibians, noted:

“After 145 years of herpetological studies with about 50 scientific publications only, the status of knowledge of amphibians and reptiles of Malawi..... is still rudimentary.”

There is fuller documentation for amphibians than reptiles, with a number of monographic reviews of the country's frogs, either at a national level (e.g. Stewart 1967, Mercurio 2011) or as part of larger regional compilations (Poynton & Broadley 1985-1991; Channing 2002). There is no comparable national review of Malawian reptiles, although local surveys and summaries exist (e.g. Loveridge 1953a-c, Stevens 1974, Broadley 2000, etc.). The need for an updated assessment of the diversity and conservation status of reptiles and amphibians of Malawi is essential.

The first specimens collected in the Lower Shire Valley were obtained by Dr Kirk while on the Livingstone expedition (Günther 1864). Loveridge (1953a,b) reported on an expedition to Nyasaland, but did not visit the Elephant Marsh. The snakes of Malawi were covered by Sweeney (1961), whilst Stevens (1974) published an annotated checklist covering the herpetofauna of south-eastern Malawi.

There are few historical herpetological surveys within the Elephant Marsh or its surroundings. Loveridge (1953c) documented a herpetological collection made by the Berner-Carr Entomological Survey of the Shire valley in 1952, and included 15 amphibians and 14 reptiles. Blaylock (1963) reported on two trips (1961-2) to the lower Shire River, including the capture of 163 snakes in 14 days from a camp 10 km upstream from Chiromo. The habitat comprised low scrub next to the swamp and included (taxonomy updated): 97 Western Green Snake *Philothamnus angolensis*, 31 Olive Grass Snakes *Psammophis mossambicus*, 10 Spotted Bush Snake *Philothamnus semivariegatus*, 4 Stripe-bellied Sand Snake *Psammophis orientalis*, 4 Brown House Snake *Boaedon capensis*, 3 Semiornate Snakes *Meizodon semiornata*, and single specimens of Mozambique Spitting Cobra *Naja mossambica*, Olive Marsh Snake *Natriciteres olivaceus*, Rhombic Egg-eater *Dasypelis scabra*, and the Zambezi Blind Snake *Afrotyphlops mucruso*. Other herpetofauna recorded included the reed frog *Hyperolius marmoratus*, and the lizards *Trachylepis striata*, *T. varia* and *Chamaeleo dilepis*. At Tengani in the lower Shire Valley below Chiromo *Philothamnus semivariegatus*, *Psammophis orientalis*, the Puff-adder *Bitis arietans*, the Snouted Cobra *Naja annulifera*, and the second Shire record of the Floodplain Viper were also collected. Broadley (1996) reported on a small herpetological collection from the Elephant Marsh (quarter degree square 1634Bd; western edge of the Elephant Marsh near the boundary of the Lengwe Game reserve). It included the first record from Malawi and north of the Zambezi of the water snake *Lycodonomorphus obscuriventris*, and prompted Broadley to raise it to a full species (it was previously a subspecies of *L. whytei*). It remains the only Malawi record of this rare snake. Other species from the Elephant Marsh included: the frogs *Xenopus muelleri*, *Amietia angolensis* (= *A. queketti* see below), *Ptychadena anchietae*, *Phrynobatrachus mababiensis*, *Afraxalus brachycnemis* complex (= *A. crotalus*) and *A. fornasinii*; and the snakes *Natriciteres olivacea* and *Crotaphopeltis hotamboeia*. The herpetofauna of the entire Zambezi drainage basin was summarised by Broadley (2000), including a summary of the reptiles and amphibians from the lower Shire valley. His summary is incorporated into Tables 24 and 25, below.

Two short field surveys on the study area were conducted by MRAG (2016). The first occurred for five days (5-9 July 2015) during the dry season. A wet season survey was undertaken for five days (17-21 January 2016). All surveys used visual encounter survey methods. Diurnal searches involved active search of specific microhabitats, particularly beneath cover such as decaying logs or mats of vegetation. Nocturnal surveys for amphibians were undertaken in wetlands and surrounding woodland.

A total of 25 amphibian species was recorded, representing 74% of the known amphibian fauna of the region. Five were previously unrecorded from the Lower Shire Valley, but known from adjacent areas. Eight species previously recorded from the Lower Shire Valley and Elephant Marsh were not encountered in this study. These species may have been inactive during the survey periods or overlooked.

In contrast, only 21 species of reptiles were recorded, representing 46% of the 58 reptile species known from the Lower Shire Valley. Seven other common species were reliably reported to occur in the region. Two species were added to the regional herpetofauna list during the surveys and two species overlooked in the most recent surveys were reconfirmed.

None of the amphibian species known to occur are considered threatened or of conservation value. The existing amphibian fauna is considered to be similar to the original fauna before human impact, except for the possible reduction of tree frogs as a result of the loss of riparian trees. The reptile fauna is considered to be significantly impacted, with large snakes, particularly arboreal species, present in reduced numbers. Historical records show that two iconic reptiles of Malawi wetlands, the Zambezi Soft-Shell Terrapin *Cycloderma frenatum* and the Swamp Viper *Proatheris superciliaris*, both occurred in the Elephant Marsh region. These species were not recorded and are in danger of becoming regionally extinct, if not already so.

Large Nile crocodiles *Crocodylus niloticus* (>3 m) are still common in the Shire River and Elephant Marsh, but there are concerns for their continued survival. The main source of human-crocodile conflict and consequent hunting is the damage to gill nets set overnight for fishing. In addition, the crocodile farm in the area harvests eggs as well as a few adults for breeding stock.

Unfortunately, the lack of historical detailed surveys of the Elephant Marsh herpetofauna precludes objective assessment of the 'health' of reptile and amphibians communities in the region. No population estimates of the historical herpetofauna are available and it is therefore impossible to quantify possible reptile or amphibian declines or even local extirpation. Due to the extensive wetlands still present there is unlikely to have been extensive loss of amphibian biodiversity or numbers. The loss of their predators, such as snakes and large fish, may have led to increased juvenile recruitment as well as declines in adult mortality. However, these would be balanced by the loss of habitat stability resulting from hydrological changes such as increased flooding, greater water turbidity and siltation. The loss of trees, both along the riparian edge as well as marsh margin, may have affected the survival of tree frogs (*Leptopelis* sp.), which were not recorded during the present surveys. Conversely, the extensively modified marsh fringes are dried and have reduced vegetation cover than originally and this may have allowed a toads and puddle frogs to inhabit these areas in greater numbers than previously. It is thus probable that much of the original amphibian diversity in the region remains as healthy populations, and this is indicated by the high percentage (>73%) of the amphibian diversity recorded during the survey.

Anecdotal observations by a long-term (30+ years) resident with an interest in reptiles (Tony Leiato, Land Preparation Manager, Illovo; pers. comm. November 2015) indicated some potential declines in large reptiles. Puffadders were considered once very common in the 1990s in the vicinity of the Illovo sugarcane plantations, but have now become much rarer, whilst the Boomslang (*Dispholidus viridis*), Twig Snake (*Thelotornis capensis*) and Swamp Viper (*Proatheris superciliaris*) have not been seen in the region in the last 30 years, although all were recorded earlier (Loveridge, 1953c; Blaylock, 1963; Broadley 2000). Similarly, the Soft-shelled Terrapin (*Cycloderma frenatum*) was observed in the Shire River above Chikwawa 30 years ago, but has not been seen for over 15 years. The general impression in the field during the field surveys was of reduced reptile density and diversity. Certainly, the likelihood of repeating Blaylock's (1963) capture of 163 snakes in 14 days upstream from the floodplain upstream from Chiromo now seem unlikely. No specimens of his two dominant species, the Western Green Snake (*Philothamnus angolensis*, 97 specimens) or Olive Grass Snake (*Psammophis mossambicus*, 31 specimens), were even observed during the current surveys. Many of these snakes, e.g. Boomslang, Twig snake and Spotted Bush Snake, are all arboreal and their current rarity or even absence in the Elephant Marsh, may be linked to their visibility (all are diurnal) and the loss of trees. Chameleons were also not recorded during the surveys and, again, their apparent rarity may be linked to tree loss. It is likely that there is a reduction in snake numbers due to the direct persecution by the high numbers of people now living within the marsh, and indirectly from the extensive habitat destruction and frequent fires.

In summary, it is considered that amphibian diversity and populations numbers still reflect in great part that originally existing in the Elephant Marsh. However, reptiles are considered to show reductions in the numbers, and possibly even local extirpation, of arboreal snakes (Boomslang and Twig Snake), larger terrestrial species (Puffadder), and specialised aquatic species (Zambezi Flap-Shelled Terrapin and Floodplain Viper).

10.8 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 during original baseline. These were included from the MRAG 2016 study, which carried out detailed surveys, findings of which were included in the ESIA recommendations as relevant. . 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..

The ESIA report quotes their observations in remaining chapters as relevant.

11. IMPACT ASSESSMENT METHOD

The ESIA relies on the following method for impact assessment.

Cumulative and induce impacts are dealt with directly in the text (and not in a separate section). This eases understanding of issues at stake especially those related to flow reduction.

11.1 METHOD FOR THE DETERMINATION OF IMPACT SIGNIFICANCE

Impacts significance is assessed using a standardized method based on the integration of 4 criteria:

1. Affected components' value
2. Impact intensity
3. Impact extent
4. Impact duration

In addition, in order to separate risks from actual impacts, the probability of impact occurrence is assessed in all cases

CRITERIA #1 ENVIRONMENTAL AND SOCIAL COMPONENTS VALUE

Each component of the socioeconomic and biophysical environment is analysed according to its value in the study area. Value assessment is based on experts' knowledge on the component, field surveys, public consultations, discussions with NGOs, bibliographical sources, safeguards policies from the World Bank, etc. It is also a mean to put in writing stakeholders opinion about a component and to take them into account.

Value analysis does not take into account foreseen impacts, it is purely based on the component intrinsic value.

Three threshold levels are defined during the assignment: Low, Moderate and High values. A low value component does not represent an important socioeconomic or cultural feature for local communities or it does not have a high ecological value. A high value component is a significant feature for communities; it is either an important livelihood source or an element of cultural significance for communities. A high value component can also possess an important ecological value (rare plant, sensitive habitat, etc.). A high value component is also an element of particular significance for funding agencies (and presented in safeguard policies).

A moderate value is between low and high.

CRITERIA #2 IMPACT INTENSITY

Impact intensity refers to level of disruption on the component. Disruption of natural component refers to death of species, displacement, fragmentation and loss of habitats. Disruption of socioeconomic components refer to loss of income, erosion of traditional ways of life, etc. The resilience of each component to changes is also taken into account.

Three threshold levels of intensities are defined: Low, Medium and High.

A low intensity refers to an impact that will not disturb significantly livelihood and ecological elements and that will not affect the function of the component or its characteristics. High intensity refers to an impact that takes place during a critical phase of biophysical components (breeding period, migration, spawning, etc.) or socioeconomic components (harvest, etc.). It is an impact that affects a component beyond its resilience.

A medium intensity is between low and high.

CRITERIA #3 IMPACT EXTENT

Each impact is defined by its geographical extent. Three levels are established: punctual impact, local impact and regional impact.

Punctual impacts affect a component on a very small scale of the study area, i.e. a small proportion of the study area population (people or wildlife).

Local impacts affect a component on the entire or the majority of the detailed study area in opposition to regional impacts that affect a component on a larger scale and outside the detailed study area boundaries.

CRITERIA #4 IMPACT DURATION

Each impact is described according to its duration. Temporary and permanent impacts are distinguished based on their reversibility: temporary are reversible and permanent are irreversible (or last throughout the Project lifespan).

IMPACT SIGNIFICANCE DETERMINATION

Impact significance is based on the four previous criteria. The following table presents the impact importance determination. Positive impact is assessed using the same four criteria.

Intensity	Extent	Duration	Environmental and Social Component value					
			Positive impact			Negative impact		
			Low	Moderate	High	Low	Moderate	High
High	Regional	Permanent						
		Temporary						
	Local	Permanent						
		Temporary						
	Punctual	Permanent						
		Temporary						
Medium	Regional	Permanent						
		Temporary						
	Local	Permanent						
		Temporary						
	Punctual	Permanent						
		Temporary						
Low	Regional	Permanent						
		Temporary						
	Local	Permanent						
		Temporary						
	Punctual	Permanent						
		Temporary						
Impact significance	Major -	Major +						
	Moderate -	Moderate +						
	Minor -	Minor +						
	Negligible	Negligible						

Major impacts represent high level of perturbation of the component, these impacts are seldom mitigable and most of the times require compensation or Offsets, followed by measurable monitoring measures.

Moderate impacts represent noticeable perturbation of the component, however these impacts can be mitigated and need to be monitored.

Minor impacts, most of the time, only require mitigation measures without the need for monitoring.

Negligible impacts do not require any particular measures.

IMPACT OCCURRENCE PROBABILITY

Assessment of the probability that an impact will take place is based on consultant experience on similar assignments and each expert knowledge. It allows to develop preventive measures for risks and mitigation measures for impacts. Three thresholds are used.

High probability	Analysis of the baseline coupled with Project characteristics concludes that the impact will take place.
Potential occurrence	Based on previous experiences, it is possible that the impact will occur.
Risk (low probability)	Analysis of baseline coupled with Project characteristics only reveals a risk of impact occurrence.

11.2 DESCRIPTION OF IMPACTING ACTIVITIES

The current FS report does not provide much information about the construction of the Project. The following description of impacting activities are based on consultant experience in irrigation schemes and literature review. Quantity of required material, localization of borrow pits and other figures are therefore not provided in this ESIA.

11.2.1 Pre-construction

Pre-construction phase: this phase included all technical studies (including the ESIA and the design) as well as the tender process for the selection of a construction contractor and scheme operator. Decisions that will be taken at this stage are important milestones that could influence the environmental and social soundness of the Project.

Before construction, the command area and right-of-ways have to be planned and the study area will be subject to important changes in term of land ownership. Resettlement is an important impact-generating activity for which Resettlement Action Plans (RAP) shall be written.

11.2.2 Construction

Construction phase: is the construction of the water intake in the reservoir and the Feeder canal, Supini and Bangula canals and Branch canals as well as all other infrastructures.

Water intake, canals and command area construction will require major workforce and machinery deployment, waterworks, earthworks and land leveling, rock blasting, vegetation removal, concrete production and quarrying for material. These are impacting-generating activities.

Rock blasting will be carried out in MWR due to the presence of rock outcrops (granite).

11.2.3 Operation

Operation phase: is the operation of the irrigation scheme through the water intake (irrigation of the command area in the valley)

Operation of the scheme will generate impacts and will require overpassing many challenges. Most impacts during operation will come from the flow reduction in the Shire (due to water abstraction), the presence of a long open canal, and the challenges that people will face due to radical changes in their livelihood strategies. However, the purpose of the Project is to bring positive economic benefits.

Phase I will be separated from Phase II as the former will only be built when Phase I is operational.

11.2.4 Impact assessment of the Natural Resources Management (NRM) component

Activities planned under this component will have minimal or no negative environmental impacts, in fact most activities aim at conservation activities or sustainable use of natural resources. In some cases, minor works under this Project component will have to follow the mitigation measures presented in the ESMP aiming at the construction contractor such as proper delineation of work and best management practices regarding health and safety, waterworks, earthworks, etc. Social impacts involving local livelihoods will be addressed in the forthcoming Process Framework, a separate safeguards report.

11.3 IMPACT ASSESSMENT LIMITATION

This ESIA was written based on the available information at the time, particularly from the Feasibility Study reports. With the completion of the Detailed Design study for the Phase I irrigation new information will become available about the precise location, nature, or scale of SVIP environmental impacts, and this ESIA will be modified accordingly and then again publicly disclosed, including site-specific mitigation measures where relevant captured in the ESMP. Regarding the planned invasive fish barrier on the Main Canal (Section 9.7), the World Bank will contract a Panel of Experts to review in depth the design and specific location of this structure. This is to assess whether the fish barrier will function effectively, with little or no required maintenance over the long term. This expert review will be conducted in parallel with the Detailed Design of the Main Canal, and well before the start of canal construction.

12. PHYSICAL ENVIRONMENT IMPACT ASSESSMENT

12.1 INTRODUCTION

The impact assessment starts with the Physical environment, as most impacts derive from changes to physical components: water, soil, flow, etc.

LIMITATIONS

One important limitation that needs to be further refined by the Detailed Design study is the precise location of areas that may be unsuitable or challenging for irrigation due to their soil properties. This ESIA has located some heavy Vertisols, based on photointerpretation and on field work by the ESIA Soil Specialist. The Feasibility Study consultant has carried out field testing of these heavy Vertisols and concluded that most of them are indeed irrigable with specific management measures. These measures will need to be further specified during Detailed Design. To the extent that certain project-area farm lands are not technically well suited for irrigation, they will be available for other uses such as livestock grazing or planted woodlots. In addition, certain non-irrigated Set-aside Lands will keep the limited remaining areas of natural habitats from being cleared for irrigated agriculture. Impact identification matrix on the physical environment

An impact identification matrix crosses components with phases of the Project to highlight impacts.

Components	Pre-construction	Construction	Operation

Components	Pre-construction	Construction	Operation
Geomorphology of rivers	No impact during pre-construction phase	Impacts from water works: canals and water intake construction will necessitate crossing rivers and will involve water works such as building small dams and weirs, culverts, siphons and installing gabions to stabilize rivers. These will affect the geomorphology and water quality of rivers	Siltation of Elephant marsh: waterbodies, including Elephant marsh, erosion and sedimentation pattern will be modified because of changes to flow Reservoir sedimentation pattern: the water intake will impact reservoir sedimentation pattern
Hydrology			Water abstraction : Up to 50m ³ /s will be extracted from the Shire system at Kapichira reservoir Hydraulic transparency: where a canal crosses a river, if culverts are not adequately designed and installed they can act as dam and flood villages upstream. Flash flood phenomenon can damage hydraulics infrastructure
Water quality		Impacts from water works: canals and water intake construction will necessitate crossing rivers and will involve water works such as building small dams and weirs, culverts, siphons and installing gabions to stabilize rivers. These will affect the geomorphology and water quality of rivers	Water quality impairment : the scheme will impair water quality (including groundwater)

Components	Pre-construction	Construction	Operation
Soil and groundwater		Impacts from earthwork and land leveling : canal construction will necessitate important excavation of earth and rocks and the command area will be levelled	Changes in soil properties and rising water table: irrigated agriculture can lead to several changes in soil properties (salinization, soil sodicity, waterlogging, etc.). Irrigation can rise water table (leading to salinization and waterlogged soil)

12.2 AFFECTED COMPONENT VALUE

The following table shows the value of components.

Component	Component value
Geomorphology of rivers	River geomorphology is a moderately valued component. Most rivers geomorphology are subject to important natural changes due to flash floods and erosion. Siltation of the reservoir is however an important issue
Hydrology	River hydrology is a highly valued component. Communities are directly dependent on river flow and, based on historical records, any change in the past has led to significant economic and social changes
Water quality	Water quality is a moderately valued component as there is not much attention provided to water quality in the study area although it is an important element for aquatic life
Soil & Groundwater	Soil is a highly valued component in the study area as people depend directly on its properties for agriculture

12.3 GEOMORPHOLOGY OF RIVERS

12.3.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction of the scheme, canal and water intake construction will necessitate crossing rivers and will involve water works such as building weirs, culverts, siphons and installing gabions to stabilize rivers. Should these include small dams, the final ESIA will include generic dam safety measures for small earth dams and where applicable adopt the FAO guidelines on small earth dam design. These will affect the geomorphology, hydrology and water quality of rivers. As noted during ESIA preparation through field observation and confirmed by satellite imagery analysis, tributary riverbeds are very mobile: river beds can move of several tens of meters after severe floods.
- During SVIP operation, some relatively minor changes might be expected in sedimentation patterns within the Elephant Marsh due to (i) modestly reduced dry season Shire River flows and (ii) sediment arriving from irrigation drainage canals (although the irrigated farmland will be very flat and not highly erosive). The March 2017 SRBMP Management Report on Climate Resilient Livelihoods and Sustainable Natural Resources Management in the Elephant Marsh concludes that, in recent decades, changing the amount of sediment load in the marsh has had little effect on the delivery of ecosystem services. The Marsh has been remarkably resilient to sedimentation as well as flow changes, having experienced significant fluctuations in both over its recorded history.

- During operation of the scheme, the water intake will change sedimentation pattern in the reservoir (**Reservoir sedimentation pattern**). This change could lead to impact on Escom powerstation water intake.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impacts from water work. During construction, some actions and infrastructures will modify geomorphology of rivers	Siltation of Elephant marsh. During operation of the scheme, erosion and sedimentation pattern will be modified	Reservoir sedimentation pattern. The water intake will change sediment deposition pattern in the reservoir
Value of the affected component	Moderately valued		
Intensity	Low	Low	This impact is the subject of an independent study for the SVIP “Hydraulic Modeling of Intake for the SVIP (Artelia)”. Impact assessment and mitigation will be dealt with in this report.
Extent	Punctual	Local	
Duration	Temporary	Permanent	
Significance	Negligible	Minor	
Occurrence probability	Potential occurrence (as the type of water works in tributary rivers are not known)	High probability	

12.3.2 Mitigation measures

Impacts from water work

The following mitigations are recommended to limit impact on geomorphology of river:

- Any work across a river will have to take its mobility into account to avoid having rivers shifting and no longer flowing through canals. Therefore, design of the river passages shall involve installing gabions or riprap on riverbanks. In addition, it is recommended not to cross a tributary river in a meander but rather where the river is flowing in a straight line.
- When finetuning the command area in the Design phase, it is recommended to avoid developing irrigated fields too close to any river and to take into account river mobility. It is proposed to avoid all areas that are in the 1 in 10 year floods of rivers and to stabilize sharp meanders with gabions and riprap. These important aspects shall be taken into account in the Design study to safeguard rivers from being channelized and crops from floods.

Siltation of Elephant marsh

Two mitigation measures could be implemented to reduce the impact on Elephant marsh. These are related to further targeted work in the catchments and on the Kamuzu Barrage, both under the auspices of the Ministry of Agriculture, Irrigation, and Water Development:

- One is related to the Lower Shire River watershed management, which includes investments by MoAIWD as well as the Forestry Department under the ongoing Shire River Basin Management Project. These investments seek to reduce land degradation and enhance forest cover, thereby reducing erosion and the resulting sediment load within the Shire River and the Elephant Marsh.
- After the ongoing upgrading of the Kamuzu Barrage on the Shire River is completed, it is possible--but not guaranteed--that Barrage operations will be able to release more water during the dry season, thereby incrementally benefiting the Elephant Marsh. Located in Liwonde (well upstream of the entire SVIP project area), the Kamuzu Barrage partially regulates water levels in Lake Malawi, the primary water source for the Shire River and Elephant Marsh. This ESIA discusses the feasibility of releasing more water from Kamuzu barrage in the Hydrology section.

Although average flows will be reduced, there will still be periods of high flow during the rainy season, which will (i) flush out excess sediments from the Elephant Marsh and (ii) help restore the Marsh to its normal full size.

Other mitigations are related to best management practices in the command area such as good maintenance of drains, proper stabilization of dikes and banks, etc. Some of these will be the responsibility of the Bulk Water Operation for the SVIP scheme. It is also expected that the SRBMP will define and implement appropriate conservation measures that will also control soil erosion in the hilly upper and middle catchment areas, particularly along drainage lines and other watercourses. These measures will also help to reduce flooding and waterlogging in the lower Shire Basin. Most importantly for the Elephant Marsh, the SVTP Natural Resources Management Component will serve to improve the protection and management of this major wetland ecosystem, facilitating more sustainable uses by restricting the clearing of marsh areas for cultivation and the potential over-harvesting of a wide range of natural resources.

Reservoir sediment pattern

The Hydraulic Modeling of Intake for the SVIP will, once finalized, provide relevant mitigation measures.

12.4 HYDROLOGY

The flow data presented in this report are based on Chickawawa gauging station only and the data from gauging station in Liwonde were not used.

12.4.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During operation of SVIP, canal capacity will be 50m³/s, and this amount will be extracted from the Shire system at Kapichira reservoir (**Water abstraction**). This is a consumptive demand as this amount will not be released directly back in the system (about half will be released back to drains and to the water table). This will lead to modest environmental impacts on Elephant Marsh and minor impacts on tourism at Kapichira Falls:
 - Although the proposed SVIP represents a significant new consumptive demand in the Shire River, the Escom Hydropower Station has much larger non-consumptive water demands which are 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 flows would be maintained for power generation demands.

- The high demand for the Kapichira Hydropower Stations also gives to rise to issues regarding sharing of water.
- The impact of water abstraction is a transboundary impact since part of the amount that will be withdrawn from the Shire will be lost to Mozambique.
- The presence of a water intake conveying water from the reservoir close to villages will likely create, on the long-term, new expectations and new water demands from people, industries, etc. For example, Chikwawa will receive 1,240 m³ daily through a pipeline for drinking water. Therefore, discussions on water allocation and water rights could become more significant although the maximum capacity of the irrigation system's Main Canal intake is set at 50 m³/s and this will not increase over time.

Hydrology impact assessment can be divided in three:

- Hydrologically negative changes downstream of Escom Powerstation tailrace, which could lead to impacts on the Elephant Marsh;
- Hydrologically positive changes due to the significant reduction of the use of existing pumping stations along Elephant Marsh. This will partially counter-balance the flow reduction in the marsh;
- Hydrologically negative changes below the dam and upstream of the hydropower tailrace, which will lead to dry season flow reductions over the Kapichira Falls, a tourist attraction within the Majete Wildlife Reserve.

Impacts from water abstraction on tourism and the Elephant Marsh are dealt with in separate sections (Section 7.10.1.6 "Impact on Kapichira Falls Attractiveness" and Section 8.6. "Changes in Plant Composition in Elephant Marsh").

The following figure illustrates these three types of impacts.

Figure 58 Hydrological impacts



Impact downstream of Escom tailrace

The water demands for the SVIP and for the Escom power generation (Kapichira I installed capacity: 64.8 MW and Kapichira II, 64.8 MW) are presented in the table below (source: KRC, 2016). The flow reduction downstream of the hydropower tailrace is presented (in percentage terms). When both Phases I and II of SVIP developed, the Shire River flow reduction will be up to 9.4% downstream of the tailrace during a typically normal year and up to 12.4% during especially dry years (considering the net abstraction that reflects the conversion from current pumping to gravity-fed irrigation) (Source data & results: MoAWI Chickwawa Gauging station (1L12), 2017). Kapichira I and II although they borrow large amount of water, are not affecting Elephant Marsh since the hydropower scheme is a run-of-river scheme where all turbinated water is released downstream of the tailrace (non-consumptive demand). Figures show the “without Illovo scenario” since at time of ESIA writing, it was not certain whether Illovo would join or not the SVIP.

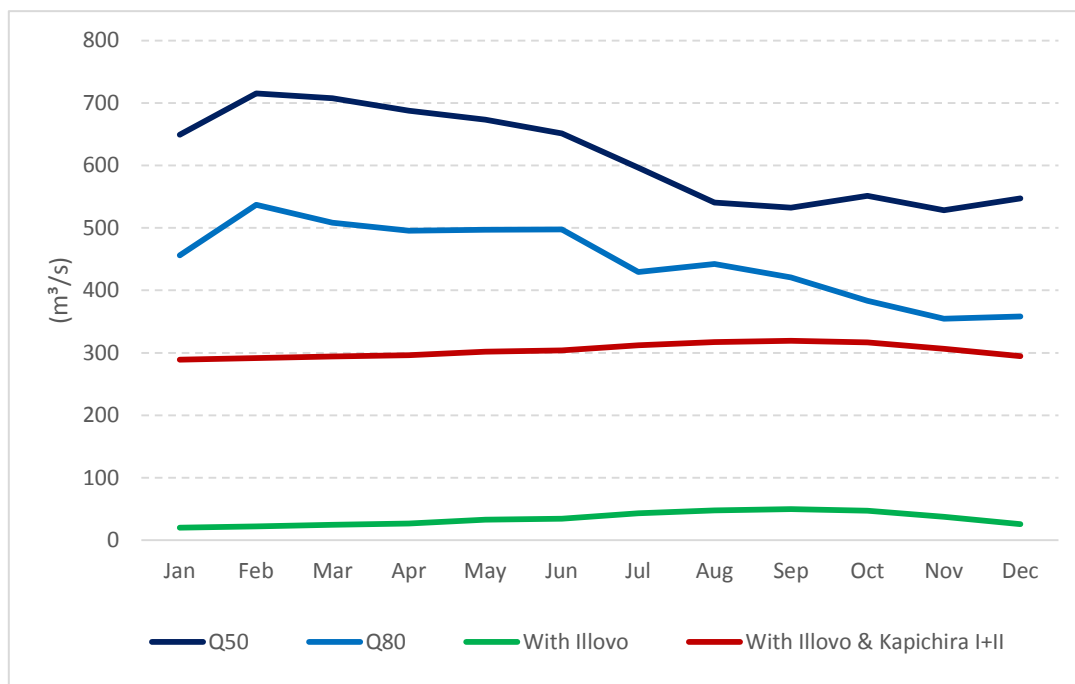
- Table 17 Water Demands for SVIP and Escom at Kapichira Dam

(m ³ /s)	SVIP	% of average flow (Median year)*	% of average flow (dry year)	Escom Kapichira I+II
Jan	20.0	3.1	4.4	269.2
Feb	22.3	3.1	4.2	269.2
Mar	24.8	3.5	4.9	269.2
Apr	26.8	3.9	5.4	269.2
May	32.7	4.8	6.6	269.2
Jun	34.5	5.3	6.9	269.2
Jul	43.1	7.2	10.0	269.2
Aug	47.8	8.8	10.8	269.2
Sep	50.0	9.4	11.9	269.2
Oct	47.4	8.6	12.4	269.2
Nov	37.2	7.0	10.5	269.2
Dec	25.6	4.7	7.2	269.2

Source data & results: MoAWI Chickwawa Gauging station (1L12), 2017

- The Figure below presents the availability of water by showing the 50% (Median Q50) and 80% (Quinquennial dry year Q80%) dependable monthly flows as well as the water requirement for SVIP without or with Illovo and with Kapichira I and II.

Figure 59 Water availability and demand at Kapichira Dam (using same hydrological data from DWR used in TFS)



Source data & results: MoAWI Chickwawa Gauging station (1L12), 2017

The previous graph shows that:

- The water supply exceeds largely the irrigation requirement for SVIP without or with Illovo when taken alone.

In addition to prevision on impact, the risk of having illegal motor pumps along the stretch of the feeder canal will create additional small consumptive demands and could affect tail enders. Illegal water connections by communities have to be given consideration, as it has been known to lead to closure of canals as shown by this example from Namibia.

Namibia Water Corporation (NamWater)...came under scathing criticism earlier this week from traditional leaders and farmers in Omusati, angered by the water utility's plan to close the Calueque-Oshakati canal. ... the proposed closure of the canal was necessitated by the high costs that come with the maintenance of the water canal, illegal water connections by community members and the apparently loss of human lives due to drowning in the canal (New Era newspaper, 2015)

Partial closure of existing pumping stations along Elephant marsh

The FS report mentions that existing pumping station could be operated when drought is expected (around once every 5 years). Occasional use of the existing pumping stations (by opposition to constant use) will reduce the effect of hydrological impact on Elephant marsh since water that will be brought by irrigation will no longer be pumped. Most stations utilization, except for Kaombe, could be reduced significantly during Phase I (sugar cane fields irrigated by Kaombe pumping station are concerned by Phase II). According to the FS report, the total amount of water pumped per average year is 9 m³/s. During the wettest months, pumps are taking 6m³/s and during the driest months, pumps are taking 13 m³/s.

The “positive” impact from partial closure of pumps is small but noticeable. It represents 30% to 25% of the flow in comparison to the 20.5 to 51.3 m³/s that will be withdrawn from the Shire system.

Impact below the dam and upstream of the hydropower tailrace: impact on Kapichira falls

This area is the most severely impacted area hydrologically. Since the scheme has been designed to optimize resource utilization with 80% assurance of supply in the critical months of September and October it is likely that flow over the falls will be very low in those months. Good records are missing for flows over the spillway, but in dry years with low lake levels (such as e.g. 2015) the flow over the falls has been known to be so low as to render the falls invisible in the dry season. It is clear from the data that the factor influencing the most the fate of the falls is the operation of the reservoir for hydropower (Kapichira I+II). As is shown in figure 8 the water availability is mainly an issue in the dry season as during the rainy season the flows are much less affected when flows in the Shire are higher and irrigation demands significantly lower. SVIP will therefore likely lead to a significant increase in the number of months per year with low flows over Kapichira Falls, the number of months being strongly dependent on reservoir management decision and future flow releases at Kamuzu Barrage.

The importance of this change is limited because:

--From a visual standpoint, the Kapichira Falls are already compromised by the view of the Kapichira Dam wall at the crest of the Falls;

--While an attractive sight overall, the Kapichira Falls are not considered to drive tourist visitation to the Majete Wildlife Reserve, which attracts tourists mainly because of its wildlife, overall scenery, and good visitor facilities. This finding was reinforced during discussions with Majete Reserve managers.

--Unlike some waterfalls with a high vertical drop, the Kapichira Falls have a gentler slope and do not have any unique “spray ecosystem” zone with distinctive plants or other species in the vicinity of the falls. A seasonal reduction in flows over the falls will therefore not significantly affect the local biodiversity.

--The tailrace of the HEP is immediately downstream of the falls where the Shire cuts a deep gorge and there will always be water at the toe of the falls. The impact is therefore limited to the area where the water cascades down rocks and boulders until it reaches the Shire. The spatial extent of this impact is therefore very limited and over a harsh section with variable flows in the baseline situation.

Table 18 Number of months when the flow is (will be) lower than 20m³/s

Nb Months	Kapichira I+II (current situation)	Kapichira I+II & SVIP without Illovo	Kapichira I+II & SVIP with Illovo
2013	0.4	6.5	7.6
2014	0.0	9.8	9.9
2015	2.4	10.1	10.2
<u>Mean</u>	<u>0.9</u>	<u>8.8</u>	<u>9.2</u>
<u>Min</u>	<u>0.0</u>	<u>6.5</u>	<u>7.6</u>
<u>Max</u>	<u>2.4</u>	<u>10.1</u>	<u>10.2</u>

Table 19 Number of months when the flow is (will be) lower than 10m³/s

Nb Months	Kapichira I+II (current situation)	Kapichira I+II & SVIP without Illovo	Kapichira I+II & SVIP with Illovo
2013	0.4	5.8	6.6
2014	0.0	9.2	9.5
2015	1.5	10.0	10.1
<u>Mean</u>	<u>0.6</u>	<u>8.4</u>	<u>8.7</u>
<u>Min</u>	<u>0.0</u>	<u>5.8</u>	<u>6.6</u>
<u>Max</u>	<u>1.5</u>	<u>10.0</u>	<u>10.1</u>

- During operation of the scheme, where canals or new farm roads cross a river, if ever culverts are not adequately designed, they can act as dam and flood villages upstream. Careful design of canals also has to take into account flash flood phenomenon that can damage the hydraulic infrastructures (**Hydraulic transparency**). All tributary rivers are reactive and have small watershed (except Mwanza and Ruu) originating in hilly areas, flowing through the plain and then to the Elephant Marsh where Shire flows. Flash floods in these rivers lead to sudden increase of water level, with high bedload transport capacity, especially right bank rivers where topography is more pronounced. When these rivers reach the plain, their currents become weaker and sediment deposit are finer, ultimately silt plumes reach the Elephant Marsh. Erosion on hill slopes increases the phenomenon. In the plain, these tributary rivers can easily flood villages due to diffuse river beds. In addition, tributary river beds are mobile, within a few years, river bed can move of several tens of meters.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Water abstraction. Up to 50m ³ /s will be extracted from the Shire system	Hydraulic transparency. When crossing the canal tributary rivers can flood upstream village if culverts are not properly sized
Value of the affected component	Highly valued	
Intensity	Medium	Low
Extent	Regional	Punctual
Duration	Permanent	Temporary

Significance	Major (and cumulative)	Minor
Occurrence probability	High probability	Potential occurrence

12.4.2 Mitigation measures

Water abstraction

In the future, it might be feasible to mitigate the impacts from reduced flows to the Elephant Marsh (and in the Shire River generally below the planned irrigation intake) by releasing more water from the Kamuzu Barrage. However, this cannot be guaranteed at this time, it will depend upon (i) Lake Malawi water levels, which naturally fluctuate over time and (ii) the Kamuzu Barrage Operating Rules, which will be developed and refined in due course by Malawi's recently-established Shire River Basin Authority.

One potential risk is having illegal pumping taking place along the western part of the canal, where no SVIP irrigation is planned (because pumping would be required). Illegal pumping using motor pumps will need to be addressed or regulated by the SVIP Bulk Water Operator to ensure that it does not significantly reduce the water available to the planned SVIP irrigation areas. In any case, since SVIP abstraction from the Shire River will be strictly limited to 50 m³/s by the size of the Main Canal intake, any unauthorized water abstraction from the canal will be an SVIP management problem but not really an environmental problem, since no additional water will be taken from the Shire River or lost to the Elephant Marsh.

For project planning purposes, it is therefore presumed that, at full SVIP development, the flows available to the Elephant Marsh will be reduced by a maximum of 32 m³/s, which represents the maximum gross abstraction of 50 m³/s at the Main Canal intake minus the 18 m³/s currently pumped from the Shire River (mainly by Illovo Sugar) that SVIP would replace. For Phase I of SVIP development, the maximum net abstraction would be only 12 m³/s. This translates to a net abstraction at full SVIP development of not more than about 10 percent of the Shire River's flow during September, the dry season month of peak irrigation water demand.

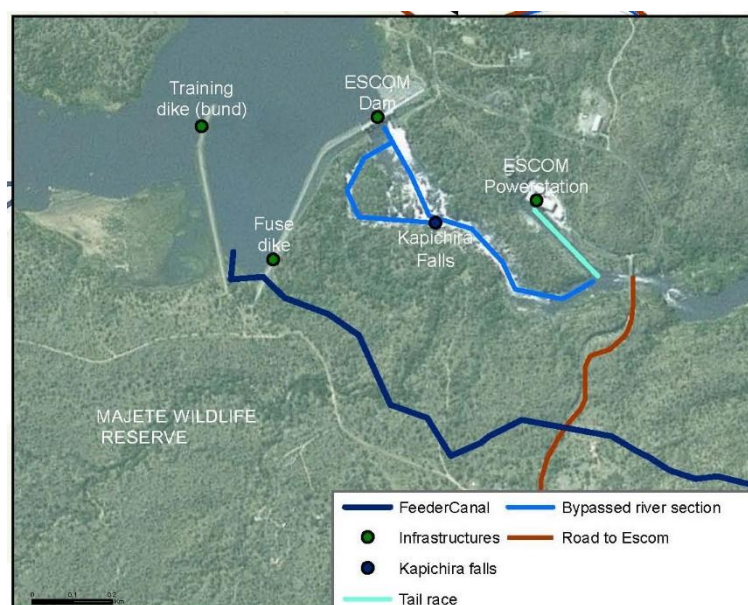
As modeled in the hydromorphological study on the Elephant Marsh (MRAG, 2016), the impacts on Elephant Marsh of water abstraction are expected to be moderate. Based on a 33-year horizon analysis of the potential effects of alternative future scenarios of flow and/or management on the ecological condition of the Elephant Marsh, using a pre-2015 morphological template and taking into account the cumulative impacts of future basin development including SVIP, the conclusions are that:

- The Marsh is fairly resilient to short-term flow and sediment changes, having experienced significant fluctuations of both in its history.
- Development and climate change in the short term do not represent a significant threat to the long-term integrity and sustainability of the Elephant Marsh, but may represent a threat in the longer term if overlain on dry periods such as those known to have occurred in the past.
- The most immediate and significant threat to the integrity and sustainability of the Elephant Marshes is pressure from subsistence users, including the clearing of marsh vegetation for flood-recession agriculture and over-harvesting of fish and other natural resources. The MRAG report recommends improved management practices within the Elephant Marsh, many of which will be supported under the SVTP Natural Resources Management Component.

Regarding the Kapichira Falls, the current flow over the falls is controlled by Egenco by opening the sluice gates of the Kapichira Dam on the Shire River (ATKINS, 2011 and NORPLAN, 2013). In effect, there currently appears to be no formal requirement for an environmental flow discharge at the sluice gates. The actual dry season flow over the falls is usually around 30m³/s but during lower water conditions (such as in the 2016 drought), there is little or no flow now over the falls. The by-passed river section at the dam toe until the toe of the water falls is 900 meters long. After 900 m, the tailrace from the hydropower station releases all flow, restoring the original flow of the Shire River since Kapichira is a run-of-river hydropower facility (what comes in goes out quickly). It is in this by-passed section that provides an attractive view for tourists at the Majete Wildlife Reserve when water flows over the falls are high (particularly during the wet season). Historically, the falls have seen great variation in flows, particularly in the early 20th century when lake levels were low and did not sustain Shire flows. In terms of mitigating such large fluctuations, Kamuzu Barrage was constructed and is currently being upgraded and an improved Shire Basin Plan and Operational Decision Support system (ODSS) is being installed for use by the MoAIWD, the Shire Basin Agency and EGENCO (former ESCOM). It will improve better data driven operations of Kamuzu Barrage and downstream infrastructure and over time improve efficiency of operations, within the overall allocations set for different sectors within sustainable limits under the Shire Basin Plan, in which the allocation at Kapichira has been modeled for the critical months of September and October. In the rainy season irrigation demands drop significantly, to 20 m³/s for the month of January (for SVIP I and II combined) while flows in the river are higher, resulting in a Q80 flow over the falls of over 200 m³/s for most of the season.

The Project will support the development of operational rules for Kapichira Reservoir between EGENCO and the scheme operator under MoAIWD, based on monitoring during project duration. To inform the operating rules, the project will support monitoring of the actual flows over the fall during SVTP-I before canal operation starts, under the auspices of both EGENCO and MoAIWD to have better reference of the flow situation over the falls in the wet and dry season as well as localized biodiversity, and to include consideration for safeguarding minimum environmental releases as determined necessary over the spillway for adoption when operation commences for Phase I, to be updated in SVTP-II prior to construction of Phase II.

Figure 60 By passed river section



Regarding the transboundary impacts of SVIP, the Shire River in Malawi is part of the Zambezi basin which is under the oversight of the Zambezi Commission. The Commission has been contacted through a Riparian Notification Letter to the governments of all the other Zambezi River Basin countries (Mozambique, Tanzania, Angola, Botswana, Namibia, Zambia, and Zimbabwe).

Hydraulic transparency

The estimates of the frequency peak flows for the sub-basins of right-bank tributaries intersecting the SVIP canals are given in the table below (calculations based on the flood frequency relationship established by Mkhanda & Kachroo, 1998). Based on these data, culverts and under passages have to be carefully designed and super-sized to allow dry passage of wildlife, the Q100 shall be taken into account to size box culverts and culverts. Another rationale to make large culverts is that larger culverts are less likely to result in flooding of the main irrigation canals; such flooding can lead to the entry of Lower Shire/Zambezi fish species into the canal system, posing an invasive species risk for Lake Malawi. In addition, tributaries that are crossed by the primary canal have to be stabilized with gabion or rip rap and the primary canal shall always cross a river perpendicularly and in a place where the river is flowing in a straight line (to reduce the impact of river mobility). The Design study shall take this measure into account.

Figure 61 Peak flow of right bank Shire tributaries

Tributary rivers name	Catchment Area at SVIP Canal (km ²)	Peak Flow (m ³ /s)				
		Q2	Q10	Q20	Q50	Q100
Mwambezi	160	41	111	138	171	195
Masakale	102	34	91	113	140	160
Nthumba	70	29	77	96	119	136
Mwanza	1621	112	304	377	467	535
Nkombedzi Wa Fodya	418	62	168	209	259	297
Namitalala	65	28	75	93	116	132
Phwadzi	219	47	127	158	196	224
Namikalango	140	39	105	130	161	184
Nyakamba	78	30	81	101	125	143
Mikombo	47	24	65	81	100	114
Mafume	61	27	73	90	112	128
Lalanje	77	30	81	100	124	142

12.5 WATER QUALITY

12.5.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction of the scheme, canal and water intake construction will necessitate crossing rivers and will involve water works such as building small dams and weirs, culverts, siphons and installing gabions to stabilize rivers. These will affect the geomorphology and water quality of rivers (**Impacts from water works**). In addition, concrete wash water can seriously pollute water by increasing its pH. Water works could increase turbidity, especially during construction of the water intake in the reservoir. There is a risk of oil spill from refueling of machinery and storage of fuel barrel. The following picture shows an example of inadequate oil storage taking place when machinery is working in river.

Figure 62 Poor oil management



Source: BRLi, 2015

- During operation of the scheme, drainage from irrigated fields will impair water quality (including groundwater) (**Water quality impairment**). Drainage will transport pesticides, fertilizers and silt. The chain of consequences will be long, as these pollutants will impact aquatic life in many ways:
 - Pesticides are known to induce mutation in herpetofauna and fish species and affect the food chain up to piscivorous birds and fishes;
 - Fertilizers are known to induce eutrophication and changes in plant communities especially when flow is low. This could worsen invasive plant colonization of Elephant marsh;
 - Silt are known to transport pollutants (as they cling on silt) and to impact fish by smothering eggs and affecting gills of many species (impacts on fish are discussed in a separate section).

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impacts from water works. Construction activities will bring silt and other pollutants to rivers	Water quality impairment. Drainage in watercourses will impair water quality
Value of the affected component	Moderately valued	
Intensity	Low	Medium
Extent	Punctual	Local
Duration	Temporary	Permanent
Significance	Negligible	Moderate
Occurrence probability	Potential occurrence (as the type of water works in tributary rivers are not known)	High probability

12.5.2 Mitigation measures

IMPACTS FROM WATER WORKS

Several mitigations are possible to limit impact from water works on water quality, they apply to the construction contractor:

- Work close to tributary rivers shall be carried out during the dry season when rivers are dry
- Best management practices shall be implemented for water work, such as :
 - Mandatory use of silt floating fences in the reservoir when building the water intake;
 - Mandatory use of silt fences when working close to rivers;
 - Refueling activities away from any waterbody (at least 100 m);
 - No evacuation of concrete wash water in waterbodies;
 - Emergency spills containment kit in all vehicles and machinery.
- Request in tender documents that companies develop a method for environmentally friendly water work (reservoir and river) and spill containment. Selection criteria shall include a scoring system for the water work method.

WATER QUALITY IMPAIRMENT

Several mitigations are possible to limit impact from drainage:

- Since the command area will remain at a certain distance from the marsh (to avoid floods), several settling pond could be designed to allow silt and attached pollutants to settle in ponds rather than reaching the marsh. However, this would also reduce the amount of water that returns back to the marsh and these ponds would be washed away during floods. This mitigation is therefore not recommended.
- The Integrated Pest Management Plan has developed measures to ensure that only authorized pesticides are used.
- Measures presented in section 6.4. to limit erosion will also bring benefits to water quality.

12.6 SOIL & GROUNDWATER

12.6.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction of the scheme, canal construction will necessitate important excavation of earth and the command area will be levelled (**Impacts from earthwork and land leveling**). Based on the current feasibility study (KRC, 2016), earth work for the canal is as follow (for an lined canal, estimated based on information provided from the Feasibility study):
 - Feeder canal excavation for the canal bed: +/- 1 Mm³
 - Feedar canal backfilling for embankment: +/- 1 Mm³
 - Supini canal excavation for the canal bed: +/- 0.2 Mm³
 - Supini canal backfilling for embankment: +/- 0.2 Mm³

-
- Bangula canal excavation for the canal bed: +/- 0.8 Mm³
 - Bangula canal backfilling for embankment: +/- 0.8 Mm³
 - Excavated material may not always be suitable for backfilling material, therefore there will be needs for space to deposit spoil material and to exploit borrow pits. Opening of borrow pits and quarry will lead to numerous risks on safety of local population (see section 7.7) and possibly on habitats (see section 8.5).
 - Irrigated agriculture can lead to several changes in soil properties. Salinization, soil sodicity, waterlogging, loss of soil are common risk under gravity irrigation (**Changes in soil properties and rising water table**). In addition, there is a risk associated with the presence of poorly drained Vertisols in Zone B and C (heavy Vertisols).
 - Salinisation and Alkalinisation: soils with a high risk of further salinisation or alkalinisation need special attention. However, available analytical data sets indicate that such areas are limited in size and can be sustainably managed with good management. Salinity levels in the project area are generally low and if levels should go up, soils can be easily flushed with excess drainage water. Alkalinity is in fact a more serious problem but occurrence of alkalinity at any serious scale is not indicated by available analytical data. Impact of the Project on soil salinisation is not expected as the Project is supposed to ensure good management levels.
 - Soil erosion: with respect to a possible increase of erosion in irrigated land, the Project is not expected to cause an increase of runoff, flooding and erosion as most land is currently already under cultivation, in a rather flat area and because it is anticipated that Project infrastructure and conservation measures will further control erosion. The great majority of land included in the Project is already used as rainfed arable land and this land will only change to another agricultural use, namely irrigated land. In fact, the project will improve the quality of land wherever possible in order to construct economically sized land parcels.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impacts from earthwork and land leveling. Construction of the canal system will lead to important earth movement	Changes in soil properties and rising water table. Several changes in soil properties could take place in the command area
Value of the affected component	Highly valued	
Intensity	High	Medium
Extent	Local	Punctual
Duration	Temporary	Permanent
Significance	Moderate	Minor
Occurrence probability	High probability	Risk (low probability)

12.6.2 Mitigation measures

IMPACTS FROM EARTHWORK AND LAND LEVELING

Several measures can be implemented during construction, they apply to the construction contractor:

- Some spoils from excavation could be used as soils for agriculture, soils could be given back to communities to level land or spread in the command area. Soil cannot be sold by the contractor to surrounding communities;
- No spoils can be stored even temporarily close to waterbodies including Elephant marsh or parks;
- Unusable spoils shall not be left in mounds but shall be flattened at the end of construction and revegetated;
- Borrow pits shall have gentle slopes to minimize the risk of injuries and death;
- Borrow pits and quarries location shall be done in consultation of local authorities to minimize impacts on land users;
- Borrow pits and quarries shall not be left unrestored at the end of work (unless requested by local authorities) and shall be filled with unusable soil to reduce their depth or shall be transformed into wetlands or livestock drinking ponds where appropriate;

Figure 63 Borrow pit with dangerous steep slopes (left) and typical impact from blasting (right)



Source: BRLi, 2015

Suitable borrow pits to be transformed into wetlands are those that are impermeable and filled with water even during the dry season. The following pictures shows a borrow pit where slopes could be transformed and native plant could be planted. Ideally, the wetland creates different habitats with different depth of water and limits the access to cattle.

Figure 64 Suitable borrow pit for the creation of a wetland



Source: BRLi, 2017

CHANGES IN SOIL PROPERTIES

Monitoring of soil properties is highly recommended. Soil water levels and salinity will require very close monitoring to provide early warning of problems. It is recommended to follow typical parameters that help detect acidity or alkalinity of the soil such as pH, Cation exchange capacity (CEC), Magnesium (Mg^{2+}), Calcium (Ca^{2+}), Organic matter (OM), Organic carbon (OC) and Exchangeable Sodium Percentage (ESP).

Areas rated as non-suitable for irrigation within the Project area can be evaluated for other land uses, such as infrastructures but also for settlement, amenities, grazing, set aside conservation land and forestry. It is expected that, after the land evaluation exercise of the FS or the Design study, such unsuitable areas have been identified and mapped with a definition of their characteristics. Future uses should be determined in land use plans at design phase, in which community preferences, e.g. as for forestry and woodlots can be reflected.

The planning of multi-purpose areas has also to be incorporated in overall land use planning, both inside and outside the Project area. However, it is presently not yet possible to precisely map these areas since the FS has not identified non-suitable areas. This ESIA has identified some lands that could be designated as set aside lands. They are described in a section hereunder.

Encompassing land with serious limitations or risks, such as very poorly drained areas with severe risk of flooding, will also have certain limitations for other uses. Future use of such land will have to be carefully planned for. Sustainable land use planning may help to establish a balance between all intended land uses, including large-scale agro-industry, small-scale irrigation, settlement, forestry and nature conservation.

For poorly drained Vertisols, rice could be included as a crop, for which use the current Project areas of Zone B and C could even be slightly enlarged, extended down slope or sideways. The use of rice with associated irrigation infrastructure and constructions will also help to control current severe erosion by flooding (sheet and gully erosion).

13. IMPACT ON SOCIOECONOMIC, CULTURAL AND NATURAL HERITAGE

13.1 INTRODUCTION

This section focuses on two elements: cultural heritage and natural heritage impact and mitigation. Natural heritage refers to the two parks: Majete Wildlife Reserve (MWR) and Lengwe National Parks (LNP). Natural heritage impact assessment deals with all impacts on these parks that are not related to biodiversity such as impact on tourism, infrastructures and landscape. Impacts on biodiversity are studied in the last two chapters of this report. Other socioeconomic impacts are presented and assessed and some mitigations are provided. However, to avoid repetition with the Communications, Community Participation, Land Tenure and Resettlement Policy Framework study, many references are made to this study.

13.2 IMPACT IDENTIFICATION MATRIX ON SOCIOECONOMIC, CULTURAL AND NATURAL HERITAGE

Components	Pre-construction	Construction	Operation
Settlement, community organization and land tenure	Village reorganization and resettlement: the project will lead to major changes in terms of land occupation and will necessitate physical and economic displacement	Workers influx: the project will require important workforce consisting of foreign workers. Land will also be required for machinery storage and workers camps. There is a risk that buildings and amenities do not respect quality standards	Rapid social changes: there is a risk that people do not change their lifestyle and develop skills rapidly enough to adapt to the new irrigated environment Hinterland effect: the development of irrigation may be associated with an increase in human activity and local economy, which may lead to additional pressure on resources (wood for charcoal, fish, etc.)
Infrastructures		Permanent loss of buildings and other infrastructures: canals could necessitate destroying buildings and other infrastructures Disruption of access : canals will cross roads, trails, path disrupting access for communities and cattle to grazing sites or to urban centers	Inadequate maintenance of canals and infrastructures: there is a risk that the irrigation system is not adequately and regularly maintained
Economics		Disturbance to existing agriculture: work will disturb cropping practices since some households will control physically	Potential delays in irrigated agriculture development: any delays in the project completion or skills acquisition could delay the

Components	Pre-construction	Construction	Operation
		different areas of land Job opportunities: work will require unskilled and skilled labour for construction	benefits Over supply of crops: increase in production could reduce prices and affect rain fed producers Benefits of irrigated agriculture: the project overall goal is to benefit local communities Reduction of fisheries: with less water in Elephant marsh, fishery could be impacted Impacts on livestock rearing: the Project will require adaptation of this livelihood strategy
Health and safety		Construction risk and nuisances: communities and workers are at risk from important works along canals and quarries	Bilharzias: the Project will lead to an increase of bilharzia in the command area Drownings: the presence of primary canals may lead to drownings
Gender aspect			Increase workload for women: with increasing yield, the project may add to the workload of women Improved access to water: with the presence of canals, women will travel shorter distance to fetch for domestic water (<u>although canals are not intended to provide safe drinking</u>

Components	Pre-construction	Construction	Operation
			water) Risk of unfair distribution of benefits: access to financial services is a strong barrier to women and youth empowerment
Vulnerable people			Impacts on vulnerable people: landless people could be disadvantaged by the Project and land distribution
Cultural heritage		Loss of physical cultural heritage: the canal alignment route and borrow pits will affect some known and unknown cultural heritage sites (mainly pottery)	
Natural heritage	Decision on the type of canal and its alignment: decisions regarding the canal layout during the design stage will have long term impacts on parks Decision on the status of canals inside parks: the presence of canals inside parks will require a clear definition of their status Tender process and selection of a construction contractor: the tender process for the selection of the Project construction contractor represent a high risk for parks as it is	Impact on tourism: construction activities in MWR and LNP and close to Ng'ona lodge will have deleterious impacts on tourism Impact on Majete buildings, roads and infrastructures : Malaria research camp, Heritage center, Entrance gate, Wildlife research camp, Community camp site, electric fences, access road to the park, access to Kapichira falls viewing site will all be disturbed by construction of the Feeder canal Impact on Lengwe roads and	Loss of ownership of park management on the western side of LNP: with the canal severing the park in two and the weak presence of rangers in the western part of the park, management may lose "ownership" of the western part of the park Impact on Kapichira falls attractiveness : the viability of the falls as a sight to see for tourists may be compromised on long term with reduced flows The presence of canals inside

Components	Pre-construction	Construction	Operation
	a crucial step in the development of binding environmental measures	infrastructures: the fence and park roads will be impacted	parks will be long-term agent of changes: the presence of canals and other infrastructures inside parks will require additional efforts and inputs from park management in order to maintain parks' integrity. Canals may become agents of negative changes in parks as their management will have to deal with a new stakeholder (the scheme operator), whose decision and actions may negatively impact parks. In LNP, the maintenance road along the canal may be used by communities as "travel path" as it is the case with an existing road inside the park

13.3 AFFECTED COMPONENT VALUE

Component	Component value
Settlement, community organization and land tenure	This component, as most socioeconomic components, is highly valued since it relates to important topics for communities, stakeholders and funding agencies
Infrastructures	Infrastructures are moderately valued components. Outside of the Kapichira dam, the study area does not have buildings nor any construction of high interest.
Economics	These components, as most socioeconomic components, are highly valued since they relate to important topics for communities, stakeholders and funding agencies
Gender aspect	
Vulnerable people	
Health and safety	
Cultural heritage	
Natural heritage	

13.4 SETTLEMENT, COMMUNITY ORGANIZATION AND LAND TENURE

Most impacts on these topics are addressed in the study called “Preparation and implementation of a Communications, Community Participation, Land Tenure and Resettlement Policy Framework (CCPLTRPF, COWI, 2016)” and its various components: Communication strategy, Gender and youth strategy study, Grievance redress mechanism, Resettlement Policy Framework, Stakeholders’ views report.

This ESIA does not repeat the impact assessment and the proposed mitigation on gender and vulnerable people, land tenure and resettlement carried out by COWI.

13.4.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During pre-construction, the project will lead to major changes in terms of land occupation and will necessitate physical and economic displacement including acquisition of land for the canal and other infrastructures. According to COWI (2016), economic and/or physical resettlement will concern for Phase I 21,000 households and for Phase II 27,367 households (**Village reorganization and resettlement**). However, only 10 settlements will be directly impacted by the canal alignment and will have to be physically resettled. During construction, some lands will also be temporarily be required. The experience with Illovo and land acquisition is still, 50 years later, in people’s mind and local communities are suspicious of the government and SVIP trying to alienate customary lands. Construction will also disrupt existing access patterns.

- During construction, the Project will necessitate important workforce consisting of foreign workers. Land will be required for machinery storage and workers camps. There is also a risk that buildings and amenities do not respect quality standards (**Workers influx**). Worker influx from other regions in Malawi and from Mozambique can also lead to impacts and conflicts with local communities because of settlement, development of shanty towns, employment, sexual transmitted disease, and disrespectful behavior toward women. In addition, both Mwabvi Wildlife Reserve and LNP are at risk by people migrating to the command area and using them as sources of wood to build new houses. The same risk could come from the important resettlement activities that will take place and the need for new building material for resettled communities. Mwabvi is not surrounded by the irrigation scheme but only at 3 km from Phase II Zone D. The Matandwe Forest Reserve, close to Mwabvi Wildlife Reserve, suffers from logging and gardens from surrounding forest dependent communities. It is also at risk also from increase logging for building material because of its lack of official management (it is actually managed by Traditional Authorities). Mwabvi is accessible by road while the forest reserve is only accessible by trails. The two small reserve: Nyasa and Nyala wildlife reserve are privately owned and are not at risk.
- During operation of the scheme, there is a risk that farmers do not change their lifestyle and develop skills rapidly enough to adapt to the new environment (**Rapid social changes**). The entire agricultural system including its livestock components will be forced to make dramatic adjustments. These changes may overwhelm local coping mechanisms and may generate social resistance.
- During operation of the scheme, the development of irrigation may be associated with an increase in human activity and local economy, which may lead to additional pressure on resources (wood for charcoal, fish, etc.) and land (**Hinterland effect**).

ASSESSMENT OF IMPACT SIGNIFICANCE

	Village reorganization and resettlement. Major changes are foreseen in terms of land occupation	Workers influx. Land will be necessary and there is a risk that infrastructures do not respect quality standards. Influx could be associated with social impacts	Rapid social changes. There is a risk that people do not change their lifestyle and develop skills	Hinterland effect. Increase in human activity and local economy may lead to additional pressure on resources (wood for charcoal, fish, etc.) and land
Value of the affected component	Highly valued			
Intensity	High	Medium	Medium	Medium
Extent	Local	Punctual	Local	Local
Duration	Permanent	Permanent	Temporary	Permanent
Significance	Major	Moderate	Minor	Moderate
Occurrence probability	High probability	Potential occurrence	Risk (low probability)	High probability

13.4.2 Mitigation measures

VILLAGE REORGANIZATION AND RESETTLEMENT

The current CCPLTRPF assignment aims at collecting people grievances and communicate about the Project. The Communication strategy report provides a tool to ensure social acceptability of the Project.

Regarding resettlement, with current knowledge, some avoidance measures were proposed by COWI at the Resettlement Policy Framework stage, the complete set of measures will be developed in the Resettlement Action Plan (RAP) which is still to be produced once the Design study will start.

The Resettlement Policy Framework includes a method for valuation for compensation of agricultural produces, forest and fruit trees.

WORKERS INFLUX

Recruitment policies

Recruitment policies will need to consider social issues and project acceptability. Considering the high local impact of the Project in terms of land and disruption of existing lifestyles, it is recommended to maximise local employment. Local benefits would be maximised and some of the negative impacts of construction mitigated if residents, especially the most severely project-affected people (PAPs), are given priority for recruitment. This will require:

- That the tender document for the construction contractor specifies that a method for local employment shall be developed by bidding firms. This method shall involve consultation of Traditional Authorities (TAs) with the list of required non-qualified work force. The need to have women and youth employment was also highlighted in the Gender and Youth Strategy (COWI, 2016). In addition, in the area, there are local capabilities thanks to past experiences with Illovo schemes. Ideally people would get employed in the vicinity of their homes and some transport arrangement would be provided when feasible.
- Social preparation and the incorporation of eligibility for priority in employment into the RAP Entitlement Matrix, together with an official mechanism for providing names to the construction contractor and for follow-up to track the numbers of PAPs employed.
- The inclusion of appropriate wording in the construction contract.

Land occupation

LNP shall be aware of the risk of workers influx and encroachment and increase logging activities in the park as some its western parts are already occupied by settlements, this risk also applies for Mwabvi Wildlife Reserve and the Matandwe Forest Reserve. These reserves are located outside the Project area but close enough to be affected by population influx and associated need for building material (wood) and land (3 km from Phase II Zone D). There is a risk of increase land occupation in Elephant marsh as well. To mitigate impact, additional rangers provided by the DNPW shall be present in Mwabvi during the construction phase, the DNPW shall be aware of the risk in order to take the precautionary measures. Funding could be provided once Phase II is implemented to hire additional rangers in Mwabvi and to patrol the area to keep illegal loggers away from the Matandwe Forest Reserve.

Avoiding the creation of shantytowns from people attracted to the site to find work is difficult when local enforcement are limited in number. Local law enforcement have to be aware of the risk and shall be ready to answer any complaints about illegal settlement and collaborate with traditional authorities on a regular basis to rapidly take action.

Workers code of conduct

The project developer and construction contractors will be expected, in advance of any construction work, to promulgate this code of conduct for workers (and related visitors), including local workers, workers from other region or countries, and expats. Induction training shall include a cultural induction, delivered with the help of Traditional Authorities.

The following is the code of conduct, it shall be taught during the induction training:

- Prior to entering a village for the first time, the village headman shall be met for the construction contractor to show his respect and present works and activities and to describe the safety risk.
- No alcohol or any form of drugs shall be consumed in the communities by any project employees. The contractor/developer should have and enforce an alcohol and drug-free policy (in the work place and while driving vehicles and machinery).
- Workers and visitors should not make any disrespectful gestures or use any swearing words to anyone either in the community, or along the access road.
- No unlicensed person shall drive work vehicles. Drivers shall be tested prior to starting work on the project, and have a valid license. International workers shall be responsible to provide a translation into English of their driver license.
- Construction company vehicles or trucks shall not be permitted to pick up anyone who is not an employee of the Project, except in case of an emergency.
- Heavy machinery shall only be operated by those who have the license and proven skills to use those types of machines. This shall be embedded in the recruitment and other policies of the contractor. International workers shall be responsible to provide a translation into English of their machinery license. This will help avoid health and safety problems.
- Workers and visitors shall drive slowly when passing villages that are very close to the access roadside or pedestrians walking along the side of the road.
- Drivers and passengers shall watch out for domestic animals, cattle or people crossing the access road. In case of collision with an animal, full compensation shall be paid in consultation with the village headman.
- Workers who will engage in prostitution, sexual harassment and poaching shall be fired and brought to the police for legal prosecution.
- Induction training about sexual harassment shall be given to all workers. During these induction trainings, the police law enforcement shall be present to explain the national laws that make sexual harassment and gender-based violence a punishable offence.
- It is forbidden for all workers to purchase bush meat, any animal parts, any living animals or any mineral (gold, stones). It is forbidden to fish, hunt, capture wildlife, free-roaming pets, engage in trading activities in or outside the Project area. Any worker engaged in such activities shall be laid off.

Sexually transmitted diseases

Reducing this risk will start by sensitizing staff and neighbouring population as well providing an easy access to condoms. Prohibition of prostitution will be enforced (see code of conduct).

Outside abstinence, the only proven method for preventing the spread of HIV during sexual intercourse is the correct use of condoms. Sexual education is one of the most efficient action against HIV diffusion. It cannot be done without reference to culturally values for its social acceptance. Peer-to-peer education is necessary to obtain results. Poverty, difficulties to have enough food and gender inequalities favour HIV transmission. Preventing HIV transmission shall be done in the field with general education and sensitization of workers by health workers.

Increased risk of contracting HIV often correlates with other sexually transmitted infections. Their treatments reduce the risk of infection by HIV. The treatment of the HIV-infected by anti-retroviral drugs reduces their viral load and accordingly the risk of transmission to sexual partner(s) or from mother to child. The knowledge of personal viral status is important to reduce the risk of transmission and initiates change in the behaviour. Sensitization and induction training shall be provided to all new workers as well as referrals to the appropriate services.

Grievances during construction

It is recommended that the CCPLTRPF grievance redress mechanism encompasses the construction phase to allow community to communicate with the construction contractor about their concerns and grievances (and behavior of workers). The role of the contractor in this activity shall be formalized in its contract. This could be done by holding mandatory monthly meetings between the contractor and village headmen, by providing a mailbox at the contractor camp site to collect grievances and a billboard so that communities can read answers from the contractor.

RAPID SOCIAL CHANGES

The current CCPLTRPF assignment aims to collecting people grievances and communicate about the Project. The Communication strategy report provides a tool to ensure social acceptability of the Project.

HINTERLAND EFFECT

Providing for adequate woodlots and grazing land set-aside areas, as part of the SVIP's participatory land use planning process for the irrigated farming communities, will reduce pressures to encroach upon nearby protected areas to obtain construction wood, fuelwood, or livestock forage. Some measures of the SRBMP will also aim at improving use of natural resources especially in Elephant marsh.

13.5 INFRASTRUCTURES

13.5.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction, canals could necessitate destroying buildings and other infrastructures (**Permanent loss of buildings and other assets**). At current stage, the number of infrastructures is not precisely known as the Design study has not started. The Resettlement Policy Framework and the future Resettlement Action Plan will provide details about affected infrastructures. The risk to infrastructures could also come from blasting activities.
- During construction, the canal will cross roads, trails, path disrupting access for communities and cattle to grazing sites and urban centers (**Disruption of access**). The estimated number of affected roads and footpaths is provided in the Resettlement Policy Framework (RPF). According to the RPF, 10 tarred roads, 57 gravel roads and 17 footpaths will be severed by canals for Phases I and II. In addition, most canals (except at plot level) will become a barrier to walking and a serious hazard for cattle and people trying to cross. Personal observations from the Consultant of people and domestic animal crossing an under-construction lined canal with slope 1H/1.5V reveal that:
 - in the absence of a nearby bridge, during construction, people are forced to cross lined canal, some of them slip especially elderly people.
 - many juvenile cows try to fetch for stagnant water and end up stuck and sometimes wounded in the canal, this happens regardless of the presence of cattle bridge. It is very difficult to take them out;
 - mature cows do not usually take risks;
 - goats have no problem entering and exiting a dry canal.

It is probable that given the time necessary to rescue the cow on the following pictures (more than 15 minutes and the help of three people and a rope), if the canal would have been filled, the animal would have probably drawn.

Figure 65 Stuck cow in a lined canal



BRLi, 2017

- During operation, there is a risk that the irrigation system and infrastructures proposed in this ESIA to mitigate impacts are not adequately and regularly maintained (**Inadequate maintenance of canals and infrastructures**). The risk may also come from the fact that water hyacinth is present in Kapichira reservoir and may invade canals, that silt will be deposited in canals and that community may use canals as waste dumps.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Permanent loss of buildings and other assets. Canals could necessitate to pass through several buildings and assets	Disruption of access. Canals may sever footpaths and cattle paths	Inadequate maintenance of canals and infrastructures. There is a risk of canals and water intake siltation and invasion of plants in canal and drainage channel
Value of the affected component	Moderately valued		
Intensity	Low	Medium	Medium
Extent	Punctual	Local	Local
Duration	Permanent	Permanent	Permanent
Significance	Minor	Moderate	Moderate
Occurrence probability	High probability	High probability	Risk (low probability)

13.5.2 Mitigation measures

PERMANENT LOSS OF BUILDINGS AND OTHER ASSETS

As mentioned in the Resettlement Policy Framework, a number of locations where impact of the canal can be reduced considerably without any additional construction work has been identified. Changes were proposed to avoid village areas and graveyards as much as possible. The result of the proposed changes is a reduction of affected villages from 19 to 6 and affected houses from 121 to 26 in Phase I (a similar investigation has not been done for phase 2 yet.) (COWI, 2016).

During construction, before blasting, it will be important to assess risk to infrastructures by doing a groundtruthing survey of well, houses, churches, buildings, etc. Groundtruthing shall involve local authorities and the construction contractor.

DISRUPTION OF ACCESS

Bridges shall be built to allow for access across canals where existing footpaths and roads are impacted (10 tarred roads, 57 gravel roads and 17 footpaths will be severed by canals). In addition, these footpaths and bridges shall be strong enough to allow cattle to pass. It is recommended that they be built as the canal progresses to avoid forcing people and cattle to travel long ways to cross the canal or crossing the trench affecting the canal banks and leading to safety risks.

People/cattle bridges shall be built every km of main canals. Therefore, the Project may require up to 133 people/cattle bridges. As discussed in the baseline report, there is no identified livestock route, movement of cattle is diffused in the Study area, therefore sufficient provision for additional livestock bridges shall be planned. Sensitization to livestock owner is also recommended so that they take less risk for their livestock by:

- not using canal maintenance roads with their livestock ;
- carrying out with them ropes in case of juvenile cows entering the canal

In the command area, some footpaths shall also be designed to allow people to cross secondary canals, these shall be 1.5 m wide. Spacing between these footpaths shall not be more than 1 km.

In addition, whenever a canal crosses a seasonal river, box culverts shall be large enough to allow people to walk under the canal.

It is not recommended to build people/cattle bridges in Branch canals or smaller canals as the presence of livestock in the command area will lead to conflicts with farmers.

INADEQUATE MAINTENANCE OF CANALS AND INFRASTRUCTURES

In many irrigation schemes, the scheme operator is in charge of maintenance of main canals (lined canals) and the water intake while the water user associations are in charge of maintenance of tertiary canal and small drains. However, due to the nature of the Project and the need to install many mitigation infrastructures, it will be important that the SVIP determines the responsibility of each actors in order to allow these infrastructures to function on the long term. Such structures include:

- Bridges (cattle, pedestrian and vehicle) ;
- Safety stairs and ladders for villagers to bath and wash and to exit in case of falls ;
- Wildlife passes ;
- Tiger fish barriers ;
- Wildlife fences;
- A trash rack against water hyacinth and debris at the water intake.

This ESIA recommends that wildlife passes and tiger fish barriers do not become public infrastructures and therefore be at risk of poor maintenance but be the responsibility of the scheme operator as privately owned infrastructures.

Creation of bylaws to regulate the use of the canal shall also be made to avoid people throwing garbage in the canal, building informal (and often dangerous) bridges, or degrading the canal. Therefore, maintenance shall be accompanied by some form of law enforcement.

It will be also important to train farmers and management entities in maintaining their drains and canals as well as not to use the canal as a waste dump. This is a major responsibility and requires a significant level of managerial and technical skills and physical resources (facilities and equipment). Fees will be collected and in-kind contributions will be compulsory (maintenance of on-farm channels). The creation and training of such water management entities is a major task and will require (i) enactment of the relevant legislation, (ii) significant social preparation, and (iii) intensive hands-on support and training at start-up and over the initial years of operation, and (iv) provision of facilities and equipment. Failure, or delay, in operationalising the on-farm management will result in inefficient use of water and poor system maintenance, with lower crop yields, wasted water, an increased risk of impeded drainage, groundwater rise and secondary salinisation, and significantly reduced project benefits.

In addition to trash rack sized to stop the water hyacinth, the current method to remove the water hyacinth at Kapichira reservoir (biocontrol using insects) shall continue on a regular basis to avoid having the plant invading canals and night storages.

13.6 ECONOMICS

Most impacts on these topics are dealt with in the study called “Preparation and implementation of a Communications, Community Participation, Land Tenure and Resettlement Policy Framework” and its various components: Communication strategy, Gender and youth strategy study, Grievance redress mechanism, Resettlement Policy Framework, Stakeholders’ views report.

13.6.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction, work will disturb cropping practices since some households will control physically different areas of land (**Disturbance to existing agriculture**). New lands may not be ready for cropping immediately because of timing, lack of water, or the need for land preparation including levelling, boundaries and drains.
- Work will require unskilled and skilled labour for construction creating local employments (**Job opportunities**).
- During operation of the scheme, people will have to change their habits in terms of livelihood strategies. People in the valley, while incredibly poor, adapt to their situation by having flexible livelihood choices depending on the environment. They grow cotton and maize if there is adequate rainfall. They have goats, cattle and chickens and move the cattle and goats around to whatever pasture is available. They fish in the river and floodplains. They grow maize (dimba farming) on the floodplain, following the river down so that the crops get the moisture in the soil and survive long enough to be harvested before the water table drops too low. This livelihood strategies will be profoundly modified with SVIP as people will rely mainly on irrigated agriculture. Any delays in the Project completion, adaptation from people to irrigated agriculture or skills acquisition could delay the benefits (**Potential delays in irrigated agriculture development**). The project relies on a knowledge-, inputs- and labour- intensive model of production at the field and household level. This model is untested at household level under the environmental, social, economic and institutional conditions prevailing in the study area. If the model is not feasible, there will also be a delay in project benefits as potential solutions are tested and applied.
- During operation of the scheme, increase in production from irrigated fields could lower price at local markets and affect rain fed producers (**Over supply of crops**).

- The project overall goal is to benefits local communities (**Benefits of irrigated agriculture**). The Project positive impact in term of income will bring indirect changes such as improved health and education, new agribusiness investments, economic development and increase in wage labor.
- During operation of the scheme, with less water in the Shire River, fishery in Elephant marsh could be impacted (**Reduction of fisheries**). Currently, fisheries are already declining due to rapid human population growth, there is also an issue with regulation and use of illegal gears. The project impact will create an additional pressure on this resource. Fishing is a particularly important livelihood activity in the eastern and southern parts of the marsh. The value of the fish caught from the marsh could be between US\$1.5 – 8.8 Million per year (Anchor Environmental Consulting, 2016). The DRIFT report (Ecosystem Functional Model by Southern Waters in association with Streamflow Solutions, Anchor Environmental and MRAG for the SRBMP, 2016) does not foresee a reduction of open water surface (but depth) in the marsh (where most fishery takes place) however it foresees a reduction in rooted vegetation where spawning takes place.
- The project construction and operation will require adaptation of livestock rearing activities (**Impacts on livestock rearing**). The canals and command areas will represent obstacles to movement of cattle mainly toward Elephant marsh and will reduce the land available for grazing. The presence of vast irrigated areas could lead to conflict between cattle owners and farmers. In addition, smallholder livestock farmers fear that they might be deprived of access to crop residues from SVIP which are likely to be sold to the highest bidder. Other grievances collected from livestock farmers by COWI (COWI, 2016) are as follow:
 - The proposed schemes with large contiguous command areas will block livestock accessing the Shire River and other watering points.
 - Access to the few ponds currently used as watering points for livestock may be blocked by the schemes or may be located inside the schemes.
 - There is a fear among livestock owners that irrigation water could introduce new diseases or enhances and perpetuates existing ones.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Disturbance to existing agriculture. New lands may not be ready for cropping immediately because of timing, lack of water, or the need for land preparation including levelling, boundaries and drains	Job opportunities. Work will require unskilled and skilled labour for construction	Potential delays in irrigated agriculture development. Any delays in the project completion or skills acquisition could delay the benefits
Value of the affected component	Highly valued		
Intensity	Medium	Medium	Medium
Extent	Local	Local	Local
Duration	Temporary	Temporary	Temporary
Significance	Minor	Minor (positive)	Minor
Occurrence probability	High probability	High probability	Potential occurrence

	Over supply of crops. Increase in production	Benefits of irrigated agriculture. The	Reduction of fisheries. Fishery could be	Impacts on livestock rearing. The

	could lower prices and affect rain fed producers	project goal is to benefits local communities	impacted by SVIP	project will require adaptation of livestock rearing activities
Value of the affected component	Highly valued			
Intensity	Medium	High	Low	Medium
Extent	Regional	Local	Punctual	Local
Duration	Permanent	Permanent	Permanent	Permanent
Significance	Major	Major (positive)	Minor	Moderate
Occurrence probability	Risk (low probability)	High probability	Potential occurrence	High probability

13.6.2 Mitigation measures

DISTURBANCE TO EXISTING AGRICULTURE

According to the Resettlement Policy Framework (RPF), loss of annual crops would be avoided by starting the project after the harvest. In addition, the RPF has recommended the construction of bridges and footpaths across canal to allow people to continue accessing their field or to commute. These passages shall be built as the canal progresses and not at the end to avoid creating a long trench with dangerous embankments.

Land acquisition and land consolidation shall be planned in advance of construction, so that farmers have some time to adjust to their farming condition before the additional stress of physical construction. Land acquisition shall be phased according to the Project (Phases I and II).

JOB OPPORTUNITIES

As mentioned in the previous section, job creation shall bring benefits to the community as long as local employment is favored.

POTENTIAL DELAYS IN IRRIGATED AGRICULTURE DEVELOPMENT

Resources shall be provided to support the delivery of advisory services, adaptive research and development, the strengthening of research-extension-farmer linkages, the improvement of market linkages, and increased pluralism in market delivery. These resources could be provided by the Ministry of Agriculture, Irrigation and Water Development and the Proposed organizational setup presented in the Agricultural Development Planning Strategy study (PWC, 2016). Pilot trials shall also be put in place and Phase I success shall be tested prior to implementing Phase II.

OVER SUPPLY OF CROPS

In order to avoid oversupply of crops at local market, the project shall focus on exporting crops. In addition, the Project shall study the possibility to transform vegetable for the food industry (tomato sauce, etc.). Measures to mitigate the impact are developed in the in the Agricultural Development Planning Strategy study (PWC, 2016).

BENEFITS OF IRRIGATED AGRICULTURE

The overall goal of the Project is to increase livelihood of communities. The benefit from the Project will also influence several other socioeconomic indicators: general health and education level of the community, etc. These positive side-effects can be numerous and relatively easily achieved:

- Greater food security than rain-fed production and increase in the monetary income will reduce poverty and food shortage.
- Change in behaviour and acceptance of new mentality particularly associated with health.
- Increased access to efficient health system.
- Better access to schools.
- Development of agribusiness in the area.

Enhancement measures are well detailed in the Agricultural Development Planning Strategy where efficient organization of producers are proposed. Institutional measures will also be developed as well as assistance and training to producers once the Project starts. Creation of water users associations is another example of an enhancement measure.

REDUCTION OF FISHERIES

Impacts on fisheries could be compensated by creating fish farms. Factors to consider for fish farming are presented in the “Agricultural Development Planning Strategy” study (PWC, 2016). In addition, the current study under the SRBMP called “Climate resilient livelihoods and sustainable natural resources management in the Elephant Marshes, Malawi” will provide (once available) more details on institutional measures to implement to ensure proper natural resources management, including fisheries.

IMPACTS ON LIVESTOCK REARING

Mitigation for smallholder livestock farmers were discussed in consultation meetings by the consultant in charge of the Agricultural Development Planning Strategy (PWC, 2016). The following mitigations reflect smallholder grievances:

- Construction of drinking spots along the main canals. Drinking spots shall take the form of pipes or cattle troughs. One cattle trough should be installed at each village at a location outside of it and on both side of the main canals. A first estimate would be 40 cattle troughs (20 on the western side and 20 on the eastern side). These troughs shall be made of concrete to limit seepage and the quality of concrete shall be equal to the quality of the lining for the canal. Their size shall be around 5 by 5 meters.
- Phasing the installation of people/cattle bridges as canal construction progresses is recommended to avoid creating a long trench without any passage for cattle.
- Construction of people/cattle bridges. People/cattle bridges shall be installed at each km along the main canals (a total of 133 people/cattle bridges), but Project proponents shall make provisions for additional bridges. Bridges shall be made of concrete and include high walls to avoid accident. From the consultant experience in irrigation schemes in Africa, along a 22km main canal, 3 people/cattle bridges were initially installed, after complaints from livestock owners, a dozen additional bridges were built. Today local government are requesting more people/cattle bridges. Based on this example, it seems important to provide one people/cattle bridge per km.
- Establishment of conflict management structures at village level and guidelines to deal with farmer's conflicts.
- Formalization of the marketing of crop residues and organic manure to foster strong collaboration between livestock and irrigation farmers and to ensure reciprocal gesture in the disposal of crop residues by crop farmers in exchange of manure.

- In order to ensure that crop residues are available to smallholder farmers, small scale farmers shall have access to the crop residues realized from crops grown on their traditional land parcels.
- Some lands that cannot be farmed (see section on set-aside land) shall be designated as grazing areas and, if possible, planted with grass in consultation with livestock owners.
- Command areas from vast contiguous patches of land and outside of roads, urban places and rivers they offer very few direct access to Elephant marsh grazing sites. It will therefore be important to designate cattle corridors so livestock can access the marsh. This will not only reduce the risk of conflicts between farmers and livestock owners but also the risk of conflicts with people living in urban place (Nchalo, Ngabu, Chikwawa). At this stage, these corridors cannot be proposed, but the Design study shall take this measure into consideration.

13.7 HEALTH AND SAFETY

13.7.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction, the public and workers are at risk from important work along canals (**Construction risk and nuisances**). The main risks are related to collision with vehicles and trucks as people will inevitably use construction road; with dust and speed the risk is non-negligible. Other risks related to worker safety include:
 - Risk of workers not wearing any Protective Personal Equipment (PPE). From experience of the Consultant in construction sites in Africa and China, most workers (particularly daily workers) never wear any PPE either because the construction company does not provide any equipment to save money, because workers sell them on the local market, or because the weather is too hot to wear a helmet and safety shoes. Without complete review of the common PPE management approach, SVIP construction sites will not be different.
 - Risk due to poor hygiene and general state of workers camps when surplus material, wreckage and rubbish are found everywhere on site and when toilettes and used water are not correctly evacuated out of the site.
 - Risks due to workers lower standards in terms of safety precaution especially when working close to water and the risk of electrocution at the water intake when welding.
- During operation of the scheme, an increase of waterborne disease in the command area, mainly bilharzia, is expected (**Bilharzias**). Other diseases could see their prevalence increased due to the Project.
- During operation of the scheme, the presence of main canals and night storage may lead to drownings (**Drownings**). Branch canals whose depth are between 0.4 and 1.1 meter are not drowning hazards but still represent a risk for children.

Figure 66 Trucks and pedestrians sharing construction roads & rubbish in construction camps



Source: BRLi, 2015

ASSESSMENT OF IMPACT SIGNIFICANCE

	Construction risk and nuisances. The public and workers are at risk from important works along canals	Bilharzias. An increase of bilharzia in the command area is expected	Drownings. The presence of main canals may lead to drownings
Value of the affected component	Highly valued		
Intensity	Medium	Medium	High
Extent	Punctual	Local	Local
Duration	Temporary	Permanent	Permanent
Significance	Minor	Moderate	Major
Occurrence probability	Risk (low probability)	High probability	Risk (low probability)

13.7.2 Mitigation measures

CONSTRUCTION RISK AND NUISANCES

Dust and pedestrian on construction roads

All gravel roads used by trucks shall be sprayed on a regular basis. Due to low availability of water, it is recommended that the construction contractor pays Illovo to spray road with sugar molasses as it is done along Illovo roads. Molasses offer long lasting dust control. It is recommended that roads be sprayed three times a day (morning, mid-day and evening), except when a heavy rain takes place. Molasses is 3 to 4 times more efficient than water in dust deposition rate (Gotosa et al., 2014). Spraying molasses will however not be accepted in LNP and MWR due to its strong smell and associated increase in Biological Oxygen Demand (BOD) in nearby watercourses.

It is also required that the construction contractor provides transportation to a designated place for workers at the end of their day of work. This will help reduce the number of pedestrian walking on construction roads.

Risk of workers not wearing any PPE

- In the call for tender document, bills of quantities shall request that answering firms provide cost estimates for helmets, gloves and safety boots (and other safety equipment). For each proposal, the foreseen budget has to be verified by the authority in charge of proposal analysis to make sure that figures are coherent as PPE are in fact expensive.
- In call for tender document, the method to ensure that PPE are returned to the employer shall be provided. This method could be a deposit on equipment, which shall be recovered at the end of the contract by the worker or penalty fees for workers losing their equipment, etc.

Risk due to poor hygiene and general state of workers camps

It is recommended to:

- Require the tendering contractor to develop measures for the safe evacuation of wastewater and wastes from the various camps, to forbid the evacuation of wastewater in watercourses and forbid burning wastes.

Risks due lower standards among workers

- In the call for tender document, a Health and Safety specialist shall be required. He/she shall have a certificate in H&S and a copy of his certificate shall be provided in the proposal (with the translation if it is in a foreign language), he/she shall be mobilized at beginning of contract.
- Working close to water shall be subject to very high H&S standards given the fact that : the water intake is located in MWR, that there are a lot of crocodiles on site, and that the risk of electrocution is high when welding in a damp environment. Return of experience from the consultant has highlighted that many workers around pumping stations or water intakes are welding in damp condition due to poor sheet piling installation and poor drainage around the construction site where water intrusion from the river and stagnant water from rain become hazardous situations. In fact, sheet piling will also keep crocodiles from entering the site.

Figure 67 Working in damp condition around a pumping station



Source: BRLi, 2016

Other generic measures regarding health and safety on site are:

- Request in the call for tender document that tendering firms develop a Code of Practice to manage health and safety risks associated with excavation work.
- Ensure that the project proponent and financiers signal that best H&S standards should apply to this project (policy leadership).

- Include standard best practice health and safety provisions in the construction contract (and tender), together with :
 - appropriate Bills of Quantities items so that at least some elements of H&S are pay items (financial incentive),
 - a mechanism for withholding payments if the contractor is not compliant with the H&S provisions (especially PPE). Note that the provisions should include insurance to enable the contractor to pay for treatments required by his workers including those of all sub-contractors, together with any subsequent disability payments.
 - Include a specific task in the supervision contract concerning H&S supervision and compliance, together with the staff resources to carry this out, and including a training task for the employer's staff.
 - Require the contractor to implement an H&S program and training throughout the construction period including an induction training.
- The construction contractor shall establish and enforce the code of conduct for drivers and suppliers. An induction training shall be provided (see previous section).
- Require the contractor to install speed breakers in all access roads. These shall be made of soil spoils and shall be compacted to last. One speed bump shall be installed every 200 meters.
- Require the contractor to install construction fences around excavators and trucks loading excavated earth.
- Require the contractor to have a small clinic and nurse available on-site all the time with first aid kits. This would also entail that a replacement nurse is available (on-call). In addition, one vehicle shall remain available at all time to drive wounded staff to Blantyre.
- When using dynamite for blasting, local population shall be warned ahead through radios, public posters, churches and local authorities. A safety patrol with an alarm has to ensure that all individuals are evacuated from quarries area prior to blasting.

As highlighted throughout this ESIA, the selection of the construction contractor will require a conscious decision by the Project proponent and financing agencies prior to tendering for a construction contractor. In many observed cases by the Consultant, the terms of references and contracts for construction contractors do not include measures developed in the ESIA (and ESMP). In addition, many measures proposed in this ESIA involve a cost for the construction contractor, call for tender shall be clear on the requirement to quantify health and safety measures in the Bills of Quantities (PPE, speed breakers, construction fences, etc.).

Lastly, in the call for tender for the scheme operator, it is recommended to require that firms provide a health and safety protocol for work in canals.

BILHARZIAS (ALSO CALLED SCHISTOSOMIASIS)

In order to reduce the burden of schistosomiasis, the following actions shall be implemented:

- 1) reduction of the contact between water and human by the use of boots and protective clothes. This reduction of contacts with water is feasible with farm workers but not with children and adolescents.
- 2) reduction of the infection of the snail's fauna by avoiding defecating in or near water and avoiding urinating in water. Health sensitization is the only efficient way to reduce the release of feces or urine in water. It only can be obtained by a long-term strategy of education including scholar education.

3) the elimination of the snails by molluscicides. This action is neither realistic nor sustainable at the scale of thousand hectares of irrigated area and hundreds of kilometers of canals. However, thorough and regular maintenance of the canals by the scheme operator and farmers, particularly the elimination of aquatic plants, reduces the proliferation of snails. Drying up canals during several weeks is also efficient. This will be done for secondary and tertiary canals after the dry season.

4) preventive mass campaigns of chemotherapy with praziquantel. To be efficient, these campaigns have to be done with the entire population and repeated each year. Praziquantel is not an expansive drug and it is well-tolerated. It is effective against both urinary and intestinal schistosomiasis, resulting in a reduction of the severe forms but not in an interruption of their transmission.

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 their clinics. Their relatives have also access to free treatment. Outgrower workers as well as the neighbouring population can be treated for free at Kasinthula bilharzias health post. A microscope examination of urine is done there but not an examination of feces because of the lack of knowledge regarding intestinal schistosomiasis in the area. Seven hundred patients were tested in this health post in 2015 and 400 were treated.

In order not to increase the schistosomiasis burden and to ensure its sustainable reduction, the control of the intermediate hosts shall be aimed by the reduction of the contacts between human skin and water, by the sanitation to reduce defecation and urination in or near canals and drains, by preventive treatments of the human population and by curative treatments of infected people. This integrated control is an aim but it is not easy to realize:

- The gastropods intermediate hosts still need water or slow current and aquatic vegetation to settle (next figure). The maintenance of the primary, secondary, tertiary, and drainage canals free of vegetation and solid debris is of great importance to limit the mollusk's proliferation. "Regular emptying of canals" is theoretically efficient but the *Bullinus* are able to support desiccation buried in the mud. Hence, to have some results, emptying should persist during many weeks. This is not an appropriate measure for agricultural production. The molluscicides products are not efficient on a long term and on a large scale and they have various negative effects on the environment.

Figure 68 Canal in Kasinthula with still water and aquatic vegetation along the banks



Source: BRLi, 2016

- The reduction of contacts with infected water is possible for the farmers using boots and protective clothes but at the same time, children and adolescents appreciate to play in water. In addition, many daily activities will be done in canal like clothes washing. Therefore, a true reduction of water contacts is not really realistic neither.
- The reduction of the infestation of the gastropods by human excreta is possible for feces (intestinal schistosomiasis) and more difficult to obtain for urine (urinary schistosomiasis). It can be obtained by health education to sensitize people on the use of pit latrines. To be really used, the latrines should be clean and easily accessible and communal latrines are rarely clean. Private latrines near the households are more useful. The actions of sensitization and health education have to be repeated during many years to obtain the beginning of a result. Collaboration with the education sector is crucial for health education.

Figure 69 Communal pit latrine in Kasinthula, an elegant but rarely used structure



Source BRLi, 2016

- Treatment of the patients by oral praziquantel is neither difficult nor expansive. It is better to do a microscopic diagnosis to confirm the cause of the symptoms (parasites eggs are easily observed in urine or faeces). At present time, this observation is performed at Kasinthula health post but only in urine. In fact, intestinal schistosomiasis is unknown by the health workers and consequently underestimated. Existing capacities for diagnosis and treatment should be strongly reinforced.
- Systematic mass treatments by praziquantel are given to the primary school pupils in Chikwawa district as in other districts of the country. To be efficient, this treatment should be repeated yearly. It would be of interest to extent this mass treatment to adolescents and young adults outside the school system.
- The increase in cash income thanks to the Project associated with awareness may also lead to increase in the use of praziquantel.

LEPTOSPIROSIS

Leptospirosis is prevented by the use of protective clothes and boots and avoiding contact with fresh water in the canals. Thus, this prevention is not different from that of schistosomiasis. Leptospirosis, however, is much rarer and much less transmissible. Before any excessive concern for this disease, it would be of interest to conduct a serological survey among the cane workers.

OTHER WATERBORNE DISEASES NOT DIRECTLY LINKED TO IRRIGATION SCHEMES

Soil-transmitted helminthiasis

Measures against **soil-transmitted helminthiasis** are:

- use of pit latrines for defecation
- washing hand after defecation
- protection of the feet by shoes
- protection of the food from flies

These measures are possible with the workers and generally with adults but more difficult to obtain from the children and adolescents. Systematic mass treatment with a deworming drug is not useful because of the apparently low level of parasitism in the area. Surveys among pupils would be of interest to confirm this low prevalence.

Cholera

Regarding **Cholera**, its prevention is similar with intestinal schistosomiasis but with a stronger implication: schistosomiasis is a chronic disease which does not kill (or rarely after a long delay without treatment) while cholera can kill in few hours. Defecation in pit latrines, hand washing with soap, access to clean water are the main weapons to prevent cholera transmission.

Cholera transmission is prevented by sanitation and by personal hygiene actions:

- Use of latrines for defecation or at least, defecation away from houses, paths, water pools and supplies, places where children play, etc. and covering feces with earth or sand ("The cat method" for ending open defecation).
- Handwashing with water and soap after defecation and before any contact with food or drink. Washing is efficient with any ordinary soap even with dirty water.
- Drinking safe water and safe water use for cooking, teeth brushing, children bathing. The easiest way to obtain safe water is to put 2 at 3 ppm of chlorine (five to ten drops of bleach for 10 liters of water). The disinfecting power of free chlorine persists from 24 to 48 hours.

To reduce the risk of cholera and at the same time of other infectious diarrheas, providing people with safe drinking water is one of the most useful action. From the Feeder canal, a main pipe can conduct the water by gravity to a treatment center (decantation and chlorination) then to the main villages and settlements (as developed in the FS). The biggest difficulty is not to construct this water transport network but its maintenance. To be sustainable, the water delivery by standpipes should be lucrative for the operator in charge of the distribution and also economically accessible for this poor population. Conversely, free distribution of water will never be sustainable because the lack of maintenance of the network and of the treatment center. Everywhere in the world, payment of water is a sensitive issue, especially with traditional farmers. This issue exists also for the water used in irrigation scheme. It should be part of health education to make people accept the principle of paying for this service.

To increase sanitation, it is also necessary to develop the use of pit latrines. To be useful, the latrines should be a part of the household and remain clean and private. Building useful pit latrines can be only be the result of health education and of appropriation of hygiene messages by the majority of the population.

Malaria

As mentioned in the Baseline report, **Malaria** is not directly linked to irrigation schemes as the area is already surrounded by puddles, wetlands and dambos. Suppressing its transmission, given the environmental conditions of South Malawi lowlands, is not possible at the present time. However, the incidence of malaria attacks and their severity can be reduced.

The main action to minimize the incidence is to reduce the contacts between *Anopheles* mosquitoes and human beings by the use of insecticide treated bed nets during the night. The nets should be in good condition, well bordered. Depending on the insecticide, the fabric and the manner of impregnation, this impregnation is efficient to repulse mosquitoes during six months to two years at best. Selling nets is more effective than distributing them for free (often, free mosquito nets end up being sold as fish nets for quick cash). The increase in cash income associated with awareness can promote these purchases. The irrigation project may be a good opportunity to promote health education and use of bed nets for all, not only for children and pregnant women. House-spraying is not realistic, less efficient and use much more insecticide than the impregnation of the nets.

The best way to reduce malaria attack severity is a prompt and exact diagnosis and a prompt treatment by an effective drug. The Malawian ministry of health guidelines prescribe to use an oral artemisin combined therapy like arthemeter plus lumefantrine for uncomplicated attacks and parenteral artesunate for the severe ones. These drugs are highly effective. The prevention of the effects of malaria during pregnancy on the foetus is done by a preventive intermittent treatment with sulfadoxine-pyremithamine. At present time, various health structures in the Study area do not have any anti-malarial drugs. Improvement of the health structures in staff and in equipment is absolutely necessary to reduce malaria burden. However, nothing can be done regarding canal or drain design or the irrigation techniques to reduce the prevalence of malaria.

Onchocerciasis

Regarding **Onchocerciasis**, because of the strong link between the *Simulium* blackflies and running water in streams and rivers, there is no risk of invasion by these vectors of onchocerciasis in the lowlands along the bank of the Shire River and canals. The possible presence of *Simulium* larvae at the tiger fish barrier (if it involves a weir) is more anecdotic than of health interest.

DROWNING

It is recommended to carry out sensitization at primary schools to inform children about the danger of canals. Children are curious and will inevitably "test" the canal; sensitization shall be on going, shall use simple illustrations and involve teachers.

It is also recommended to build large concrete stairs at each village crossed by a main canal (Feeder, Bangula and Supini). The primary purpose of these stairs would be to allow people to access water without danger. These stairs shall be large enough so that people can use them to fetch for water and clean their clothes (10 meters wide). An estimate, based on density of villages around main canals, gives about 40 stairs for the whole scheme (20 on the western bank and 20 on the eastern bank). It is not recommended to:

- build stairs on both side of a canal at any location, it could be interpreted as an invitation to cross the canal (especially at time of low low).
- build stairs north of Chikwawa as the area has very little population density (although this may change in the near future).

- to decrease the slope of the canal bank as the canal could become available to cattle. Return of experience from a long canal in Namibia has revealed that not much could be done to evacuate a drowning adult cow anyway. In area where ramps with gentle slope will be built for canal maintenance, the concrete shall have a higher coefficient of friction or shall be textured to improve grip (with a broom), gritty material can also be added to the surface. This way, if a cow comes to drink it will have a better grip to exist the area. Access for cattle to these ramps shall not be encouraged (fence, etc.).

Stairs shall only be built at village level to maintain a certain level of control over the use of canal. To reduce the incidence of drowning, fixed ladders shall be fixed every 500 m on both side of the canal along the full length of the Feeder, Bangula and Supini canals (with alternating position as well). Fixed ladders shall be installed in night storages as well (as mentioned in the FS). Due to their greater depth night storages shall also be fenced.

It is also recommended that the general population be informed about the presence of the canal and the restriction of access and use that apply to people (no fishing, no canoe, no motor pump, etc.).

The water intake shall never operate rapidly; gates shall be opened progressively to avoid creating a sudden increase of water in the canal.

Discussions with irrigation specialists have raised one limitation with fixed ladders : as they are made of iron they often are stolen. Alternatives to iron shall be studied such as hard plastic (replaceable plastic railing) or recycled half rubber tires embedded in the concrete lining (with holes to avoid retaining stagnant water). Notches can also be made directly in the concrete to offer some grip to people trying to exit the canal.

13.8 GENDER ASPECT AND VULNERABLE PEOPLE

13.8.1 Description of impacting activities

- With increasing yield, the project may add a burden to the workload of women (**Increase workload for women**). However, on the other hand with **improve access to water** thanks to the presence of canals, women will travel shorter distance to get domestic water (fetching for water is “traditionally” done by women). Water shortage and distance to travel to collect water are serious constraints in the study area.
- Access to financial services is a strong barrier to women and youth empowerment (**Risk of unfair distribution of benefits**). Women often depend on their own capital and other informal sources of capital. In the study area, businesses owned by women are less likely to be registered by government authorities compared to those operated by men. This makes women less likely to access credit from formal banks as they would not have certificates of registration.
- Landless people and squatters could be disadvantaged by the project (**Impacts on vulnerable people**).

	Increase workload for women. The Project may become a burden to the workload of women but on the other hand time spent to get	Risk of unfair distribution of benefits. Access to financial services is a strong barrier to women and youth empowerment	Impacts on vulnerable people. The Project benefits may not reach vulnerable people

	water should decrease with Improved access to water		
Value of the affected component	Highly valued		
Intensity	Low (the negative impact is counterbalanced by the positive effect)	Medium	Medium
Extent	Local	Local	Local
Duration	Permanent	Permanent	Permanent
Significance	Minor (positive)	Moderate	Moderate
Occurrence probability	Potential occurrence	High probability	Potential occurrence

13.8.2 Mitigation measures

The Gender and Youth Strategy Study (COWI, 2016) has developed a series of measures to mitigate impacts from the Project in the “Proposed guidelines and activities” section. These measures aim at the preparatory phase as well as the Project implementation stage.

The following are mitigation measures that are developed in the Gender and Youth Strategy Study (COWI, 2016).

PREPARATION PHASE

Preparation phase are measures that were already implemented by the consultant (COWI, 2016).

Recruitment and capacity of consulting /project teams/missions

- Ensure that all terms of reference for consultants and staff have a gender aspect/expert in them ;
- Train/orient all project staff and consultants on gender and youth issues, including orienting them on SVIP ;
- Where possible, ensure that the composition of staff at all levels is at least 50% women, to be in line with the 50:50 policies.

Implementation of stakeholder consultation process, community mobilisation and engagement for the SVIP

- Implement communication activities at all levels in the project area (ADC and VDC levels)
- Develop community mobilisation guidelines that incorporate gender issues.
- Ensure information education and communication materials are accessible to the illiterate, especially women.
- Ensure women, youth and the poor are included in all field level activities, meetings and capacity building processes.

Preparatory studies, baselines data collection, analysis and reporting

- Orient all enumerators on gender and youth issues related to Chikwawa and Nsanje
- Ensure that all data collection instruments are able to collect gender and youth disaggregated data.

- Ensure that all data collection tools are gender/youth-audited by the CCPLTRPF Gender and Youth Expert
- Ensure that data is analysed and disaggregated by sex and age to capture gender and youth issues.

Institutional development and formation of irrigation options, water user institutions, SVIP governance and management committees

- Ensure that gender and youth issues are used as criteria for choosing the SVIP irrigation institutional model.
- Ensure that women, youth and poor people are represented and actively participate in irrigation management entities
- Train all irrigation management entities on gender and youth issues
- Ensure women, youths and poor are included in the management, governance, implementation and technical teams of SVIP
- Build capacity of individual farmers on gender and youth issues, including decision making at household level
- Ensure no discriminatory practices are being used to limit participation of women and youth.
- Ensure that voices of women, youths and poor are heard by management of the water management entity
- Implement positive discrimination, if the irrigation or water users committees do not have representation from women, youths and the poor

Land redistribution, resettlement policy framework and grievance mechanism

- Ensure that PAPs are gender, age and poverty defined, so that it is known who is most affected by resettlement
- Ensure that women, youths and poor are also provided with land in the schemes. Government can lease off land and reallocate equitably amongst beneficiaries.
- Ensure that women and youths and poor who lose land are appropriately compensated. During compensation, ensure that all household members have access and control of the compensation by adopting a household livelihood and planning approach that is being implemented in Chikwawa by the Ministry through IRLAD project.
- Ensure that District Council teams, Committees and experts that value lost assets during compensation, value land as well, not just structures on it.
- Ensure that District Council teams, Committees and experts that value lost assets during resettlement planning do not sexually abuse women or girls (or any form of gender based violence)
- Ensure that land assessment teams include women and youths and ensure that land losses of female headed households are assessed by female officials/experts. Whoever does the valuation should be gender trained.
- Ensure that gender and youths sensitive spaces are created for women to lodge their grievances on unfair practices.
- Ensure that grievances by women are handled by women. Traditional leaders should ensure that women are included in any primary justice structures that they have in place or are to be created.
- Encourage land being registered jointly in the name of the woman and the man.

Monitoring and evaluation of gender and youth activities

- Ensure that the intervention logic of any project being designed has SMART and gender and youth sensitive indicators and take into account poverty
- Ensure that monitoring the progress made in applying gender and youth approaches in irrigation projects is regularly undertaken.
- Ensure that all indicators at input, output, outcome and impact level are disaggregated by gender, age, household headship, location and marital status, where necessary. Indicators that can be used are included in the annexes.
- Ensure that programme targets are gender and youth disaggregated
- Ensure that monitoring and evaluation terms of reference and teams have gender and youth expertise.

PROJECT CONSTRUCTION AND OPERATION PHASE

Policy level commitment to mainstream gender and youth issues in the SVIP

- Promote SVIP as multiple-use (irrigation, domestic and livestock uses) irrigation and water programme.
- Ensure that women enjoy de jure and de facto equality in access to land and other property, including inheritance and purchase.
- When water management institutions do not have any or few women and youth, introduce appropriate institutional measures, such as minimum quotas for women and youth to increase participation of women and youths
- Provide improved coordination among concerned water management institution to facilitate the implementation of multiple-use water projects.
- Support equal employment opportunities in water management institution for both genders and for youth and older people.
- Provide and support capacity building around gender and youth issues in water management entities with particular attention to extension staff.
- Ensure effective linkages with gender and youth ministries and CSOs

Land administration, allocation and tenure arrangements for women, youth and poor people

- Conduct participatory assessments to understand the social organization of agricultural production and the specific gender and youth division of labour in the project area.
- Implement mechanisms to ensure that the landless are also provided land and participate in irrigation activities
- If irrigation schemes involve land titling or retitling, new land titles should be granted to women or to husbands and wives jointly. Youth should also be included.
- Disaggregate land ownership data by gender and age to understand land ownership issues amongst women and youth.
- Conduct local/grassroots advocacy work with traditional leaders to improve land ownership by women and jointly by woman and man
- Ensure that irrigation schemes have both commercial as well food security objectives by adopting integrated farming systems, not just commercial mono-cropping

Construction of various irrigation infrastructure and installation of equipment

- Ensure that women and youth are involved so that they also benefit from the employment created, where feasible.

- Ensure gender sensitive resettlement in terms of targeting, compensation and provision of services to new locations.
- Provide social safeguards to protect women and girls from being sexually abused

Gender and youth division of labour

- The irrigation scheme should provide labour for irrigation activities in the farm. The irrigation model should not allow farmers to work using their own labour in the blocks.
- Ensure that planners involved in the projects are aware of women's and youth contributions to farm and household production to enable them design plans that are appropriate for women.
- Irrigation designs should carefully evaluate the availability of women's and men's work in the family and expected impacts of intervention on women's and men's income, time use, and social power.
- Community labour contribution to irrigation projects should take into consideration the contribution of women and men at household level. Where possible, this labour should be for to compensate for time lost.
- Provide appropriate labour and time saving technologies to those beneficiaries, especially those who are already overburdened with labour at household level.

Access and control over economic and social benefits from participation irrigation services

- Income from irrigation at household level should be transparently used by adopting a participatory expenditure management at household level
- Provide equal access to training, finance/credit and related irrigations services for men, women and youths.
- Provide training opportunities for the youth and women in advocacy and engagement and inclusion
- Provision and promotion of (agriculture-related) vocational skills for youths which will enhance the growth of the sector
- Monitor use of irrigation income/earnings at household level

Water user organizations and other institutional arrangements.

- Ensure that by-laws of irrigation schemes/WUAs or its constitution provide equal opportunities for all members. Ensure that it has some affirmative actions that favour the disadvantaged groups.
- Ensure that there are no discriminatory practices that are being used to limit participation of women and youth, even when bylaws provide for equal opportunity. These may include high membership fees, landlessness, access to water etc.
- Implement positive discrimination, if the criteria for irrigation scheme or WUA membership is discriminatory

Socio-economic empowerment of women and youths in and around irrigation schemes

- Improving access to finance to enable women and youths participate in irrigation technology and value addition
- Integrate/promote village loans and savings and income generating activities in irrigation schemes
- Training women and men on human rights and the importance of women's participation in decision making at all level

- Introducing functional literacy classes in water management institutions to improve women's and illiterate men's ability to read and write so that they can effectively participate in agricultural decision making processes

Designing and implementing multiple use irrigation services

- Implement a strong consultation process during the planning and implementation stages to understand gender dynamics
- During implementation, conduct training programs addressed to women to help them manage and maintain the points of supply will also be necessary. Ensure that planners understand women's and girls' water needs as women and girls will be the main users of those watering points
- Translate multiple water needs into affordable small- and medium-scale technical irrigation designs
- Ensure that water points are created for domestic and other social uses, especially livestock.
- Introduce community water points because tap water may not be feasible as houses are not mostly permanent.

Irrigation scheme management and farmer management

- Ensure that all farmers aggregate their land so that no single farmers is identified by or works on their own land.
- When forming groups, ensure that membership fees are affordable and those that cannot afford are supported with cash transfers to be able to pay
- Adopt management arrangements that have been used for the Phata Irrigation Schemes where possible
- Ensure that farmers are organised in a way that ensure women and youth participate in the activities of the scheme and benefit from it
- Implement gender training programmes for staff and communities around the schemes
- Implement gender sensitive transparent and accountable irrigation revenue management
- Adopt agronomic principles that use technology other manual labour and ensure that farmers are paid when they provide labour.

Reaching the poorest and most vulnerable groups

- Ensure that the vulnerable and often-overlooked groups such as women, youths, PLHIV, elderly, landless workers and poor women farmers are included in all stages, including during consultation, resettlement and land reallocation, during implementation and monitoring and evaluation.
- In order to know who vulnerable rapid vulnerability assessments should be included in the consultation processes.

Monitoring and evaluation of gender and youth activities

- Ensure that the intervention logic of any project being designed has SMART and gender and youth sensitive indicators
- Ensure that monitoring the progress made in applying gender and youth approaches in irrigation projects is regularly undertaken.
- Ensure that all indicators at input, output, outcome and impact level are disaggregated by gender, age, household headship, location and marital status, where necessary. Indicators that can be used are included in the annexes.
- Ensure that programme targets are gender and youth disaggregated

- Ensure that monitoring and evaluation terms of reference and teams have gender expertise.

Gender and youth capacity building and sensitization at various level

- Cabinet level:
 - Presidential directives
 - Gender and youth briefings and awareness sessions
 - Policy briefs on gender and youth
- Ministries and departments:
 - Establish focal points in ministries
 - Train planning and monitoring and evaluation officers on gender and youth
 - Joint planning and monitoring teams
 - Technical support on gender and youth
- District Executive Committee Members :
 - Allocate resources for gender and youth analysis, gender and youth training and mainstreaming
 - Train of the District Executive Committee on gender and youth
 - Establish focal points in sectors
 - Joint planning and monitoring teams
 - Technical support on gender and youth
- Community structures :
 - Orient local leaders (such as Councillors, Traditional Leaders, Religious Leaders on gender and youth issues and women's and youth' rights
 - Train of the ADCs, VDC and AECs on gender and youth
 - Conduct gender and youth analysis together with District and Community Teams
 - Train community-based volunteers in gender and youth issues such as gender and youth participation in decision making
 - Conduct participatory gender and youth analysis, planning and monitoring at community level
 - Establish local gender and youth forums or advocacy groups
- Household level :
 - Sensitisation of men, women and youth on the roles and importance of women and youth and women's and youth' rights

In addition, impact on landless and vulnerable people is addressed in the Resettlement Policy Framework (COWI, 2016), this will be further be studied once the Resettlement Action Plan is produced.

13.9 CULTURAL HERITAGE

13.9.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

-
- During construction, excavation of the canal will affect some known and unknown cultural heritage sites mainly pottery (**Loss of physical cultural heritage**). Identification of affected pottery sites is in annex of Vol.1 (Baseline report). No sacred sites will be affected by the canals. Based on COWI work (2016):
 - The actual main canal alignment is not running through graveyards with the exception of one case where a branch canal is crossing a graveyard. The canal alignment is proposed to be modified to avoid this situation.
 - Religious structures, such as local churches and other places of worship, were also recorded as points of special interest during the land use mapping by COWI. A significant number of religious structures were identified, but none will be affected by the main canal or the branch canal alignments.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Loss of physical cultural heritage. During construction, excavation of the canal will affect some known and unknown cultural heritage sites.
Value of the affected component	Highly valued
Intensity	Low
Extent	Punctual
Duration	Permanent
Significance	Minor
Occurrence probability	High probability

13.9.2 Mitigation measures

Due to the identification of 87 cultural heritage sites (46 by the MDoA and 41 by BRLi), of which more than half might be impacted by the Project's land-transformation activities, mitigation measures will be necessary in the form of a Cultural Heritage Management Plan (CHMP). The CHMP allows avoiding or limiting adverse impacts and looking for opportunities to maximise the benefits of those resources. This management plan is included in the ESMP (Vol.3).

The World Bank's Operational Policy 4.11 on Physical Cultural Resources states that "as an integral part of the EA process, the borrower develops 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". According to OP 4.11, this management plan needs to be consistent with the country's overall policy framework and national legislation and needs to take into account institutional capabilities with regard to physical cultural resources.

Concerning the institutional capabilities of managing physical cultural resources, it is important to mention that Malawi has limited financial and professional resources to implement holistic cultural heritage management projects. Under these circumstances, a conventional North American CHMP strategy, with avoidance of all sites as the primary goal of the project, does not appear appropriate to the circumstances at hand. The fact that considerable numbers of archaeological sites have been discovered and many more sites may be buried underneath the surface, constitutes another important finding of this study, indicating the high probability that the sites buried underneath the surface will be revealed once land-transformation activities start.

Furthermore, the IFC's Performance Standard 8 states that "the client will identify and protect cultural heritage by ensuring that internationally recognized practices for the protection, field-based study, and documentation of cultural heritage are implemented".

At this early stage, the following mitigation measures are recommended by the consultant, which comply with national legislation and internationally recognized practices concerning heritage protection. The MDoA should also be directly involved in the implementation of the Project's CHMP. However, as the staff of the MDoA is equally tied up with a lot of administrative responsibilities, there should be room to engage professional individuals and/or a structure active in cultural resource management that can assist in the implementation of the Project's CHMP. The training of University students and representatives from the MDoA should also be carried out during all stages of this CHMP in order to strengthen the national capacity in cultural heritage management in the context of development projects.

PHASE 1: PRE-CONSTRUCTION DATA COLLECTION (FOR DETAILS SEE ESMP)

The following measures shall be implemented before construction starts:

- **Artifact collection** using hand excavated shovel pits or augers to assess the depth of sites and range of artifacts and controlled excavation of high priority sites (see Baseline report and ESMP). One element is to be noted: many of these sites were identified in or along rivers in 2016 by the consultant and there is a chance that flash floods have washed them away;
- All artifacts collected shall be catalogued and described, and curated in Malawi through a governmental institution (MDoA). Artifacts could be exposed in the valley at the Tisunge! Lower Shire Heritage Centre at the entrance of LNP;
- Appropriate analyses of collected artifacts such as ceramics, copper objects and slag, etc. will be completed as they are collected;
- A report will be issued describing and interpreting the cultural resources found and placing them within a broader cultural-historical framework; and
- Publication of results in peer-reviewed journals.

PHASE 2: MITIGATION PLAN DURING CONSTRUCTION (FOR DETAILS SEE MANAGEMENT PLAN)

During construction, the following mitigations shall be implemented:

- Contractor training and awareness program based on identified cultural sites, sacred sites and graveyards;
- An initial one or two month period of selective archaeological monitoring of surface clearing and earth work during construction in areas with poor surface visibility and/or a high probability for cultural resources buried below the surface; assessment of artifacts recovered during land transformation activities; training of Malawian students in archaeological monitoring;
- Salvage excavations at sites deemed as of high priority (see annex of Vol.1 Baseline Report and ESMP);
- Once the initial period of archaeological monitoring and salvage excavations is over, the Project will apply Chance Find Procedures (see Vol.3 ESMP for the details). Personnel from the MDoA should decide about necessary management measures;
- Avoid/minimize construction-related impacts to known cultural resources (see Vol.1 Baseline report).

13.10 NATURAL HERITAGE

This section describes impacts on parks on a socioeconomic aspect (tourism, management and infrastructures). The section on “Terrestrial habitat and wildlife” discusses impacts on parks from an ecological point of view (wildlife movement, etc.).

Measures have been developed in close consultation with concerned park management.

13.10.1 Description of impacting activities

The impact matrix has identified several activities and impacts presented in the following sections.

13.10.1.1 Decision on the type of canal and its alignment route

During pre-construction stage (design stage), decisions regarding the canal layout will have long term consequences on parks. The current canal alignment route (based on the FS) is 2.45km inside Majete Wildlife Reserve and 14km inside Lengwe National Park (Bangula canal). Technical studies shall evaluate the feasibility of several options inside two parks to minimize impacts. This section presents some case scenarios as an introduction for other sections.

OPEN VERSUS CLOSED CANAL

Majete Wildlife Reserve (managed by African Parks)	Lengwe National Park (managed by the Government)
An open canal leads to significant impacts as: - An open canal is not compatible with touristic activities as the Feeder canal passes in the “High Intensity Tourism Zone” and that it will have to be heavily fenced or walled to keep large animals (elephants, hippo, crocodiles, etc.) from entering the canal and : - Risking their life (the canal will be a death trap) - Damaging the canal - Using the canal as a pathway to access areas outside the reserve and entering in conflict with communities An open canal will represent a physical and aesthetic barrier for tourists; MWR will lose its attractiveness in the eastern side of the Park. From discussion with African Parks, a closed canal is the favored of the two options as it will minimize impacts on several level (tourism, wildlife movement, risk of drowning, etc.)	An open canal leads to impacts as: The open Bangula canal will pass through the “Central Wildlife Viewing Area” which is the area where most wildlife are located and tourists are visiting the park. An open canal may lead to, depending on its layout, significant wildlife drownings. However, in LNP, an open canal can be seen as an opportunity to provide water for wildlife since the park suffers from water shortage.

EARTH VERSUS LINED

Majete Wildlife Reserve (managed by African Parks)	Lengwe National Park (managed by the Government)
Earth canals look more natural than lined canals. Therefore, having a lined canal has an impact on landscape. Lining in canal is one of the factor that leads to drownings as concrete gets slippery and the smooth surface of concrete does not allow animal to have a good grip.	

CURRENT ALIGNMENT ROUTE OF THE CANAL

Majete Wildlife Reserve (managed by African Parks)	Lengwe National Park (managed by the Government)
The current alignment route of the canal which runs along a 2.45 km route inside MWR could	The current alignment route of the canal which runs along a 14 km route inside LNP leads to

be optimized to short cut the reserve as it leads to numerous impacts (as presented in sections hereunder).	numerous impacts. However, there is no possible short cuts for a gravity canal (as presented in sections hereunder). A canal may become an opportunity for wildlife if properly designed, as water is scarce in LNP.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Decision on the type of canal and its alignment. Decisions regarding the canal layout during the design stage will have long term impacts on parks
Value of the affected component	Highly valued
Intensity	High
Extent	Local
Duration	Permanent
Significance	Major
Occurrence probability	Potential occurrence (as no decision will probably be made before the Design study)

13.10.1.2 Decision on the status of canals inside parks

During pre-construction stage, the presence of canals inside parks will require a clear definition of their status. Decisions regarding the canal and (water intake) status may have long term impacts on MWR and LNP as it will influence how their access inside these parks is managed and how park management will be consulted in the Project decision making process.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Decision on the status of canals inside parks. The presence of canals inside parks will require a clear definition of their status
Value of the affected component	Highly valued
Intensity	Medium
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	Potential occurrence

13.10.1.3 Tender process and selection of a construction contractor

During pre-construction phase, the tender process for the selection of the project construction contractor represents a high risk for parks (and all other social and environmental components) as it is a crucial step in binding environmental measures. This tender process represents a high risk for MWR and LNP for several reasons:

- The construction contractor may not have any environmental sensitivity nor a proactive attitude (no environmental policies or no expert among its staff, etc.), or may not have any experience in work in sensitive areas such as parks.
- The tender document and the contractor's contract may not include sufficient binding environmental measures or may not have any leverages in case of non-compliances.
- Parks management may not have any official supervision role of construction activities within the parks and may not have any authority over the contractor in cases of non-compliances. Whenever a serious non-compliance is observed by park managements, the long chain of communication toward decision may hinder quick actions.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Tender process and selection of a construction contractor. The tender process for the selection of the Project construction contractor represent a high risk for parks as it is a crucial step in the development of binding environmental measures
Value of the affected component	Highly valued
Intensity	High
Extent	Local
Duration	Temporary
Significance	Major
Occurrence probability	Risk (low probability)

13.10.1.4 Impact on tourism

Construction activities in MWR and LNP will have very serious deleterious impacts on tourism on a financial point of view especially at MWR since:

- Aesthetic aspects of tourism will be compromised at the Kapichira dam with the water intake structure and make this location no longer viable for tourism.
- Work will create visual disturbances to visitors and impact the natural experience during the construction process. Physical excavation, blasting and terracing along the path of the canal and access roads will affect landscape.
- Noise from equipment will impact visitors experience at day visitor center, headquarters and Thawale lodge. The path of the canal passes close to the community campsite and during construction will make this a very unattractive destination and as a result affect business at the campsite. The revenue from this campsite goes directly to the community which they utilize for social welfare and community projects. This revenue will be significantly impacted due to loss of business during construction.
- Work will lead to intense truck traffic inside MWR, most likely along Mkulumadzi Road (because of topographic constraints and cliffs, the access road along the Feeder canal route will most likely not be practicable for trucks). An estimate of 100,000 m³ will be excavated for the canal in addition to the 560,000 m³ to 640,000 m³ of dredged sediment at the reservoir (water intake) (Artelia, 2016). Depending on the duration of work inside MWR, this will lead to a tremendous amount of trucks passing inside the reserve as shown in the following table.

Table 20 Estimation of the number of trucks

Indicative work duration inside MWR*	Number of trucks passing through the reserve (given a load of 25 m ³ per truck) for a total of 100,000 m ³ of earth (canal excavation in MWR) + 560,000 m ³ to 640,000 m ³ of dredged sediment
1 year	26,400 to 29,600 trucks travelling on week days represents about 100 to 116 loaded trucks per day or about 12 to 15 trucks per hour or about 1 loaded truck every 5 minutes. Trucks will travel back, therefore the number of loaded and unloaded trucks passing through the reserve will be about 1 truck every 2-3 minutes
2 years	26,400 to 29,600 trucks travelling on week days represents about 50 to 58 loaded trucks per day or about 6 to 8 trucks per hour or about 1 loaded truck every 10 minutes. Trucks will travel back, therefore the number of loaded and unloaded trucks passing through the reserve will be about 1 truck every 5 minutes

* at time of the ESIA the work duration inside MWR was not known.

- Loss of revenue from tourism business due to visual, aesthetic and noise impacts which will make MWR a less attractive destination during the construction process (the number of paying tourists was around 8000 for the year 2015).
- LNP will be affected but to a lesser extent since construction will take place far from the main activities which are concentrate at the eastern end of Old Lengwe. In addition, in LNP the access to construction site can easily be done by the existing road outside the Park (the road used by communities that surrounds the park). Lastly, LNP does not actually attract much tourists and incomes from tourism are low (see Baseline report: "in 2015, the number of paying visitors had remained steady at 556).

Boat trips in MWR will not be affected during the construction process since the jetty is located on the other side of the spur dike (training dike) opposite to the water intake.

Ng'ona lodge (also called Mwembezi lodge) is a private property (the land tenure was not verified by the consultant, the owner of the lodge declared she owns the land around the lodge) that will be affected by work as the road that leads to the lodge will be used by machinery and trucks, this road follows flat land and cannot be diverted due to changing topography. The owner of the Lodge was met at time of the Consultant last mission to present the impacts.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impact on tourism
Value of the affected component	Highly valued
Intensity	High for MWR, Low of LNP and Ng'ona lodge
Extent	Local
Duration	Temporary
Significance	Moderate (MWR) / Minor (LNP and Ng'ona lodge)
Occurrence probability	High probability

13.10.1.5 Impact on Majete buildings, roads and infrastructures

Construction of the Feeder canal may have impacts (dust, vibration, etc.) on several buildings and infrastructures of Majete Wildlife Reserve: Malaria research camp, Heritage center, Entrance gate, Wildlife research camp, Community camp site, electric fences, access road to the park, access road to Kapichira falls viewing site are the closest infrastructures to the future canal. Certain tourism roads will no longer be viable during construction because they will be used by construction machinery or very close to the construction site (Hall-Martin, start of Mkulumadzi road along Shire and Kapichira falls road). Chikwawa to Majete main road (D135) condition will be affected due to regular use of heavy construction equipment and passage of trucks. Many electric fences will directly be affected in areas where the canal crosses (exit point of reserve close to office, entrance and exit points at the entrance gate complex and along Mwambezi river), shutting down electric fences during construction may lead to animal escape outside MWR. Boreholes for drinking water (for reserve staff housing) could be damaged due to blasting. The following figures are buildings that are relatively close to open section of the canal (based on information provided by the FS report).

- Office building: 120 meters
- Entrance gate: 400 meters
- Heritage center: 425 meters
- Community camp site: 225 meters (and 200 from the buried section of the canal)
- Wildlife research camp: 290 meters

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impact on Majete buildings, roads and infrastructures. Infrastructures will be disturbed by construction of the Feeder canal
Value of the affected component	Highly valued
Intensity	Medium
Extent	Punctual
Duration	Permanent
Significance	Moderate
Occurrence probability	High probability

13.10.1.6 Impact on Kapichira Falls attractiveness

The small reservoir is created by Escom dam to feed the hydropower plant. At the dam wall, a flow over Kapichira Falls that bypasses the turbines is currently released by sluice gates.

During SVIP operation, the attractiveness of Kapichira Falls as a tourist attraction will be reduced over more months of the year. With a flow of less than 10 m³/s, due to the presence of large boulders, the falls become more or less "invisible" to visitors.

Figure 70 "Invisible" falls at 5m³/s (November 2016)

Source: BRLi, 2016

As mentioned before, the number of months in which this may occur (intermittently or for long durations) is dependent on many management decisions, beyond the overall allocations, but estimates are that this may increase from about 6.6 months (as in 2013) to over 10.1 months in dry years when both SVIP I and SVIP II are constructed. This is a noticeable difference from the baseline situation. In fact, an accurate statement is that SVIP will withdraw what currently functions as an environmental flow over the Falls in the dry season, leaving only room for a flow during the rainy season. However, as described in section 12.5.1 such data is uncertain and depends on Kapichira Reservoir Management by ESCOM and the MoAIWD. However, in terms of their attractiveness for tourism, the most impressive flows over the Falls are during the rainy season, when the difference in flow with and without SVIP will not be very noticeable. It is also important to note that, based on discussions with Majete Wildlife Reserve managers, tourist visitation to Majete is not dependent upon the Kapichira Falls. Although these falls are an attractive spot to visit within the Reserve (and most impressive during the wet season), tourist visitation to the Reserve is driven by other factors--notably Majete's diverse and abundant wildlife, extensive natural habitats, and comfortable facilities.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impact on Kapichira falls attractiveness. With SVIP, the attractiveness of the falls from a tourism standpoint will be less (due to reduced flows) except during the wet season (January-March).
Value of the affected component	Highly valued
Intensity	Medium
Extent	Punctual
Duration	Permanent
Significance	Moderate
Occurrence probability	High probability

13.10.1.7 Impact on Lengwe roads and infrastructures

Construction of Bangula canal will have an impact on fences and access roads of Lengwe National Park. The canal crosses paths inside the park at 4 locations:

- North Thicket Drive,
- South Thicket Road,
- Makanga Drive
- Tsanya Drive

These paths are used by tourist to travel in Old Lengwe. They were upgraded with World Bank funds (SRBMP) in 2015.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impact on Lengwe roads and infrastructures. The fence and park roads will be impacted
Value of the affected component	Highly valued
Intensity	Medium
Extent	Local
Duration	Temporary
Significance	Moderate
Occurrence probability	High probability

13.10.1.8 Loss of ownership of park management on the western side of LNP

Construction and operation of Bangula canal will split the park in two and could aggravate the weak message of ownership that management sends due to low presence of rangers in the western part of the park. The park has porous boundaries and surrounding villages do not fully accept the presence of a park (personal communication with park staff, 2015) as many use it as grazing area (personal observation, 2015, LNP General Management Plan GEF, 2016), as a source of timber (personal observation, 2015, satellite imagery interpretation, 2016) and as a source of bush meat (WESM, 2016). Deforestation, poaching and village encroachment are identified as the most threatening ecological issues of LNP by the general management plan (GEF, 2016). If the canal crosses the Park, a new infrastructure inside the Park, it may be interpreted by villages as a message that park management is “letting go” the western part of the park, leading to increasing occupation in this area and utilization of the Park resources. The presence of a canal could also become very attractive for livestock owner as watering point, further increasing the presence of cattle in the park.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Loss of ownership of park management on the western side of Lengwe. Construction and operation of the Bangula canal will split the park in two, this could be interpreted as a message of weak ownership
Value of the affected component	Highly value
Intensity	Medium
Extent	Local
Duration	Permanent
Significance	Moderate

Occurrence probability

Potential occurrence

13.10.1.9 The presence of a canal inside parks will be long-term agent of changes

Three new situations will bring challenges to park management:

- the presence a linear infrastructure inside parks ;
- the presence of new stakeholders with different interests ;
- new chains of responsibilities in decision making process.

The presence of a canal and the water intake will require additional efforts and inputs from MWR and LNP management in order to maintain parks' integrity. Negative impacts from linear infrastructures crossing natural habitats are well documented in Africa and the Feeder and Bangula canals will probably not be the exceptions. These canals may become agents of negative changes as management will have to deal with new stakeholders (the construction contractor and the scheme operator during operation), who's interests and actions may negatively impact them. Operation may also bring unexpected impacts from surrounding communities with increase encroachment as it is the case with linear infrastructures. In addition, there is a possibility that new impacts arise due to changes in layout, changes in scheme operator and unexpected events. If any such unexpected event takes place, the decision making chain of responsibilities may be too complex to allow parks to rapidly take action because of the presence of new stakeholders with fundamentally different interests:

- the construction contractor who's interest will be to deliver infrastructures within the delays and the allocated budget;
- the scheme operator who's interest will be to ensure delivery of water to water user associations within its budget (and, without proper sharing of information, may not be aware of all environmental and social risks);
- park management who's interest is the safeguard of wildlife and habitats while maintaining tourism financially viable.

Other risks may come from mitigation measures themselves as they may not work on the short and long terms since they are no or few return of experiences in Africa for many of the proposed mitigations (see other sections on the tiger fish and wildlife passes). The maintenance road along the canal will also represent an agent of change especially in LNP where communities will use it as a travel path as it is the case with an existing "unformal" road inside the park (see Vol.1 Baseline report). The following are examples of unpredictable impacts that could arise:

- Changes in wildlife behaviors regarding the canal: wildlife entering the canal to travel (causing damages to structures, leading to wildlife-human conflicts, etc.);
- The canal becoming very attractive to wildlife as drinking spots, as the quality of water will be better than in the reservoir or puddles from boreholes;
- Accident involving wildlife: what will happen if an antelope falls in the canal, breaks its legs and needs assistance to be extracted from the canal? What will happen if an animal drowns and dies in the canal? Who will pay for such unexpected impacts, who will extract the dead animals from the canal? How will maintenance interventions on the canal be planned? Who will pay for maintenance of wildlife passes? An animal in distress in a canal could give parks a bad image if the situation is filmed and published on social media, etc.
- Poaching from maintenance staff: what will happen if an employee of the irrigation operator is caught poaching?

All these represent risks that are difficult to assess.

In LNP, there is a risk that the Project aggravates existing issues in the Park:

- There is a risk that livestock use wildlife passes or drink from the canal, as currently in some areas cattle rearing takes place inside the park and law enforcement do not seem to efficiently fight this (farmers are even burning grazing sites inside the park to prepare for the rainy season!);
- There is a risk that poachers have an easier time hunting wildlife close to the canal as it may become a drinking spot;
- There is a risk that the canal may be used by villagers either to shortcut their travels (to the other side of the park) or to fetch for water.
- There is a risk that buffalos be tempted to exit the park and enter in surrounding fields. It has been reported that, in 2013, buffalos entered Illovo fields and remain there for a while causing damages to crops.

ASSESSMENT OF IMPACT SIGNIFICANCE

	The presence of a canal inside parks will be long-term agent of changes. The presence of canals and other infrastructures inside parks will require additional efforts and inputs from park management in order to maintain parks' integrity
Value of the affected component	Highly valued
Intensity	Medium
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	Potential occurrence

13.10.1.10 Summary of impact significance

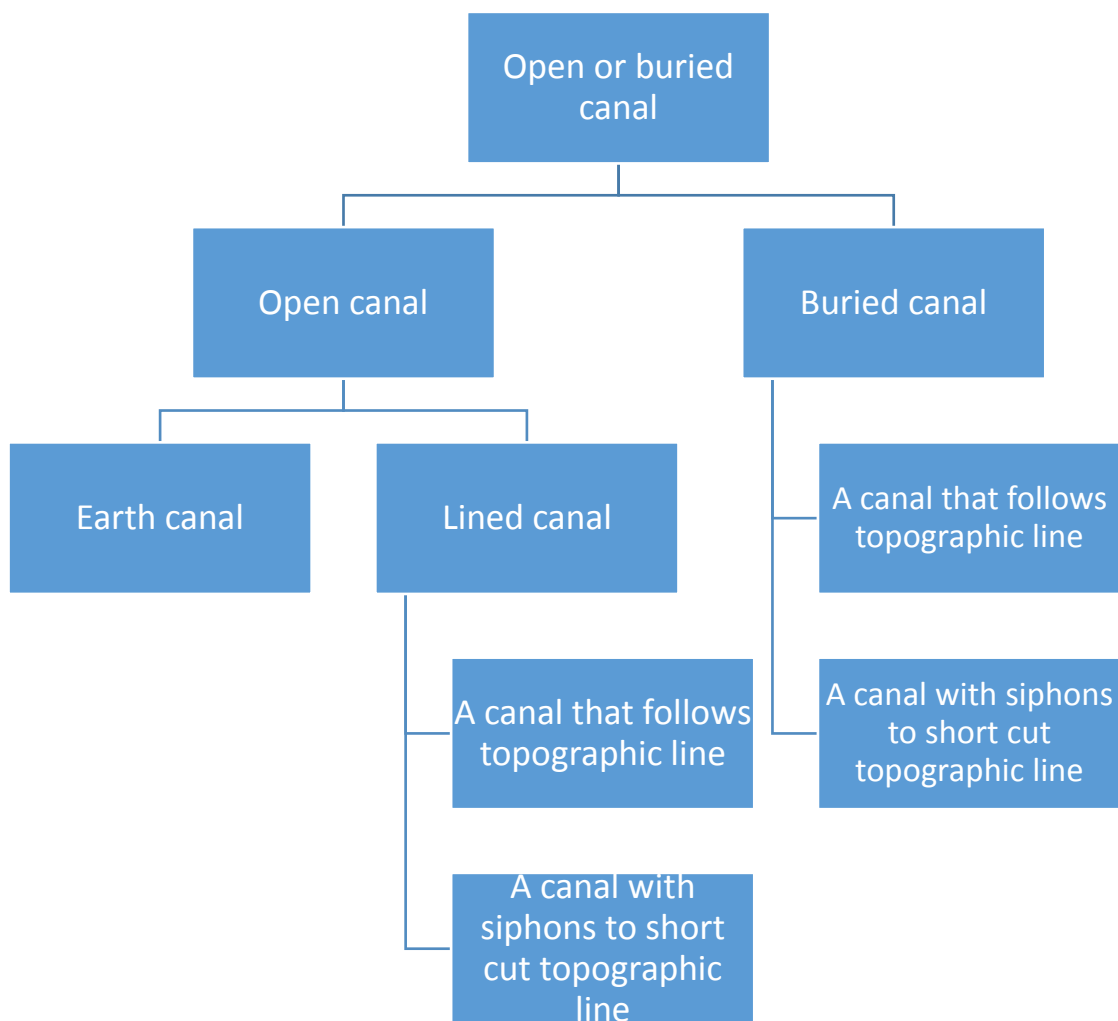
Impacts	Significance	Occurrence probability
Decision on the type of canal and its alignment route: Decisions regarding the canal layout during the design stage will have long term impacts on parks	Major	Potential occurrence
Decision on the status of canals inside parks: the presence of canals inside parks will require a clear definition of their status	Moderate	Potential occurrence
Tender process and selection of a construction contractor: the tender process for the selection of the project construction contractor represent a high risk for parks as it is a crucial step in development of binding environmental measures	Major	Risk (low probability)
Impact on tourism: Touristic activities will be compromised during construction activities across MWR and LNP and Ng'ona lodge	Moderate (MWR) / Minor (LNP and Ng'ona lodge)	High probability
Impact on Majete buildings, roads and infrastructures: Infrastructures will be disturbed by construction of the Feeder canal	Moderate	High probability
Impact on Kapichira falls attractiveness: The viability of the falls as a sight to see for tourists may be compromised on long term with reduced flows	Moderate	High probability
Impact on Lengwe roads and infrastructures: Construction of the Bangula canal will have an impact on fences and access roads of Lengwe National Park	Moderate	High probability
Loss of ownership of park management on the western side of Lengwe: Construction and operation of the Bangula canal will split the park in two, this could be interpreted as a message of weak ownership	Moderate	Potential occurrence
The presence of a canal inside parks will be long-term agent of changes: The presence of canals and other infrastructure inside parks will require additional efforts and inputs from park management in order to maintain parks' integrity	Moderate	Potential occurrence

13.10.2 Mitigation measures

13.10.2.1 Decision on the type of canal and its alignment route

There are several avoidance and mitigation measures when it comes to the layout of the canal. The following sections show the different options that could optimize the canal.

CANAL OPTIONS INSIDE MWR



Open versus buried canal

MWR: An open canal should be avoided as much as possible and the Design shall favor a buried canal or at least a closed canal in the area where the canal runs within the park fences. The canal route is important for tourists (viewpoint of the Kapichira falls in the rainy season, etc.) and for wildlife (access to drinking spots along the river).

A buried canal should be designed in order to mitigate the serious impacts on MWR. For the 50m³/s, underground pipelines will not be technical easy and difficult to access for maintenance, however underground concrete box culverts is a feasible option as presented in the FS. They would have to be designed to sustain the passage of vehicles and large animals such as elephants. This is why the term “buried canal” is more appropriate than “closed canal” as it implies a higher resistance to heavy loads.

LNP: there is less incentive to have a closed canal in Lengwe mainly because wildlife suffers from water shortage, a well-designed canal could even be an opportunity to have more water available for wildlife. More water could event lead to an increase of the carrying capacity of the Park.

Earth versus lined canal

MWR & LNP: an earth canal looks more natural than a lined canal. Therefore, having a lined canal has an impact on landscape. According to the FS, since soil permeability is very high in MWR water leakage will be very high if an earth canal is chosen. Therefore, the canal will be lined with concrete. In addition, given the presence of large mammals in MWR who enjoy using watercourses to bath such as elephant and hippopotamus, an earth canal will quickly be destroyed by these animals.

The FS has stated that soil properties allow for an earth canal in LNP with two permeability tests. However, fieldwork by the consultant along the canal alignment revealed that some areas are sandy. In-depth assessment would be required before stating that an earth canal will be implemented.

Changing the alignment route to reduce impacts (MWR)

The canal has to follow topographic contour lines. The question of changing the alignment route to short cut topographic lines were addressed and the FS has identified areas where an inverted siphon will allow to short cut topographic lines.

A section of the Feeder canal is passing close to building, this will call for mitigation measures (see section hereunder).

In addition, in many areas, the micro topography is very irregular as shown in the following figure along the canal foreseen alignment route (this was taken following the topographic pegs).

Figure 71 Example of the micro topography along one km of the Feeder canal (between KP 2.8 and 3.6)

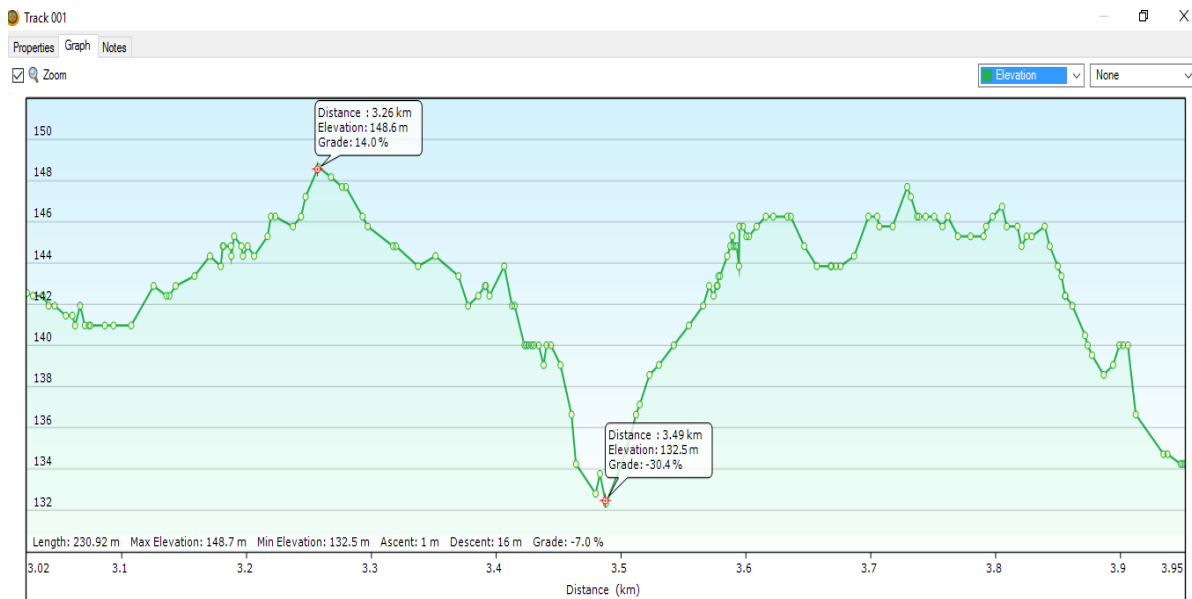


Figure 72 Exact alignment of the Feeder canal inside MWR according to the FS



A topographic peg is visible on the tree on the right photo. Source: BRLi, 2016

Summary of options for a canal inside MWR

The following sections highlight the differences between open and buried canal inside MWR. The current Final FS has optimized the Feeder canal based on technical and economic criteria with sections both open and buried (see project description). During the ESIA process, several options were studied by the FS, some were adopted others rejected:

- (i) location of the intake at Kapichira Dam, rather than Hamilton Rapids to greatly reduce the impact on MWR (adopted);
- (ii) location of the intake on the Left (East) Bank of the Shire River, completely out of MWR (rejected due to high cost and significant technical limitations with a canal crossing the Shire);
- (iii) location of the intake below Kapichira Dam (rejected, because pumping stations would be required, which would substantially raise the operating costs for the new irrigation farmers and make the project less financially viable); and

(iv) locating all of the Main Canal underground within the Majete Reserve (rejected because it would complicate construction of the invasive fish barrier, because the planned decorative walls will effectively prevent most wildlife from entering the canal, and because of the high investment and maintenance costs associated with underground canal).

This ESIA also highlights the need to study ways to optimize the canal based on environmental (under section 8.5.2) and touristic issues (under section 7.10.2). Whether the Feeder canal layout from the FS is final or not, the Design study shall further develop ways to minimize as much as possible impacts on MWR.

One guiding principle is that the canal alignment shall be optimized to have as much as possible buried section and to short cut to the maximum possible the distance inside MWR and to remain as far as possible from the reserve buildings (entrance gate, etc.).

CANAL OPTIONS OUTSIDE MWR

A water intake on the left bank of the reservoir beside Escom water intake

The relevance of having a canal inside MWR has been given consideration due to the major impacts on tourism and wildlife (chapter 8). During mitigation workshops (November 2016), it was requested that the FS studies the possibility of having a water intake on the left bank of the reservoir with an aqueduct crossing Shire River around the Escom tailrace. The riverbed and banks at this location are made of large rocks, and seems to be stable. Having an intake on the other side of the reservoir would keep MWR intact. This water intake could be located beside the current intake for the hydropower station. Unfortunately, due to the lower topography on the east bank of Shire, this option would represent a significant economic expense for an irrigation scheme that revolves around gravity irrigation. In addition, Escom has the intention to develop more infrastructures on this site. This option has been assessed in the final FS and proven not to be feasible.

CONCLUSION

These options have been presented to African Parks as part as stakeholder consultation, according to them a buried canal would be better than a lined canal, if stretched of the canal are open, African Parks has requested that vehicle and wildlife passes be installed as well as walls to avoid drowning.

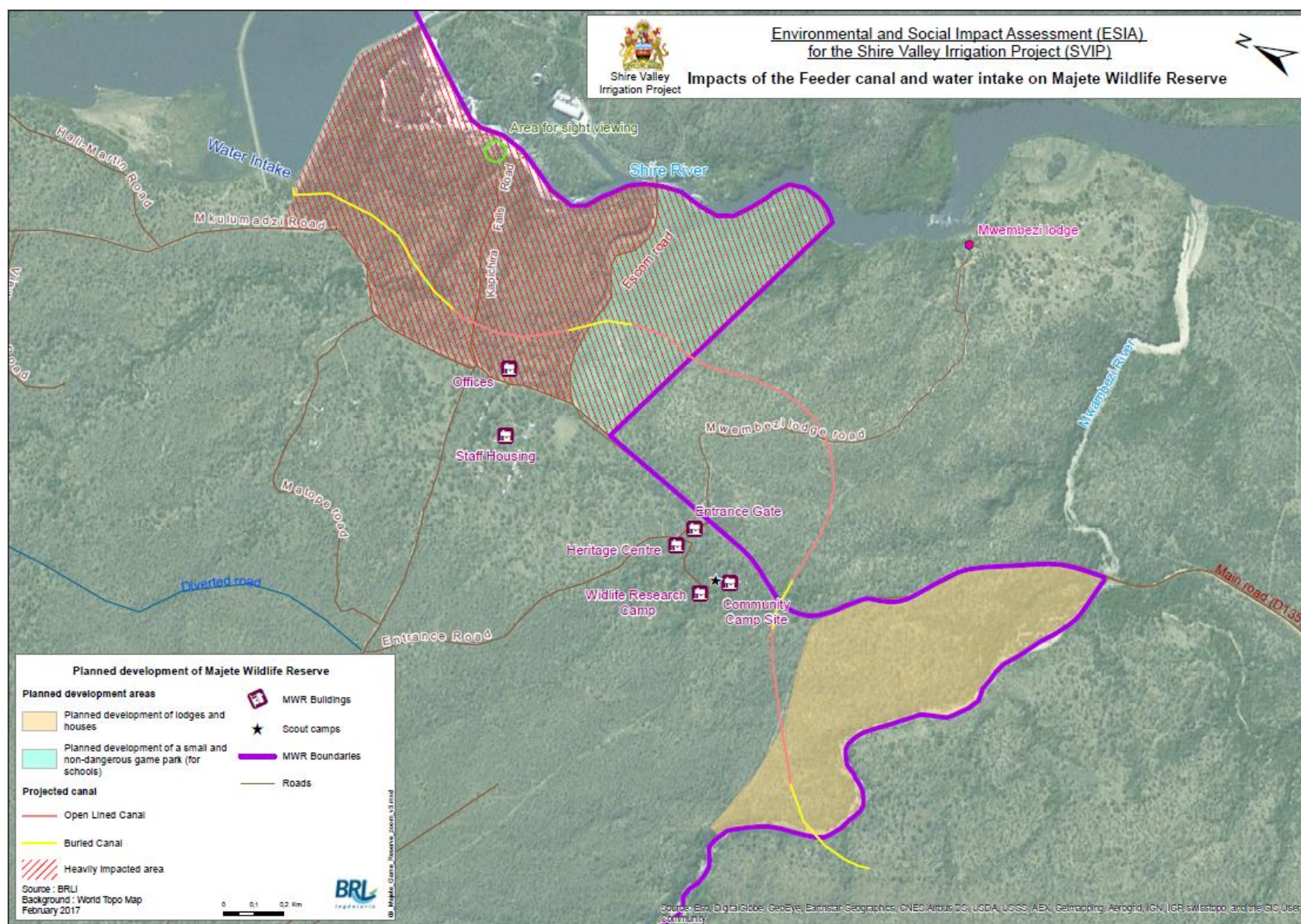
In areas where the canal is lined and open, major impacts on wildlife are to be expected, and mitigation measures should be implemented, their feasibility is studied in this report in the section on Ecology Impact (chapter 8). Therefore, in the final Design, the entire length of the Main Canal within Majete must be either buried, covered, or walled off to prevent wildlife (including all large mammals) from falling into the canal.

African Parks has plans to develop two areas impacted by the Feeder canal

It must be noted, that there is a large portion of MWR that is not fenced, but still falls under the MWR management to the East of the main road where the proposed canal will now run through. MWR reserves the right to develop this area and has a plan to do so. African Parks has approved one project within MWR boundary: a small area for non-dangerous wildlife observation (antelopes, etc.) for school trips and children. This area is located on the Feeder canal alignment route between KP 1.25 and 1.65. In this area, the canal will be open and will require mitigation to avoid children and animal drowning. On the other hand, at this location, an open canal can provide water for wildlife by creating a small wetland which would become an important asset. The wetland could be around 30 meters in diameter and shall be lined with concrete to avoid seepage, with a depth of 0.5 m, it would require about 350 m³ of water from the canal, filled every two days, this would be the equivalent of 1230 m³ per week (or 0.002 m³/s) which is negligible in regard to the volume of water in the canal. Another project is under study along the canal alignment route: the development of housing and lodge units at the southern tip of MWR. These two areas are presented in the map hereunder.

Buried canals reduce aesthetical impacts and erase the need for wildlife passes. However, a buried canal does not mitigate all impacts such as those related to construction activities since it requires blasting activities.

All have to be studied in depth at the design stage, in consultation with African Parks. In addition, all options have to be studied in light of recommended mitigations for ecological impacts (see chapter 8).



CHANGING THE ALIGNMENT ROUTE TO REDUCE IMPACTS (LNP)

Due to topographic constraints illustrated on the topographic map and characterized on the field, the canal cannot shift further westward from the Old Lengwe to minimize impact on thicket habitat (see chapter 8). The next figure illustrate topographic changes across the canal section (from BRLi field work). Therefore, there is no possible measures to change the alignment route, siphons are not necessary since there is not steep slopes inside the park.

Figure 73 Elevation constraints in LNP



13.10.2.2 Decision on the status of canals inside parks

The canals shall remain within the MWR and LNP “administration” and the right-of-way of canals shall not be alienated from MWR and LNP. Access to the intake and canals for maintenance will be managed in accordance with African Parks and LNP access restrictions (and inspection to avoid poaching). This means that there shall not be any independent access gate to canal maintenance road inside MWR and LNP. Scheme operator staff shall enter and exit parks as every visitors entering the parks.

In case of wildlife passages (and other civil engineering infrastructures within the park), their status shall be clearly defined in order to clarify who will be responsible for maintenance of such passages and infrastructures. A Memorandum of Understanding between the project operator and African Parks/LNP will be necessary to ensure long-term commitments.

African Parks/LNP management need to become important stakeholders in the project next steps including in the design review phase and advice on the tender process for the construction and operation of the scheme.

13.10.2.3 Tender process and selection of a construction contractor

The tender process for the pre-selection and selection of a construction contractor is a crucial step, it is at this stage that risks can be partly managed. It is therefore strongly recommended that:

- the tender document requires that the construction contractor has several references in work in parks or environmentally sensitive areas and that these references be verified to ensure that work went well (reputation of the contractor shall be checked before the selection). In order to verify the contractor's reputation the following method shall be applied:

- The bidding document and contract shall reflect the new requirements of the World Bank as highlighted in the document “Summary of Environmental, Social, Health and Safety (ESHS) Enhancements Standard Procurement Documents (SPDs) & Standard Bidding Documents (SBDs)” One of its requirement is that: “Applicants/Bidders/Proposers are now required to make a declaration listing any civil works contracts that have been suspended or terminated by an employer and/or performance security called by an employer, for ESHS reason/s.”
 - The bidding process shall be a two-step one with pre-selection and selection
 - The Procurement specialist shall include “special pre-selection criteria” such as :
 - Number of past failures to complete the contract.
 - Length of time in business.
 - Self-assessment of past client relationship
 - Self-assessment of other relationships (surrounding communities and stakeholders) presenting past claims by NGOs, claims by traditional authorities, etc.
 - Description of past injuries where the bidder is required to provide with a list of past injuries and deaths on construction site
 - Past projects concerned by an ESIA, ESMP and RAP and monitoring and auditing activities. A reputation
 - A “Tender Panel” shall be put in place for the pre-selection process. This panel shall assist the Procurement Specialist in the evaluation of each criteria. This panel shall be composed of NGOs, and important stakeholders such as DNPW, African Parks, etc.
 - For each of these criteria, the bidder shall provide answers and the procurement specialist shall set thresholds. Investigation could be done by the procurement specialist in compliance with national regulation.
- the tender document for short-listed firms includes all applicable environmental and social measures from the Environmental and Social Management Plan (ESMP).
 - the tender document quantifies needs in terms of mitigation to ensure that the contractor adequately budgets mitigations such as rehabilitation of areas affected by earth work.
 - African Parks and DNPW be involved in proof reading the tender document and the contractor’s contract (or at least parts of it that relate to work within their boundaries) and shall be part of the Tender Panel.
 - the tender document requires the contractor to have a wildlife or environmental specialist in its staff (in addition to a health and safety specialist) that reports to and consults with African Parks and LNP on a daily basis.
 - the contract includes sufficient leverages in cases where the contractor does not respect the various site sensitivities. Delays in payment or reduction of payment shall be applied for non-compliances.
 - local law enforcement be involved in cases of serious unlawful activities such as poaching and prostitution.
 - that the tender document and the contract clearly state roles and authority of African Parks and LNP (DNPW) as well as chains of responsibilities during construction.
 - the contract includes obligation of termination for work in a set timeframe (and compensation for African Parks in case of delays).
 - In addition, African Parks and the DNPW should have a right to review the Design for the upcoming Phase I and to propose improvements, as Phase I will soon start.
 - African Parks and the DNPW shall have the full authority to stop work and take quick actions in cases of serious non-compliances and offences without having to go through long processes of communication. This authority shall be formalized before construction starts and shall be added in the contractor’s contract.

In order to benefit from the return of experience of the work inside MWR, it will be important that environmental measures regarding Bangula canal in LNP be adapted once work has reached Phase II.

13.10.2.4 Impact on tourism

The following mitigations will reduce impacts on tourism:

- The most important mitigation is the provision of funds for compensation due to loss of business. With about 1 truck passing every 1 to 5 minutes, tourism will be affected and, even if work is confined, wildlife will probably hide further inside the reserve (this leads to other impacts as detailed in Chapter 8). A fund for losses shall be provided for the time of construction in addition to fund to produce pamphlets or online advertisements prior to work and after work is over to present the work and to advertise the reserve after work (distribution of vouchers, etc.). These compensations are detailed in the ESMP (Vol.3).
- Regarding transportation of dredged sediment, discussion shall be engaged at Government level about ways to dispose of this large amount of sediment and about the need to avoid storing them within MWR. This will be covered, as necessary in a Dredged Materials Management Plan.
- African Parks wishes that construction of the Feeder canal starts and finishes between January and February the same year (in the quietest time of year), or at least that the core of the work takes place during these two months. For noisy operations (blasting, dredging, etc.), the contractor and African Parks shall define times for construction. Noisy processes will be preplanned with warnings and shall not take place during Friday through Sunday and holidays (days which receive a majority of the overall tourist visitation). To minimize disturbance to wildlife as well as tourists, blasting will only be allowed during 11 am to 2 pm (the hottest hours of the day, with generally the least wildlife activity).
- Earth works shall be limited to the path of the canal and all bare soil shall be rehabilitated at post construction in consultation with African Parks. The same rule applies to LNP and rehabilitation shall be done in consultation with DNPW.
- Excavated materials shall be dumped in predetermined area such as a quarry, outside MWR/LNP or only in designated areas specified by African Parks/DNPW.
- Surplus materials suitable for road surfacing shall be used for upgrade of road surfaces in MWR/LNP under the supervision of MWR management/DNPW.
- The contractor will have to restore the road from Chickwawa to the reserve and budget this restoration.
- Temporary construction roads and tracks shall be limited to immediately adjacent site along the canal in the predefined footprint (10m) from the canal path, these roads and tracks shall be rehabilitated upon completion of construction based on decision by AP (either decommissioned or kept and upgraded for visitors).
- The dredger for the water intake (as part of the preparation for the water intake) shall operate at night, if possible (between 9pm to 5am), dredged spoils cannot be stored in MWR (even temporarily).
- The FS report has recommended that noise and dust barriers be installed close to MWR offices and community camps to reduce visual, air quality and noise impacts. In fact, the barrier shall be moved as construction progresses (using mobile noise barriers). These noise barrier must be absorbent (non reflective) and have to be high enough to absorb noise from blasting (at least 3 meters high). Only certified absorbent noise barrier shall be used. Whenever blasting will be used, the best method shall be used. In South Africa, several firms have developed environmentally friendly technics for rock blasting in sensitive areas. An example of such method is called "precision rock blasting" in which cartridges are introduced in drill holes. This technic leads to minimal vibration, noises and flying debris (CN Plant Hire & Rock Blasting, 2016).

- Other compensation proposed by MWR management include:
 - Paving the actual road from Chickwawa to the reserve. This will not lead to impacts as the existing road is already graded
 - Providing a pipeline to extract some water from the canal for water supply for our staff village of around 30 households. The actual borehole for the staff village gives yield issues in the dry season.

Figure 74 Mobile noise barrier



Source : Sound Fighter © System, 2016

All specific equipment required to mitigate impacts shall be installed and on-site prior to beginning of work. The schedule of work shall be agreed upon before beginning of work.

Ng'ona lodge (also called Mwembezi lodge) is a private property and the impact from the canal construction and the canal RoW shall be assessed in development of the RAP. Mitigation and compensation includes dust control (with the same frequency as MWR), access road repair, compensation for loss of business, production of information pamphlet for clients, compensation for loss of tree, etc. The lodge will however probably not be affected by noise (as it is located 30m lower than the canal).

Phasing the work inside MWR and Ng'ona lodge private property in three distinctive confined areas is absolutely necessary (so that no work takes place in several areas):

- “Heavily impacted area” (first phase)
- Mwembezi lodge private property (also called Ng'ona lodge) (right outside MWR) (second phase)
- Southern MWR (third phase) from Siphon #2 to Siphon #3

This three phases shall be completely fenced, in order to completely isolate work and to keep wildlife away.

The Design study has to study ways to phase the Project, this would require that excavation is done in one area and followed directly by concrete lining work before reaching the next phase.

Phasing the work shall be mentioned in the call for tender of the construction contractor so all interventions are planned.

13.10.2.5 Impact on Majete buildings, roads and infrastructures

Since the Feeder canal is passing very close to many MWR buildings, mitigation and compensation in case of damages to building and infrastructures should be planned:

- To avoid causing disturbances to reserve buildings (and to keep canal as far as possible from them), an inverted siphon is designed in the FS to short cut the reserve as much as possible (as discussed above).
- Destruction of building is not likely to take place. However, if for any reason it is necessary, the developer has to compensate African Parks for all buildings that will be destroyed to complete rebuild of facility in agreed upon location to a minimum of a similar standard and extent the cost of replacement of such building (according to OP 4.12 on involuntary resettlement). New buildings will have to be completed before the start of construction of the canal so that there is seamless transition to the new facilities before the existing facilities are affected. Costs are in the ESMP (Vol.3).
- All reserve infrastructures shall be assessed prior to machinery deployment. Groundtruthing site visit with African Parks and the contractor shall be done in order to ensure that the contractor repairs all damages to road, water boreholes, building, fences, etc. Pictures shall be taken to assist groundtruthing visit. The main road to Chickwawa should be inspected prior to construction by African Parks, the contractor and Escom to determine a baseline status and to inform any damages that are incurred during the construction process.
- Roads (Hall Martin drive and beginning of Mkulumadzi road) will not be usable by tourists during and after construction due to disturbance and the changed environment. Compensation will be necessary to reroute roads and provide alternatives for tourists to avoid the Hall- Martin road and alternative routing to access southern portion of Mkulumadzi road. The previous map shows a proposed alternative road for tourists (diverted road). In addition, a vehicle bridge shall be installed at Kapichira falls road and on the road to Ng'ona lodge (outside MWR property). Alternative roads and the diverted road shall be finalized prior to all other activities inside the reserve.
- The Contractor shall regularly maintain Chikwawa to Majete main road (D135) in good condition, and the possibility of upgrading this road to asphalt should be considered.
- At a minimum, daily dust control interventions must be put in place along Chikwawa to Majete main road (and within the park). During the dry season (May to November), dust control shall be done every two hours (with water only). This will also ensure that villages close to the road are not impacted by dust. The source of water for dust control shall be taken from outside MWR and outside the Kapichira reservoir and in consultation with local communities. If water is pumped from the Shire, the access shall be stabilized to limit erosion in the river (concrete access ramp).
- Areas where fences will be affected will have to be compensated. Contractor will ensure there is no breach of the fence during construction. All repairs and newly required fence sections will be for the cost of the contractor but done by approved African Parks contractors.
- African Parks also proposed as a compensation for impacts that a pipeline be built to bring water to the rangers housing compound (about 30 houses).

13.10.2.6 Impact on Kapichira falls attractiveness

An interesting mitigation that was considered would be to implement timed releases at the sluice gates and to inform MWR visitors on time and season where the falls will be visible. Timed releases of flow is however not recommended since:

- effective coordination of timing of flow releases between ESCOM and African Parks would entail high transaction costs and limited likelihood of real success (visually impressive flows at a guaranteed, pre-arranged time of day are not very likely to happen in practice);

- daily flushing of the falls would be harmful to aquatic and terrestrial wildlife adapted to the dry season Kapichira Falls environment of relatively dry falls with numerous dry boulders and some trickles and pools of water.

As mentioned above, the most impressive flows over the falls will remain during the rainy season which will be less impacted by SVIP.

13.10.2.7 Impact on Lengwe roads and infrastructures

Where Bangula canal crosses roads, a vehicle bridge shall be installed. Based on available map of the park, there are four areas where a bridge shall be installed:

- North Thicket Drive,
- South Thicket Road,
- Makanga Drive
- Tsanya Drive

The map on impacts on LNP shows these roads.

In addition, the project may impact boreholes for watering point that were funded by the SRBMP (still underconstruction). These will have to be avoided or rebuilt to a new location if necessary since Bangula canal may also be utilized to create watering points.

Access to the canal RoW by the construction contractor shall be done from the side of the Park (northern and southern part) and not from existing touristic roads. However, during operation, access to the canal service road shall be done by the Park's entrance only and not by an independent road.

13.10.2.8 Loss of ownership of park management on the western side of Lengwe

The activities of the current Shire River Basin Management Program and the new General Management Plan under SRBMP (GEF, 2106) have developed their own measures. Since the ESMP (Vol.3) only addresses Phase I, Phase II ESMP shall be coherent with SRBMP.

LNP could receive long term funding to improve its governance in the Park, this would include funding for additional staff on field. As part of mitigation for SVIP impacts, a permanent ranger scout for a team of rangers should be installed along the Bangula canal to keep poachers and settlers away. In that case, it is suggested to install this scout close to a wildlife pass as presented in the next sections. Park management also has to require its staff to move further west from their usual rounds.

13.10.2.9 The presence of a canal inside parks will be long-term agent of changes

In order to prepare for long term risks and to ensure that stakeholders interests and mainly those of parks are not affected by others, clear chain of responsibilities have to be defined taking into account all possible situations and “worst case scenarios”. A Memorandum of Understanding (MoU) shall be signed between African Parks and the scheme operator for MWR and between the Department of National Parks and Wildlife (DNPW) and the scheme operator for LNP to ensure long-term commitments. It is recommended that this MoU clearly states that African Parks and the DNPW shall never be responsible for animal damages to project infrastructures and that maintenance of all wildlife passes and other infrastructures proposed in this ESIA shall be done (and budgeted) by the scheme operator (including the fences or walls around the canal).

Regarding LNP, it is recommended to:

- Install a ranger scout along the canal close to a wildlife overpass ;
- Install an artificial wetland on the eastern side of the canal (as presented in Chapter 8) ;
- To sort out all existing issues as described in the General Management Plan of LNP (GEF,2016) (poaching, illegal wood clearing, lack of reliable fence and buffalo entering Illovo field, current issue with Bailey Bridge that has collapsed, lack of field equipment, vehicles and communication equipment, etc.) before implementing any sort of mitigation or compensation measures as these existing issues could aggravate with the Project implementation. This implies that compensation for LNP due to impacts from SVIP could also be oriented to solve current issues:
 - Installing fences to keep buffalos from entering Illovo estate (part of SRBMP funds is currently oriented at installing new fences) and future irrigated lands.
 - Building a new bridge across Nkembedzi Wa Fodya River to replace the current Bailey Bridge (however this may be done before Phase II because it is completely destroyed).
 - Improving existing infrastructures and equipment of the park.
 - Improving existing drinking spots for wildlife.
 - etc.

For both the LNP and the MWR and in fact for all other risks presented in this report, the PPP report shall clearly highlights the environmental and social risks in order to properly inform the future scheme operator and investors.

14. ECOLOGY IMPACT ASSESSMENT

14.1 INTRODUCTION

This section deals with impacts of the Project on biodiversity.

CRITICAL NATURAL HABITAT

Under the World Bank Operational Policy 4.04 on Natural Habitats, critical natural 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 endangered species are highly depended of their features to complete critical phases of their life cycle”.

Two elements have to be highlighted regarding the safeguard policy on Natural Habitats (OP 4.04):

- the Elephant Marsh could be considered a Critical Natural Habitat because it is proposed for Ramsar Wetland status, while the rare thicket ecosystem is contained within the Lengwe National Park which is a Critical Natural Habitat by definition under OP 4.04.
- the SVIP Program (both the upcoming Phase I Project and the proposed Phase II Project) complies with OP 4.04 because it would not cause the “significant conversion or degradation” of Elephant marsh, MWR and LNP thickets as demonstrated in this chapter.

MWR and LNP are both Critical Natural Habitats as they correspond to all criteria of OP 4.04: legally protected or officially proposed for protection, identified by authoritative sources for their high conservation value and recognized as protected by local communities.

As presented in this chapter, the Project will impact these critical natural habitats but not a point where significant conversion or degradation of natural habitats will take place as severe impacts are socioeconomic impacts (see impact assessment on Natural Heritage). Regardless, as required by OP 4.04, mitigations must be implemented.

MWR is affected by Phase I while LNP will mainly be affected by Phase II. MWR has elephants and the presence of such animal will be an issue for the integrity of the canal since elephant are known to “sabotage” infrastructures when searching for clean water (Elephant Specialist Advisory Group, 2013). This is why the canal in MWR will either be buried or walled.

Given the current issues with LNP (see Vol.1 Baseline report): poaching, lack of human resources, lack of equipment, etc. and the fact another program from the World Bank aims at improving the Park (SRBMP), this ESIA highlights that impacts on LNP could be minimized to an acceptable level as long as recommended mitigations are implemented and that the canal is used as an opportunity to provide drinking water for wildlife. In fact, the presence of water in LNP may increase the park carrying capacity for wildlife.

For both parks, the amount of cleared trees and thickets shall be fully compensated by replanting native species in degraded areas inside parks. This would involve installing a local tree nursery as soon as possible (for LNP) and providing funds to MWR for its existing nursery.

14.2 IMPACT IDENTIFICATION MATRIX ON ECOLOGY

	Pre-construction	Construction	Operation
Land cover	No impact during pre-construction phase	Rapid change in land cover: the Project will lead to significant changes in land cover	
Terrestrial habitats and wildlife		Disturbances of wildlife and vegetation: work will generate noise and necessitate forest and thicket clearing in the right-of-way destroying some habitats and startling wildlife	Habitat fragmentation: with the canal passing through MWR and LNP, wildlife habitats will be fragmented Drowning hazard for wildlife: open canals represent a drowning hazard for wildlife
Wetland habitats and wildlife			Changes in plant composition in Elephant marsh: reduction of flow due to abstraction of 50m ³ /s will affect plant composition Wildlife-human conflict: There is a risk that hippos and crocodiles enter the drains and cause wildlife – human conflicts (and casualties). Irrigated field will become very attractive for wildlife.
Aquatic habitats and fish		Disturbance to fish migration to spawning sites: works in temporary	Risk of Tiger fish invasion in the upper Shire: floods from the Shire

	Pre-construction	Construction	Operation
		rivers could lead to disturbances of fish migration	in canals could lead to invasion of the Tiger fish in Lake Malawi Reduction of suitable habitat for fish in the Elephant marsh: reduction of flow will lead to decrease of suitable habitats in the marsh Disturbance to fish migration to spawning sites: permanent infrastructures and channelization of tributary rivers could disturb fish migration to spawning sites

14.3 AFFECTED COMPONENT VALUE

Component	Component value
Land cover	Land cover is weakly valued since the area is an agricultural area with heavy pressure on land cover from this activity
Terrestrial habitats and wildlife	These three components are highly valued as natural habitats are fragile and some, as thicket in LNP, are rare and imperiled.
Wetland habitats and wildlife	
Aquatic habitats and fish	

14.4 LAND COVER

DESCRIPTION OF IMPACTING ACTIVITIES

The impact matrix has identified the following activities and impacts:

- The project construction and operation will lead to significant changes in land cover (**Rapid change in land cover**). Based on a right-of-way (RoW) of 45 m around main canals and the extent of the command area (and the definition of land cover types of the FAO, 2013), the project will permanently change approximately 34 571 ha of land cover types to irrigated crops and, to a lesser extent, to canals and maintenance roads. Most lands are already cultivated or urbanized. About 4900 ha of natural or semi natural land classes including rivers will be changed to irrigated agriculture or affected by infrastructures (river crossings, river channelization, etc.). The following table summarizes expected land cover changes (including canal RoW in LNP and MWR). The existing irrigated land for sugar cane (close to 16, 000 ha) will not be modified, therefore it is not presented in the total.

Table 21 Land cover changes

Land Cover types	Command areas and canals	Area (ha)
Built Up Area(s). These are urbanized areas (Nchalo, Ngaba, Chikwawa, etc.)	A	486.6
	B	913.9
	C	570.0
	D	738.4
	I 1	312.6
	I 2	190.0
	Bangula canal	59.0
	TOTAL	3270,5
Closed Broadleaved Deciduous Trees. This class includes dense forested areas (natural or semi natural)	I 1	12.3
	I 2	70.6
	Bangula canal	13.4
	TOTAL	96,3
Closed Herbaceous. This class includes dense grassland with sparse trees and shrubs (natural or semi natural)	B	13.1
	C	1 357.0
	A	19.1
	B	645.5
	C	950.5
	D	201.6
	I 1	208.0
	I 2	29.2
	Bangula canal	10.4
	Feeder canal	10.8
	TOTAL	2088,2
Open Woodland with Herbaceous Layer. This class includes habitats that are mainly covered by trees with open canopy and herbaceous layer. Most of LNP, MWR and hilly areas fall under this category (natural or semi natural)	A	442.5
	B	28.0
	D	988.0
	I 1	648.7
	I 2	199.8
	Feeder canal	120.5
	Supini canal	7.1
	Bangula canal	87.8
	TOTAL	2522,4
Post Flooding Cultivation. Refers to "dimba agriculture" carry out in dambo	A	861.2
	I 1	103.9
	I 2	188.9
	Supini canal	19.5
	Bangula canal	7.1
	TOTAL	1180,6
Rainfed Herbaceous Crop(s). Refers to areas of rainfed agriculture	A	2 886.4
	B	2 037.5
	C	7 736.5

Land Cover types	Command areas and canals	Area (ha)
	D	1 490.8
	I 1	2 732.3
	I 2	255.4
	A	130.7
	B	3 179.3
	I 1	3 114.7
	Feeder canal	70.9
	Supini canal	24.1
	Bangula canal	243.0
	TOTAL	23 901,60
Rivers	A	141.8
	Feeder canal	7.7
	Bangula canal	1.3
	TOTAL	150,8
Other	I 1	3.9
	GRAND TOTAL	34 571,30

ASSESSMENT OF IMPACT SIGNIFICANCE

	Rapid change in land cover. The command area will lead to significant changes in land cover
Value of the affected component	Weakly valued (highly valued land cover types such as those found in LNP and MWR are discussed in the terrestrial habitat section)
Intensity	High
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	High probability

MITIGATION MEASURES

Most changes to land cover are inevitable. However, impacts within park shall be compensated by planting the equivalent of affected trees (see next section). In addition, some land could be set apart for protection either because they are the last remaining semi-natural areas, are valuable habitats for small wildlife, because they are grazing sites or because they are flooding area that help to sustain small wetlands. With current information about the canal alignment route, no recommendation can be made for land affected by canal.

Setting aside land as a mitigation measure will not necessarily imply that irrigated land will be lost, as the limiting factor is water not as much as available land. However, it will allow the Design study to fine tune each command area taking into account these sensitive areas and to study the possibility to expend the irrigated land in areas with lesser value. A map next page shows areas worth paying attention.

The following table identifies areas that are worth considering for protection from the irrigation scheme based on FAO (2013).

Table 22 Land cover that shall be set aside for protection

Land Cover types	Command areas and canals	Area (ha)	Land to consider setting aside
Closed Broadleaved Deciduous Trees. This class includes dense forested areas (natural or semi natural)	I 1	12.3	These areas shall be protected as they most likely are valuable sources of logs for communities
	I 2	70.6	
	Bangula canal	13.4	
	TOTAL	96,3	82.9
Closed Herbaceous. This class includes dense grassland with sparse trees and shrubs (natural or semi natural)	B	13.1	These areas shall be protected as they most likely are grazing sites for livestock
	C	1 357.0	
	A	19.1	
	B	645.5	
	C	950.5	
	D	201.6	
	I 1	208.0	
	I 2	29.2	
	Bangula canal	10.4	
	Feeder canal	10.8	
	TOTAL	2088,2	2067
Open Woodland with Herbaceous Layer. This class includes habitats that are mainly covered by trees with open canopy and herbaceous layer. Most of LNP, MWR and hilly area fall under this category (natural or semi natural)	A	442.5	These areas shall be protected as they most likely are sources of logs and grazing sites
	B	28.0	
	D	988.0	
	I 1	648.7	
	I 2	199.8	
	Feeder canal	120.5	
	Supini canal	7.1	
	Bangula canal	87.8	
	TOTAL	2522,4	2307
Post Flooding Cultivation. Refers to "dimba agriculture" carry out in dambo	A	861.2	Not necessary to protect as these lands are already cultivated
	I 1	103.9	
	I 2	188.9	
	Supini canal	19.5	
	Bangula canal	7.1	
	TOTAL	1180,6	1154
Rivers	A	141.8	River channelization shall be avoided

Land Cover types	Command areas and canals	Area (ha)	Land to consider setting aside
			whenever possible and their natural flooding areas free from activities
	Feeder canal	7.7	
	Bangula canal	1.3	
	TOTAL	150,8	141.8
Other	I 1	3.9	
	GRAND TOTAL	6042,2	5752,7

By looking at updated satellite imagery, it is clear that tree-clearing activities have already removed much of the “Open Woodland with Herbaceous Layer” and “Closed Broadleaved Deciduous Trees” in the command areas, therefore some of the previous figures (Table 13) are no longer accurate and 5752.7 ha cannot be set aside. A more accurate assessment (than the assessment presented in the previous table 13) based on 2016 imagery shows that valuable open woodland cover about 720 ha of the command areas (this figure does not consider small patches of woodland). The following map, shows the 720 ha of woodland worth considering as set-aside land. In addition to woodland, in Zone A 34.5 ha of a marsh called Thanda marsh and an unnamed grazing area of 29 ha shall be set-aside as well. Among the estimated 4000 ha of heavy vertisols (see Baseline report), some 2000 ha are well delineated in Zone C, and areas considered non-manageable shall be given consideration to be set aside. About 430 ha of land are regularly flooded in Zone B along the Nkombedzi Wa Fodya River, this land also shall be considered to be set aside. Lastly, 141.8 ha of river banks with an additional buffer zone of at least 10 meters shall be protected.

The Mphoza dambo is safeguarded from the Project (see Baseline report).

Table 23 Lands to be set aside

Land cover type	Command areas	Approximate area (ha)
Open woodland (including riparian forest)	A	161
	A	181
	A	20.8
	I 1	67.7
	I 1	43.9
	B	88.8
	C (riparian forest)	12.8
	D (contiguous to Nyasa private wildlife reserve beside Kaombe sugar estate)	144 (this surface is the part of woodland beside Nyasa that is affected by the command area)
Marshes and flood prone area	A (Thanda marsh)	34.5
	B (flood prone area)	429
Heavy vertisols	C	1477
	C	672
Grazing area	A	27.8
Rivers	Everywhere	141.8 + 10 meter buffer zone on both banks

In addition, large baobab and small communal forests shall be avoided (not clear-cut) when developing the command area. It is recommended, that before clearing forest or bushes, the following protocol be followed by the Engineer in charge of work plans and supervision of work:

- Make sure that there are no protected trees, shrubs or plants (National Parks and Wildlife Act (Act No. 11 of 1992) by requesting a clearance from the Department of National Parks and Wildlife (DNPW);
- Establish contact with the DNPW to know what is the procedure in case of protected tree in the canal right of way;
- Make sure the forest or bush does not hide a graveyard by talking to village headman (part of the Code of Conduct);
- Make sure that all cut trees return to their owners;
- Make sure that borrow pits, roads and other infrastructures do not destroy protected trees.

The following two pictures show, based on the consultant's return of experience in construction of irrigation schemes, two failed mitigation measures to safeguard protected trees and the reason why they failed. They are shown as examples to avoid.



Source: BRLi, 2017

The construction contractor took the advice from the Engineer to protect the tree at the borrow pit site because of its protected status. However, the contractor's poor judgement and lack of environmental sensitivity has left the tree dead in one season. Roots were dried by exposed sun (the mound is about 5 meters high).

What should have been done: a protection area of at least 10 meters should have been delineated with construction fences, and the slope should have been more gentle to avoid affecting soil property where the tree is rooted.

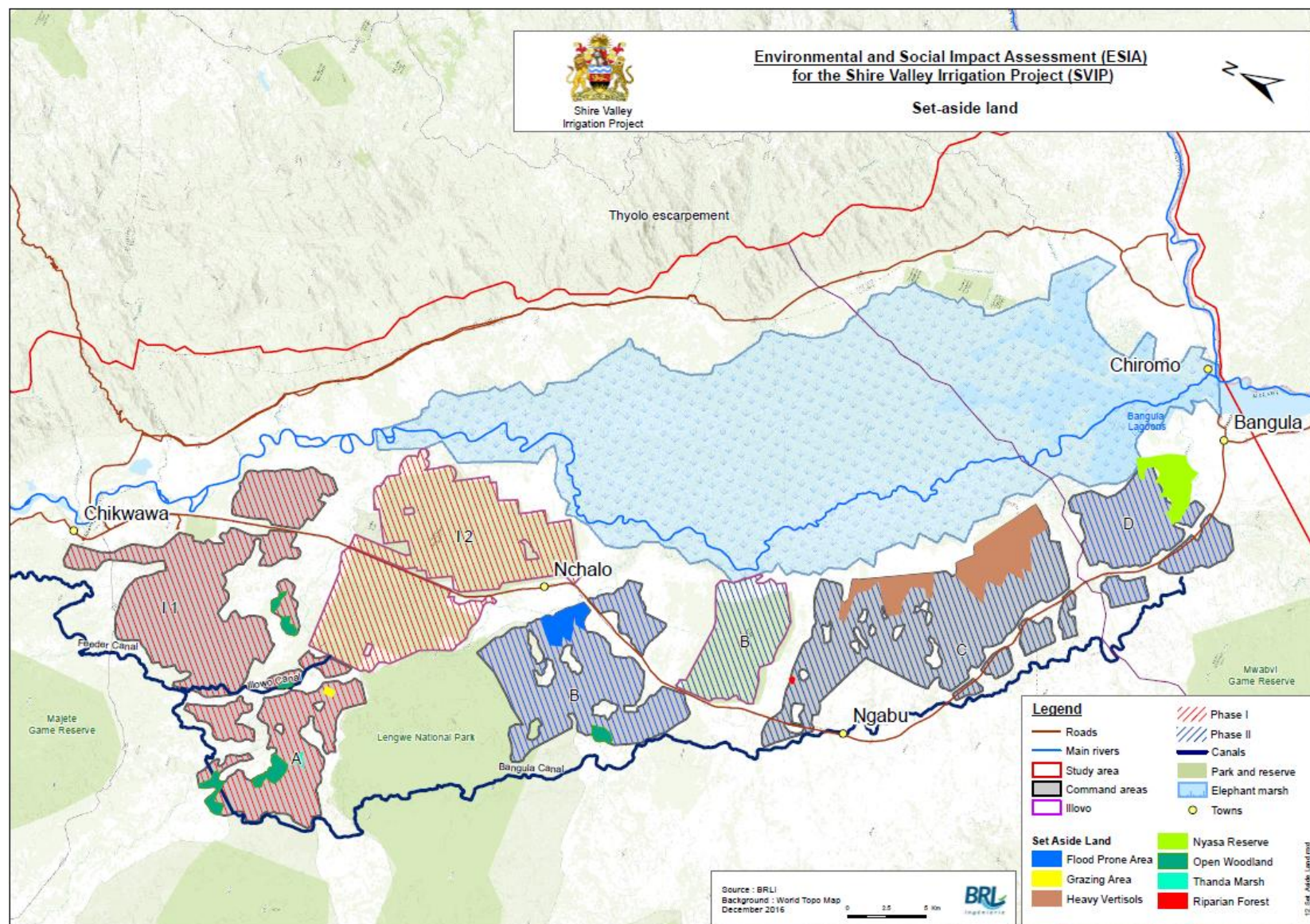


Source: BRLi, 2017

The protected tree was in the way of the canal, the project spend tens of thousands to avoid it by creating a bend in the canal route.

However, nearby excavation, the drainage ditch on the left, compaction and earth fill to create the maintenance road have left the soil impervious to water and has created drainage. The tree died in one season.

What should have been done: the avoidance measures shall not have been implemented and the tree should have either been cut and the lost compensated in close consultation with authorities or the access road should not have completely surrounded the tree. Any action leading to changes in soil properties will affect vegetation.



14.5 TERRESTRIAL HABITATS AND WILDLIFE

This section describes impacts on parks on an ecological point of view (wildlife movement, etc.) The section on “Natural heritage” discusses impacts on parks from a socioeconomic perspective (tourism, management and infrastructure).

The impact matrix has identified the following activities and impacts.

14.5.1.1 Disturbances of wildlife and vegetation

During construction of the scheme, work will generate noise and necessitate forest clearing in the right-of-way (RoW) destroying some habitats and startling wildlife. In LNP, the canal RoW will destroy about 24.8 of thickets and 34.9 ha of tree savanna. In MWR, the canal RoW will destroy 25 ha of forest. Construction activities will have several impacts on wildlife and vegetation:

- Scaring of wildlife (and potential casualties) due to construction in an area where they are accustomed to access without disturbance (this will have direct impact on tourism as well, as wildlife observation will decrease). In MWR, animals will most likely move inside the reserve due to the noise, however this area lacks water which will further stress animals. Due to lack of fences in many areas in LNP, some wildlife may be tempted to exit the park and lead to human-animal conflicts (especially buffalos);
- Persecution of slow moving animal (snakes) from workers;
- Changes in habitat quality (risk of invasive plants colonization on bare soil and risk of increasing turbidity in the reservoir due to waterworks). The invasive tree *Prosopis glandulosa* was often observed in the Study area, this tree often colonizes ditches;
- Animals will not be able to cross canals under construction to access Shire river below the Kapichira dam wall (MWR) and to access the western part of Old Lengwe (LNP) as the excavation will create an impassable trench;
- Increased poaching risk with foreign and transient construction crews operating in and adjacent to MWR and LNP.

In addition, resettlement activities will take place in the command area. Resettlements are known to increase pressure on natural resources mainly trees for logs to rebuild houses and on available land to resettle people. This impact is difficult to assess but was raised by a traditional authority during a consultation meeting with COWI consultants (COWI, 2016). LNP, Mwabvi Wildlife Reserve and Matandwe Forest Reserve which are close to the SVIP Phase II are at risk.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Disturbances of wildlife and vegetation. Forest clearing will permanently destroy valuable habitats and work will startle wildlife
Value of the affected component	Highly valued
Intensity	Medium
Extent	Punctual
Duration	Permanent
Significance	Moderate
Occurrence probability	High probability

14.5.1.2 Habitat fragmentation

Canal construction and operation will fragmentize wildlife habitats especially in parks. In MWR, open stretches of the Feeder canal will have impacts on wildlife capacity to move toward the Shire below the dam wall where many fetch for water in the river. Elephants however do not use this section of the river to drink due to steep slopes, rock outcrops and high current. Depending on the final layout, it may represent an impassable obstacle and it could isolate 75 ha (0.75 km²) of MWR which represent the area between the fuse dyke, the river, the road to Escom and Mkulumadzi Road. The previous map on MWR shows this area under the title “Heavily Impacted Area”. This “Heavily impacted Area” will be subject to intense truck traffic (as discussed in the Impact on tourism section). In addition, 31 ha will be isolated south of the Escom bridge to the limit of the reserve (currently it is an unfenced area).

In LNP, Bangula canal will fragmentize highly valuable thickets mainly:

- 28.74 ha of *Sterculia appendiculata* riverine thickets,
- 260.11 ha of Small-leaved bloodwood thickets, and
- 278.35 ha of *Acacia nigrescens* thicket

These will be separated from their main units as they will no longer form continuous habitats as shown on the next map. Habitat fragmentation can lead to the “edge effects” along forested areas. The edge is the area where natural habitats come in contact with manmade habitats or infrastructures (canal, road, transmission line, etc.). Edge effect causes abrupt changes in vegetation covers and reduces the true surface of forest, leading to colonization of new species. Edge effect also leads to local changes in soil characteristic from a cooler, darker and moister to a warmer, more exposed and dryer environment due to solar radiation. This change brings higher mortality of trees and shrubs along the edge. Habitat fragmentation can lead to changes beyond the line of contact with construction activities.

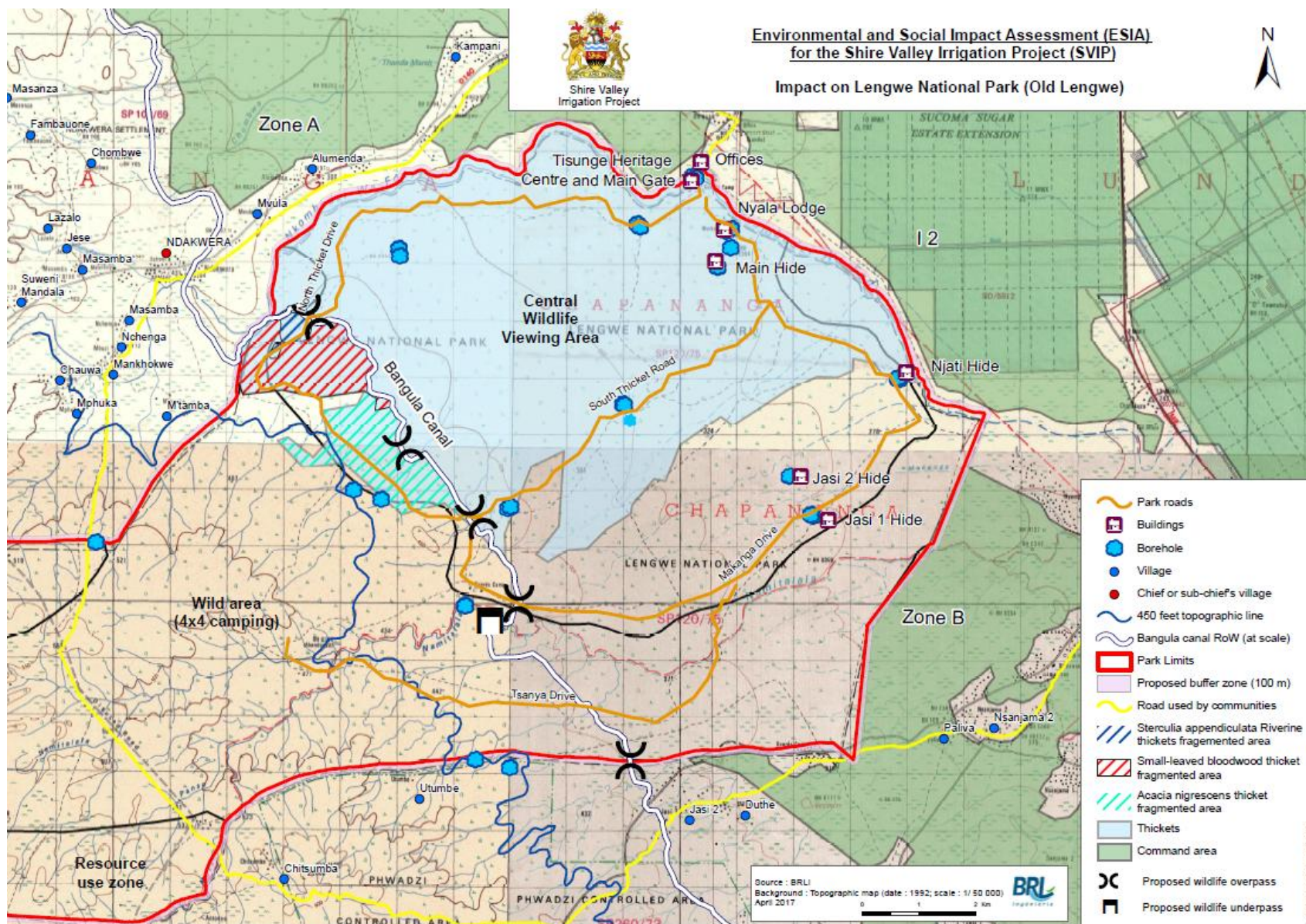
As far as today, no reliable information is available to determine Nyala movement in and out of Old Lengwe (as there are no telemetric monitoring of animal movement). However, Old Lengwe is subject to floods from Nkombedzi Wa Fodya, during which animal are known to move to the Western part of the Park. In addition, discussion with the Lodge manager (Max Del Bufalo, personal communication, 2016) and field observations have revealed that animal do move westward outside the thicket for grazing, the movement is however believed to be limited.

In LNP, the current command area layout (as received from KRC, 2016) is encroaching on the park boundaries (Zone B is encroaching on about 342.6 ha of NLP on its southern end). Final design of Phase II needs to address this and ensure that park boundary are respected. The following map show impacts on LNP and the issue with its boundaries.

In addition to this, Old lengwe which is surrounded by heavy anthropogenic activities (Illovo scheme) and villages that create pressure on the ecosystem, will be further circumscribed by Zone A (Phase I) and Zone B (Phase II) adding pressure on ecosystems.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Habitat fragmentation. Canals will permanently fragmentize habitats especially in parks
Value of the affected component	Highly valued
Intensity	High
Extent	Punctual
Duration	Permanent
Significance	Major
Occurrence probability	High probability



14.5.1.3 Drowning hazard for wildlife

During operation of the scheme, an open canal will represent a hazard for the two following reasons:

- with a lined canal, banks will be slippery and any stocked animals will not be able to escape by climbing up the banks due to lack of grip. This represents a risk for animal health even when water level is low as animals could break their legs, get stuck and die from the heat or starvation. Snakes are known to “fall” and not be able to escape as well (Namibia Environment and Wildlife Society, 2016). Slopes of 1 Vertical / 1.5 Horizontal and 1 Vertical / 2 Horizontal are hazardous for wildlife (and human).
- animals will inevitably fetch for water in main canals as the water will be clearer than in any other water sources and more easily available especially during the dry season. The Feeder canal will convey up to 50m³/s during the peak of the dry season which is also a stressful time for wildlife.

The impact mainly concerns MWR and LNP but also to a lesser extent the whole length of the primary canals as smaller wildlife will be concerned as well (snakes and small mammals especially).

Returns of experience are rare in Africa, however one example in Namibia shows that without proper planning and implementation of mitigation measures, canals can become death traps for thousands of wildlife. The Grootfontein – Omatako Canal (260 km) was built in the 80's, it is an open lined canal with steep and lined slopes (U-shaped canal). This canal is going through game farms as well as other natural habitats severing migration route of grazing animals. The canal was built 30 years ago and is still in operation. A newspaper from Johannesburg (the Star of Johannesburg, 1990) mentioned that the number of dead animal was more than 8,000 per year including endangered species. The estimate annual death is about 4,700 warthogs, 1,500 hares, 300 baboons and scores of antelopes, cheetahs, wildcats, foxes and jackals (large cats are not at risk because of their jumping abilities). Personal communication with the Namibia Environment and Wildlife Society (2016) also revealed that snakes, aardvarks, warthogs, kudu, oryx and eland are amongst the victims of drowning in this canal. The Namibian Afrikaners online newspaper called “Republikein” also reveals that casualties include domestic animals (cow and goats). In addition, the newspaper mentions that the cost of supervising the canal and the effort required to remove trapped wildlife is significant. According to the Republikein, some small animals such as pangolin are known to dig and destroy canal embankment which causes water losses and seepage. According to the article, omission to close fences and gates by maintenance staff as also led to wildlife intrusion in fenced areas (the Republikein, 2016).

The Grootfontein – Omatako Canal is still called the “Killer canal”.

Figure 75 Wildlife casualties in Grootfontein - Omatako Canal



Source: the Republikein, 2016

Discussion with Piet Heyns (personal communication, 2016) who was during planning, construction and management of the canal the Head of the Planning Division and later the Director of the Investigations and Research in the Department of Water Affairs in Namibia has confirmed that the number of casualties was and still is very high and removal of dead animals is very expensive and therefore often neglected. According to him, the largest group were/are snakes and antelopes. According to M. Heyns, many solutions were tested in order to reduce casualties: such as escape gentle slopes (escape structures) with “guides” in the canal to force the animal to use the escape structure. However, most animals when faced with “guides” were swimming on the opposite direction (and up and down the canal) and finally drowning in agony. In parks and reserve, an agonizing animal or an animal in distress is a disturbing experience for visitors and could really affect the image of MWR and LNP (tourists publishing a dying animal on social media will affect the image of parks). The following is a picture from the non-efficient escape structure with the “guide”

Figure 76 Inefficient escape structure



Source: Heyns, 2016

M. Heyns mentioned that regular farm fences were inefficient to keep wildlife from entering due to the fact that many antelopes (oryx, kudu, eland) could jump over 1.6 m high fences. Today, this canal has not seen any efficient action to fight against drowning and the cost of maintenance is affected by this issue. M. Heyns also said that, based on his experience, regardless of the fence many small animals could pass under the fence or across and drown in the canal. According to him, the only way to reduce casualties in parks is to cover or bury the canal. He also mentioned that the structure should be strong enough to allow passage of intruding wildlife. With the presence of elephants in MWR, this issue is rather serious.

M. Heyns sent the consultant a picture of a wildlife pass that was installed in commercial game farms along the Grootfontein – Omatako Canal to reduce the number of drownings. By looking at the picture, the thickness of concrete is not sufficient for large animals or herds. In the case of the Namibian canal, the width of the canal is small (3 meters) so large herds cannot cross at once and exert pressure on the pass. In the case of the SVIP Main Canal (22.6 meter wide), such thin concrete plate would not sustain the weight of elephants—which is why long underground siphons, along with walls along both sides of the open canal sections, are planned instead at Majete Wildlife Reserve.

Figure 77 Overpass in Namibia



Source: Heyns, 2016

A request to NamWater was made to obtain the reports on animal death in the canal, however since these reports are from the 90's there is no electronic version. Scan versions were expected but the consultant never received them (Report on the investigation into the influence of the Grootfontein-Omatako Canal on wild animals and methods to prevent identified problems from the Namibia. Department of Water Affairs. Research Division. Namibia. Ministry of Wildlife, Conservation, and Tourism. Windhoek: The Division: Dept. of Water Affairs, 1992).

The risk of crocodiles and hippopotamus entering the water intake is significant but easily mitigable.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Drowning hazard for wildlife. Open canals represent a drowning hazard for wildlife
Value of the affected component	Highly valued

Intensity	High
Extent	Punctual
Duration	Permanent
Significance	Major
Occurrence probability	High probability

14.5.1.4 Summary of impact significance assessment

	Disturbances of wildlife and vegetation. Forest clearing will permanently destroy valuable habitats and work will startle wildlife	Habitat fragmentation. Canals will permanently fragmentize habitats especially in parks	Drowning hazard for wildlife. An open canal will represent a drowning hazard for wildlife. There is also a risk that hippos and crocodiles enter the canal and cause wildlife – human conflicts
Value of the affected component	Highly valued		
Intensity	Medium	High	High
Extent	Punctual	Punctual	Punctual
Duration	Permanent	Permanent	Permanent
Significance	Moderate	Major	Major
Occurrence probability	High probability	High probability	High probability

14.5.2 Mitigation measures

14.5.2.1 Disturbances of wildlife and vegetation

- It is recommended to phase the installation of wildlife passes as canal construction progresses to avoid creating a long trench without any passage (wildlife passes are presented in the next section).
- Wildlife will have to be contained away from construction to avoid casualties. Construction planning will have to consider and provide for materials and costs for the containment of animals for both LNP and MWR. Such costs include erecting temporary wildlife fences around construction sites. These fences have to be wildlife approved and electrified. They cannot be domestic animal fences.
- An upgrade to existing water points in MWR (Thawale, Nakamba and Nsepete) is necessary because animals will disperse away from the construction and use the existing waterholes which will then need increased capacity. This would be in preference to having a temporary structure that may have its own impacts (water tanker coming every day).
- Slow moving animal (snakes) shall be protected from persecution from workers by providing sensitization induction training to workers.
- In MWR, construction vehicles shall access the water intake site as far as possible from the east bank of the Shire.
- Speed limits shall be set at 15km/hour for all vehicles and trucks in MWR and LNP.

- When working in LNP, the Supervising Engineer will be required to verify construction contractor fridges in their kitchen on a regular basis to ensure that contractors do not purchase any bush meat or animal parts. DNPW should provide technical support if needed (such as to identify suspected bush-meat or animal parts).
- African Parks and the DNPW need to approve all required access roads.
- In MWR, anti-erosion practices shall be put in place. They shall be designed once the Design study available. Silt fences on land and floating silt fence in the reservoir shall be installed.
- Machinery (excavator, grader, etc.) will be checked by reserve and park rangers at entrance to ensure that no mud is present on wheels and caterpillar tracks. This is necessary to avoid invasion of the water hyacinth (or other plants). In case of presence of mud (even dry mud), the machinery or vehicle will be forbidden to enter.
- No construction camp in any parks shall be authorized, workers will have to commute daily to MRW and LNP with a bus and will be subject to inspection at the end of the day (inspection of trunks, bags, ice boxes, etc.). Workers cannot spend the night in MWR nor in LNP. Identification badge of workers shall be mandatory at entrance and exit (including for daily workers). Any workers without a badge will be forbidden to enter parks. Workers cannot spend the night at rangers compounds.
- MWR and LNP shall keep provision of extra law enforcement personnel to increase patrol and law enforcement effort during construction phase and training session for workers (induction training). Costs shall be covered by project financiers.
- In LNP and MWR, the contractor will delineate the required Right-of-Way with African Parks/DNPW and RoW limits shall be marked so that no encroachment takes places. Marking will involve using construction fences (visible plastic fences to ensure that RoW is respected). One of the extra rangers hired for the time of construction will be full time along the construction to ensure that work follows the no encroachment rule.
- Access to the construction site must be restricted through controlled access points managed by African Parks, and operating hours shall be limited to 9am to 6pm. Peak game drive times are 6am – 9am and 3pm to 6pm, ideally work should avoid that timeframe. In LNP, work shall take place between 6am and 6pm.
- Code of conduct for all workers for respectful interactions with surrounding communities, tourists and wildlife will be enforced (a mandatory induction training will be provided by park staff for all workers, see previous section on Code of Conduct).
- Dredged spoils and excavated soils cannot be stored in MWR nor in LNP (even temporarily).
- Vegetation removal shall be limited to the canal path and a pre-agreed footprint either side of the canal during construction. All removed vegetation remains the property of MWR and LNP who will specify where this be stored and how.
- Post construction soil rehabilitation shall be mandatory. It will take place at the end of work in MWR and LNP and not at the end of the contractor's contract to ensure that it is done and budgeted by the contractor (during tender). Delays in payment will be applied if rehabilitation is not done in the set timeframe including removing all rubbish and construction equipment.
- Replanting of trees shall be done by WESM in LNP and by African Parks in MWR to ensure recovery of vegetation and to ensure the use of native species. Costs are presented in Vol 3. ESMP.

- Modification of Nkombedzi Wa Fodya to keep floods from affecting surrounding land is not recommended. The FS consultant in its Interim report (section 5.8.2. Flood Protection of Nkombedzi River) recommends to modify the river to keep floods from affecting irrigated land. However, this river flooding pattern allow riparian thickets to grow in LNP and also causes floods at LNP (flooding of offices and lodges), any channelization upstream of LNP may increase floods in LNP. The General Management Plan of LNP also proposes to build a small dam (a weir) on the Nkombedzi Wa Fodya to create drinking spots in the Western part of LNP and retain floods. Therefore, the proposed modifications to this river shall be discussed with LNP park management as well as WESM (Wildlife and Environmental Society of Malawi) in a concerted approach and to ensure maximum benefits for the park while protecting lands from floods. Regardless if this dam is built or not, the river shall not be modified when passing through riparian thickets and the dam shall have sluice gates to allow for flow release when needed. From personal discussion with Dowsett and Lemaire-Dowsett (2016), it is the best preserved riparian thicket in the area and such communities are scares and rare in the region. The Final Design shall exclude training work of this river, in order to comply with OP 4.04 and generally accepted environmental good practice standards.
- Regarding compensation for the losses of thicket and forest, we recommend the following revegetation measure to ensure no net losses:
 - To compensate for the 25 ha of forest cleared in MWR (mainly broadleave deciduous trees), an estimate number of trees proposed is 1 per 10meters (144 trees per ha) which represent $144 \times 25 \text{ ha} = 3\,600$ trees (square planting). To ensure conservation gains, this number shall be doubled so every cut trees is replaced by 2 trees. Trees shall be planted inside the reserve by African Parks.
 - To compensate for the 60 ha of thickets and forest cleared in LNP (mainly *Pterocarpus antunesii*), an estimate number of thicket species is 1 per 5meters (484 shrubs per ha) which represent $484 \times 60 = 29\,040$ shrubs (square planting). To ensure conservation gains, this number shall be doubled so every cut shrubs is replaced by 2 shrubs. Shrubs shall be planted in consultation with LNP management.
 - Wildlife and Environmental Society of Malawi (WESM) has the experience to carry out such planting and they shall be in charge of planting in LNP, the nursery shall be located in the valley which will require land and irrigated water. For MWR, AP has a nursery inside the reserve. Each plant shall be between 2 and 5 years old to ensure success and shall be protected with cages to keep herbivores away. The full cost assessment is in the Environmental and Social Management Plan (ESMP).
- No direct action can be proposed against the invasive tree *Prosopis glandulosa*. However, revegetation measures and rehabilitation of affected areas will help minimize the colonization of this tree in parks.

14.5.2.2 Habitat fragmentation

ECOLOGICAL CONTINUITY IN MWR

The fate of the heavily impacted area of 75 ha of the reserve (area that will be isolated due to the Feeder canal, see previous map) and the safeguard of this area and mitigation measures to ensure tourists access and wildlife access is crucial for African Parks. Therefore, the “do nothing option” for the 75 ha (called “Heavily Impacted Area” as shown on the map) is not acceptable as it leads to major irreversible impacts.

Buried canal represent 1.25 km inside the reserve, buried canal will allow animals to pass since the thickness of concrete will be sufficient (50 cm), therefore with current layout of the canal inside MWR there is no need for wildlife overpass.

In section with open canal, designing the canal in order to have gentle slopes and shallow water to allow all wildlife to “ford cross” the canal would, in theory, be a good option. It could allow the canal to be “transparent” and reduces the need of installing fences. The canal could mimic a natural watercourse with gentle slopes and meanders. Reducing the water depth and decreasing current would necessitate a larger right of way (RoW). Unfortunately, whatever the possible reduction of depth, a shallower canal would always represent an impassable obstacle since the current would often discourage wildlife from crossing, and juveniles would always be at risk of drowning (up to 50m³/s will flow in the canal). In addition, elephants would use the canal as a pathway and affect its integrity. The drowning hazard and impacts on infrastructures can only be suppressed by restricting all access to section of open canal (on both sides of the Feeder canal).

ECOLOGICAL CONTINUITY IN LNP

In LNP wildlife passes are important because the western side of the canal is a grazing site for wildlife. Even though an earth canal allows wildlife to have a certain grip on the banks, the current of the canal will always discourage many animals to cross especially at the peak of the irrigation season (dry season).

There are two feasible types of passes: underpass and overpass.

Underpasses would require that the canal be elevated. It could also be located where seasonal tributary rivers cross the canal by installing very large box culverts to allow for “dry passage”. An underpass will only offer limited passage since many animal move in herds and the limited size of the box culverts may not allow herds to pass.

Overpasses shall have very mild slopes (1 Vertical / 8 Horizontal), be high enough to pass over the canal wall or fence (2 meters) and be large enough for herds to cross (at least 50 meters wide), its design shall be done by an engineering company with experience in overpasses (and not by the consultant in charge of the canal design). The main issue with overpasses is that in Africa there is no return of experience on this infrastructure.

In LNP, where the canal will be open (see Natural Heritage section), it is suggested to install five wildlife overpass and one wildlife underpass. Overpasses shall be located in open area to minimize poaching and four of them could be shared with vehicle bridges. Discussion with Nyala Lodge management has revealed that a single large wetland would be preferable than several troughs (Max Del Buffalo, personal communication, 2016), water would be brought by the same mechanism. The wetland will allow the park to achieve an overall net gain from a conservation standpoint. This wetland shall be installed on the western part of the canal only to avoid villagers bringing their cattle inside the park to fetch for water, a ranger scout shall be installed there. The wetland could be around 30 meters in diameter and shall be lined with concrete to avoid seepage, with a depth of 0.5 m, it would require about 350 m³ of water from the canal, filled every two days, this would be the equivalent of 1230 m³ per week (or 0.002 m³/s) which is negligible in regard to the volume of water in the canal. It is necessary to install bridges for vehicle at all locations where an existing path crosses the canal. Based on actual map of LNP, the canal will cross paths at 4 locations (see maps on impact in LNP), bridges shall be designed to allow wildlife passage (with very gentle slopes and fences on the side). There is no need to install specific pedestrian passes in LNP.

All options have to be studied in depth at either the current feasibility stage or at the design stage, in consultation with LNP and Nyala lodge management.

BUFFER ZONES AROUND LNP AND ENCROACHMENT

Any encroachment by the scheme inside LNP is to be strictly avoided and park boundaries shall not be subject to any adjustment to accommodate irrigated lands. In fact, the future Zone A and B shall be designed to leave a buffer zone between the park and the scheme (where no land shall be irrigated). The current Zone B is very closed to LNP, it shall be reviewed to leave a buffer zone. The buffer zone shall be large enough to keep LNP from all impacts of surrounding activities and uses. This ESIA recommends a 100m buffer zone.

Since communities in Zones A and B will benefit from the SVIP, and since most illegal wood cutting activities and illegal grazing originate from these communities, part of their inclusion in the scheme shall be conditional on the acceptability of a “no illegal wood clearing rule” and a “no grazing rule” at each village level. Village headmen shall sign a contractual agreement or some form of engagement to respect this rule prior to their inclusion in the scheme. The SVIP shall be used as an opportunity to request some environmental engagement in exchanges of irrigation.

Buffer zone from Zone A

The Nkombedzi Wa Foydya River along the LNP shall be protected from drainage water from the scheme and from any infrastructures. Setting a minimal distance between fields and this river is arbitrary, this report suggests that no irrigated fields should be located less than 100 meters from the river.

Buffer zone from Zone B

Zone B shall be moved back from the park boundary to allow for a buffer zone of at least 100 meters.

14.5.2.3 Drowning hazard for wildlife

- The design of the water intake shall be done to ensure no crocodiles and hippos can enter the canal. For that, the trash rack in front of the water intake shall allow to retain adult and juvenile crocodiles. Spacing shall be 5 cm. However, having juvenile crocodiles entering the water intake will remain a risk. This is why a wall around the canal is also necessary.
- The issue of animal drowning is complex since :
 - fencing the whole canal to avoid wildlife drowning will affect the natural landscape of both LNP and MWR and fences require maintenance. Maintenance of electric fences is a real burden for both MWR and LNP (personal communication with several stakeholders including LNP and MWR management). In addition, in the case of LNP, fences may be stolen or vandalized (as it is the case today). Building a wall, using rocks in a concrete matrix will provide efficient protection against (for) large animals with little maintenance, will last longer and will have a better appearance. Wall with rocks in concrete is actually used to decorate many areas in MWR as shown in the pictures. Although a wall is more expensive than an electric fence as shown in the following table, it is necessary not to underestimate the risk associated with elephants. Electric fences are about

Figure 78 Cost for keeping wildlife out of canals

	Full cost (including installation and quarrying for rocks)
Electric fence in Malawi (based on current prices in MWR)	11 USD per meter
Wall made of rocks in a concrete matrix (based on current prices in MWR) (given a 0.5 m thickness and a height of 2 meters)	400 USD per meter

Figure 79 Examples of rock in concrete matrix from MWR and Ng'ona Lodge



Source : BRLi, 2016

- Having a shallower and wider canal without fence rather than a narrow and deep canal to ensure that wildlife do not drown could be an interesting mitigation. However, several animals could use this canal as a pathway to travel (and not only to cross it), which in turn could affect the integrity of the canal. Elephants are large and heavy and travel in herds; they could cause damages to the canal. Therefore, some forms of barriers are inevitable to keep elephant from entering the canal in MWR. In addition, regardless of the layout, the lined canal will always represent a drowning hazard because of slippery slopes of concrete.
- Based on return of experience from the Grootfontein – Omatako Canal in Namibia and discussion with M. Heyns, escape structures are not recommended as wildlife do not understand that these are exits (personal communication, 2016). If escape structures did not work with a canal much smaller than SVIP main canals (Grootfontein – Omatako Canal), they will probably not work with the Feeder and Bangula canals.
- If an earth canal is feasible in LNP, it may not lead to drowning as animal who enter the canal may exit it because of the better grip earth offers as shown in the following pictures taken by the consultant. In this case, a wall along the canal will not be necessary. However, with large wildlife such as buffalos, earth canal will be damaged.

Figure 80 Earth offers better grip than concrete

Source : BRLi, 2017

- A solution against animal damaging the earth canal in LNP could be an earth canal lined with prefabricated concrete mats which are flexible matrix of cellular concrete blocks (the registered technology is called the Armorflex ®). The cellular blocks offer good grip for animals to exit canals. It can easily follow meanders of the canal (to mimic a natural aspect) and allows to protect banks from erosion and gullies caused by animals. In order to be efficient, slopes have to be gentle at 1 Vertical / 3 Horizontal. The cost of this technology is, based on a quotation from the firm who produces them in South Africa (including transportation from South Africa to Malawi and taxes), about 1000 USD per meter (Technicrete, 2016) in addition to the 346 USD per meter (cost for Bangula earth canal provided in KRC, 2016). This technology would offer good protection of the canal bank for wildlife. A cost comparison is provided in the next table. These costs exclude the cost of wildlife passes which will still be needed as bridges for tourist roads will have to be built (as mentioned in the previous section, vehicle bridges will be required and these shall be adapted to become wildlife bridges as well). In this case, a wall along the canal will not be necessary as shown in the next table.

Table 24 Options to avoid drowning of wildlife in LNP

Type of canal inside LNP	Earth only	Earth canal + Armorflex ®	Lined canal + fences on both sides	Lined canal + walls on both sides
Unit cost (USD per meter)	346	346 + 1000	439 + 22 (11x2)	439 + 800 (400x2)
Cost for 14 km (USD)	4,850,400	4,850,400 + 14,000,000 = 18,85,400	6,147,600 + 308,000 = 6,455,600 (excluding the cost of fence maintenance)	6,147,600 + 11,200,000 = 17,347,600

Source: KRC, 2016 for the cost of Bangula canal (lined and earth canal), African Parks for cost of electric fences (22 USD per meter for fence on both side of the canal) and for cost of a wall (800 USD per meter for a wall on both side of the canal) and Technicrete, 2016 for the cost of Armorflex ®

Figure 81 Prefabricated concrete mats (Armorflex ®)



Source: ISG Infrastructure Specialist Group, 2016

Figure 82 Armorflex ®



Source: ISG Infrastructure Specialist Group, 2016

WILDLIFE DROWNING OUTSIDE LNP AND MWR

Outside MWR and LNP, little can be done to mitigate impacts on small wildlife such as snakes and small mammals, there are no bridge nor adaptation to canals that could reduce the impact. However, the presence of cattle troughs (see chapter 7) would possibly help to reduce drowning of small wildlife as these would be attracted to troughs rather than the canal.

CONCLUSION

The SVIP Detailed Design shall elaborate upon the alternatives recommended by this ESIA proposes.

It the light of the very high cost for walls, electric fence seems to be the best option for open canal, however they will quickly become a burden for parks management. As cost for maintenance of fences will be the scheme operator responsibility, it is not recommended to have fences, budget cuts may lead to abandonment of their maintenance, leading to breaches and animal drowning. Self-reliant and low maintenance are the two principles that should govern every infrastructures built to mitigate impacts. Therefore, walls mixing concrete and rocks shall be installed whenever the canal is open in MWR not only to preserve the landscape but mainly to reduce the cost and the risk associated with poor maintenance. If in LNP, the main rationale for the flexible matrix of cellular concrete blocks is that it would allow protecting the banks from wildlife. Earth canal may offer possibility of wildlife to exit the canal if they are stuck however, the canal may still require wildlife passes (as presented in a section above) because the canal will always represent a constraint to wildlife movement, especially when filled with water.

14.6 WETLAND HABITATS AND WILDLIFE

14.6.1 Description of impacting activities

The impact matrix has identified the following activities and impacts.

14.6.1.1 *Changes in plant composition in Elephant Marsh*

During operation of the scheme (mainly Phase II), reduction of flow due to abstraction of up to 50m³/s (with a maximum net abstraction of about 32 m³/s) will reduce the size of some plant communities in the wetland. The impact is influenced by several factors:

- The higher demand for SVIP will be during the dry season when up to 50m³/s will be directly withdrawn from the Shire River; the dry season is also when the marsh is under more stress due to shortage of water;
- The existing sugar estates--which have a fixed area of cultivable land--will reduce their pumping from the Shire River in direct proportion to the newly available, gravity-fed water they will be able to purchase from SVIP. This will locally moderate the impact, since the actual capacity of pumping stations is around 21 m³/s and up to 18 m³/s is pumped in the dry season;
- The Elephant Marsh includes many cultivated areas with flood-recession (dimba) agriculture in its drier portions; these may shift from wetlands to "drylands" as a result of reduced dry season Shire River flows. This transition is supported by satellite imagery treated by infrared to highlight plant activity, since dimba agriculture shows less plant activity at the peak of the dry season than does natural wetland vegetation. The DRIFT report (Ecosystem Functional Model by Southern Waters in association with Streamflow Solutions, Anchor Environmental and MRAG for the SRBMP, 2016) states that the western part of the marsh is expected to react more strongly to flow changes in the Shire River than other areas of Elephant Marsh.
- The Application Efficiency for furrow irrigation is 64% (KRC, 2016), which means that about one third of the water at each furrow-irrigated plot is returned to the natural environment. In this figure, part of the water goes to the water table along drains (seepage), part of it evaporates and part of it returns to surface water at Elephant marsh (as the marsh is the final receptor of drainage). The percentage of each pathway is not easily assessable. Any return irrigation flows to the Elephant Marsh (via surface water or groundwater) are considered beneficial to the Marsh from a hydrological standpoint. However, SVIP impacts upon the Elephant Marsh (including a maximum seasonal reduction of about 10% in flows to the Marsh at Phase II development) have been calculated without taking irrigation return flows into account. This is because such return flows are likely to shrink over time, since farmers might well switch to more water-efficient irrigation techniques (sprinkler or drip irrigation).

As mentioned in the baseline report, a wetland is an area where hygrophilous plant species thrive. Hygrophilous plants are those that require a certain moisture level during a certain length of the year. For most wetland plants, there are thresholds under which they can no longer grow and give way to terrestrial plants. These thresholds are unique to each plant species, most of which have not been scientifically studied in this regard. However, the DRIFT report presents a few thresholds for key species such as Phragmites reed grass and Papyrus. Phragmites are internationally known as facultative wetland plants because they can withstand seasonally dry conditions, in contrast to Papyrus which are known to be obligate wetland plant species (which cannot withstand dryness).

Determining how changes in flow will affect the area of wetland is rather difficult without long-term follow up. However, several statements can be made to describe what will qualitatively change from baseline to Project.

Table 25 Impact on wetland

Theme	Baseline	Project (Phases I and II)
Sources of water	In the dry season, damp conditions are maintained thanks to several factors: • The marsh is a depression, water remain stagnant in many areas, • The Shire and its branches and accompanying alluvial water tables, • Seepages from the Thyolo escarpment on the west bank of the marsh	The Project will slightly reduce the level of the Shire and its branches, which will lower their accompanying water tables.
Critical period for wetland plants	The critical periods for wetlands plants are not the rainy season when most areas are damp in the marsh or submerged; the critical period is the dry season when water is irregularly distributed.	The project will not change much of the wetland hydrology during the rainy season, since irrigation will be limited. The project will affect the critical period for wetland plants by reducing the Shire flow during the dry season, affecting more the edge of the marsh where conditions may no longer allow wetland plants to grow. The eastern edge is the area where water recedes earlier after the rainy season floods; it will be more severely affected. This area is also intensively cultivated (dimba agriculture). Dimba is also called recession agriculture, therefore, with reduced flow (and in the absence of controls), people would move further into the wetland to cultivate land at the peak of the dry season, further increasing pressure on wetland plant during a critical period.
Wetland zones	The baseline has described three	• Flow reduction will lead to

Theme	Baseline	Project (Phases I and II)
	zones in the marsh: • Area where dimba agriculture takes place. Dimba takes place in wetland that is the least damp during the dry season • Areas where the soil is permanently damp and where dimba agriculture is not taking place thanks to high water level • Areas of pools, where water submerges the ground.	changes in plant communities. The surface that will be affected is however difficult to assess. Dimba agriculture and facultative wetland plants will take more space at the expense of obligate wetland plant species. • Some areas where the soil was permanently damp inside the marsh may be encroached by people who lost their dimba field due to reduced wetness at the edge of the wetland and who will find new suitable conditions further inside the wetland. Baseline reports presented historical facts that linked increased dimba agriculture with flow reduction. This statement is also supported by the DRIFT report, which has identified the eastern, central and southern part of the marsh as potential new suitable area for dimba agriculture. • Water level will be lower in pools during the dry season. This could affect fishing activities and rooted aquatic plants.

The SRBMP Sub-study 4: Biodiversity of Elephant Marsh, Final version (Anchor Environmental Consulting Report, 2016) makes the following statements about the impacts of reduced Shire River flows (including those attributable to SVIP) on the Elephant Marsh:

“Marsh vegetation will be impacted by reduced flow, as drying will reduce the ability of marsh plants to resprout and therefore to persist and will also make it easier to clear marsh areas for cultivation.”

“Reduced flow through the Elephant Marsh will reduce the extent and flooding of lake and permanently inundated habitats as well as lessen the extent (and possibly frequency) to which the flood plain is flooded. These changes will affect the biodiversity of the Elephant Marsh directly as flow, sediments, vegetation and marsh fauna are intricately linked. Reduced flow through the Elephant Marsh will also facilitate encroachment by people and increase the extent of cultivation and natural resource harvesting.”

A modest reduction in the wetland area of Elephant Marsh could also change local sources of livelihood, with incremental increases in dimba cultivation and potential reductions in fishing. The recent report on Ecosystem Services of the Elephant Marsh (Anchor Environmental Consulting, 2016) estimates the total annual provisioning value of the Marsh at approximately US\$5 million per annum. Most of this value is from fish and thatching grass.

CONCLUSION ON IMPACT ON ELEPHANT MARSH

In the light of this analysis on impacts, the Project will not lead to “significant conversion or degradation” of the Elephant Marsh as defined in the OP 4.04 on Natural Habitats. Water abstraction of about 10% of Shire River flow (full development of Phases I and II) at the peak of the dry season is not likely to result in the elimination of the Elephant Marsh, a severe diminution of its integrity, or a substantial reduction in its ability to maintain viable populations of its native species. However, some change is to be expected in the area covered by different wetland plant species.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Changes in plant composition in Elephant marsh. Flow reduction will reduce the size of Elephant marsh
Value of the affected component	Highly valued
Intensity	Medium
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	High probability

14.6.1.2 Wildlife-human conflict

With the Project’s irrigated fields and somewhat reduced flows to the the Elephant Marsh, wildlife-human conflicts would be expected to increase in the absence of special mitigation measures. The actual situation in the Project is already unique, as wildlife-human conflicts in and around the Elephant Marsh have generally worsened over time. Absent adequate mitigation measures, SVIP would be expected to aggravate the following existing situations:

- Any reduction in the wetland area of the Elephant Marsh may shrink the available habitat and food resources for hippopotamus and crocodiles. The SRBMP Sub-study 4: Biodiversity of Elephant Marsh Final version (Anchor Environmental Consulting Report, 2016) states: “Crocodile-human interactions will increase if human numbers and encroachment into the remaining uncultivated regions of the Elephant Marsh persist. This will be exacerbated as fish stocks, the natural food of crocodiles, dwindle and crocodiles have to hunt for alternative prey”;
- During the dry season, there will be increased availability of fresh forage for hippopotamus closer to the Elephant Marsh thanks to irrigation;
- The irrigation drainage canals into the Elephant Marsh are likely to provide aquatic pathways for crocodile movement (currently crocodiles occupy Illovo drains as observed during the ESIA study);
- A projected increase of dimba agriculture around the Elephant Marsh (if not adequately controlled through SVIP’s Natural Resources Management Component) could increase human-wildlife conflicts (particularly with hippopotamus);

ASSESSMENT OF IMPACT SIGNIFICANCE

	Wildlife-human conflict. There is a chance that hippos and crocodiles will enter the

	irrigation drains and cause wildlife – human conflicts (and some casualties). Irrigated fields may become attractive for wildlife as a food source.
Value of the affected component	Highly valued
Intensity	Medium
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	Potential occurrence

14.6.2 Mitigation measures

14.6.2.1 Changes in plant composition in Elephant marsh

This impact is largely unavoidable since withdrawing water from the Shire River is the basis of the Project.

The water intake will be dimensioned to abstract a maximum of 50 m³/s from the Shire River. However, since some of the canal water will simply substitute for irrigation water that is currently pumped from the river, the maximum net abstraction will be 32 m³/s at full development (Phase II) and only 12 m³/s for Phase I. Based on the World Bank's International Waterways Notification Letter, this translates to a net abstraction at full SVIP development of not more than about 10 percent of the Shire River's flow during September, the dry season month of peak irrigation water demand. For Phase I, this maximum seasonal reduction in flows to the marsh would be only about 3 percent.

The Project will mitigate these impacts and enhance the conservation of the Elephant Marsh through support for:

- hydrological and biological monitoring (building on the baseline data obtained through the ongoing Shire River Basin Management Project, SRBMP);
- designation of Elephant Marsh as a Ramsar Wetland of International Importance; and
- establishment of Malawi's first Community Conservation Wetland Area under the administration of the Department of National Parks and Wildlife (DNPW). This improved protection and management of the Elephant Marsh will begin during the Phase I Project; it will thereby facilitate adaptive management to further mitigate the impacts of reduced flows from the Phase II irrigation expansion, such as through the establishment of different Wetland Area Use Zones that could limit further conversion of the drier wetland areas to flood-recession (dimba) agriculture.

Designation of Elephant Marsh as a Ramsar Wetland of International Importance and establishment of the Elephant Marsh Sustainable Use Wetland Conservation Area are both objectives of the Natural Resources Management component of SVIP, to be completed during the expected 2018-2022 project implementation period.

Hydrological and ecological monitoring of the Elephant Marsh, initiated under the SRBMP, will continue under the SVTP's Natural Resources Management Component.

Although this was considered as a mitigation measure for reduced flows into the Elephant Marsh, building weirs in the marsh to maintain a certain dry-season water level is not recommended for the following reasons:

- the severity of floods has shown how destructive the Shire River can be; many weirs or dikes might not last past the first major flood;
- weirs or dikes will block sediment transport to downstream areas;
- weirs or dikes will locally block fish movements;
- When Ruo River joins with Shire it creates a beneficial backflow that brings water to the marsh. Weirs would block the flow of Ruo into the marsh;
- Weirs and dikes may retain water but may also create dryness conditions downstream and lead to additional dimba agriculture; this happened in the past when a braided branch of the Shire River was blocked inside the marsh by Illovo Sugar.

During the January 2015 floods, the Ruo River changed its course and since then discharges directly into the Tomoninjobi Pool within the Elephant Marsh, rather than having a confluence with the Shire River downstream of Chimromo Bridge. As a result, the Ruo River now delivers more water into the Elephant Marsh than previously.

It has to be highlighted that neither SRBMP, nor any other World Bank-supported projects in Malawi, will support diverting the Ruo River channel for flood management (which could reduce inflows to the southern part of the Elephant Marsh). Any future works involving the Ruo River (possibly involving lower-impact flood management approaches) would need to be approved by the Shire River Basin Authority, which has a mandate to consider environmental management (including wetlands conservation) in the planning of new civil works in the Shire Basin.

14.6.2.2 Wildlife-human conflict

Elephant marsh is at stake when it comes to wildlife-human conflict. Hippopotamus and crocodiles are the current most conflictual animals in and around the Elephant Marsh.

CROCODILES

Crocodiles are present in Illovo drainage, it is unlikely that, with SVIP, the situation will be different. Crocodiles can move on land and in the water therefore there is little direct actions that can be undertaken, the risk will never be eliminated. To reduce the risk it is recommended to implemented the following measures (in increasing order of cost):

- Sensitize people not to use drain canals to bath or to bring cattle for water.
- Design drains with steep bank slopes to keep crocodiles from exiting them and attacking people.
- With the installation of cattle troughs along the canal, the access to the Shire for livestock could limited to some areas as part of a future wetland management (as developed in the SRMBP study on Elephant marsh).
- Install a crocodile fence across every connecting drains with the Shire. Each crocodile fence shall be fixed to the drain bed and grounded using concrete and shall be high enough to stand out during a flood. Wire mesh shall remain sharp at the top of the fence. On ground, it shall be wide enough to discourage crocodiles from moving on land and circulate around the fence to reach the drain. Such fences would need to be maintained and debris removed on a regular basis to avoid having the fence destroyed, as drains will be maintained by farmers there is a risk that they will be neglected. In addition, any major floods in the Shire River would most likely destroy the fence. Regular replacements are to be foreseen. Chances to see crocodiles climbing fences are also to be expected. All these elements are serious limitations to the success of a crocodile fence. In addition, fences would restrict movement of other species from drains to the wetland.

HIPPOPOTAMUS

Hippopotamus will be attracted to forage in irrigated fields, some measures can be proposed:

- Sensitize people not to stay late in their field, as hippopotamus are known to enter fields at night;
- Adapt crop in the command area so that cotton (non-edible crop) is cultivated closer to the Shire and food crops further away;
- Install along irrigated fields thorny branches (acacia branches) to keep hippopotamus from entering. However, it has been reported that even barbed wire are not efficient against hippos. In fact, walls could be the only efficient measure (UNDP, 2016) given the size of the irrigation scheme, efficient actions are rather limited and death of hippopotamus due to conflicts are likely to take place.

ENVIRONMENTAL FLOW

As with other impacts, the environmental flow with adaptation from Kamuzu barrage has another reason to be implemented, it will safeguard crocodiles and hippopotamus habitat and food supply and will help to minimize conflicts with farmers.

BUFFALOS ENTERING FIELDS

LNP will be surrounded by irrigated fields, to avoid all encounter with buffalos, it will be important to fence the whole Old Lengwe section of the park (or finalize the current fencing process).

14.7 AQUATIC HABITATS AND FISH

14.7.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

14.7.1.1 Disturbance to fish migration to spawning sites

During construction and operation of the scheme, works in temporary rivers could lead to disturbances of fish migration. Permanent infrastructures and channelization of tributary rivers could disturb fish migration to spawning sites as well. During construction, the main risk comes from the fact that most rivers are seasonal; the construction contractor may be tempted to ford cross-rivers when they are dry, which with time will destroy the river banks and cause erosion. Some constructors build small earth dikes with culverts to ford cross-rivers, however culverts are often undersized and earth dikes remain even during the rainy season which affects fish migration. Another impact comes from the operation of the scheme where natural rivers will be used as drainage canal collecting polluted water from the scheme and being modified to convey drainage water. River channelization reduces suitable sites for spawning.

Figure 83 Inadequate culverts in an earth dike across a seasonal river



Source: BRLi, 2015

ASSESSMENT OF IMPACT SIGNIFICANCE

	Disturbance to fish migration to spawning sites. Works and infrastructures in temporary rivers could lead to fish migration disturbances
Value of the affected component	Highly valued
Intensity	Medium
Extent	Punctual
Duration	Permanent
Significance	Moderate
Occurrence probability	Potential occurrence

14.7.1.2 Risk of Tiger fish invasion in the upper Shire

The Lower Shire River is an independent ecoregion from the Middle Shire and Upper Shire in terms of aquatic fauna. The Lower Shire River belongs to the Lower Zambezi fish fauna and, since Kapichira falls constitute a barrier to upstream movement, all the totally aquatic 'Lower Zambezi' species of the Lower Shire River are absent upstream from Kapichira falls (Tweddle et al., 1979).

Lake Malawi (Upper Shire) fish fauna is mainly endemic (several species of endemic cichlids) and fish are adapted to lacustrine conditions (low flow conditions).

The separation in fish fauna between the Lower and Upper Shire has always existed. However, now with the presence of the SVIP in the near future, a question is raised: *what if the Feeder canal, a gravity irrigation canal by-passing the Kapichira falls, leads to the upstream movement of the Tiger fish or other species that were historically separated from the Middle and Upper Shire?* In that case, *what would happen to Middle and Upper Shire fish fauna and more importantly to endemic fish fauna of Lake Malawi?*

HOW COULD THE TIGER FISH AND OTHER NON NATIVE FISHES INVADE THE RIVER UPSTREAM OF KAPICHIRA FALLS ?

Lower Shire to Middle Shire***Passage from natural rivers to the canal system and the Feeder canal***

During operation of the scheme, floods from the Shire River in secondary canals and the Mwanza River in the Feeder canal could lead to fish colonization of the canal system. Another source of risk is that people may be tempted to carry out fish farming in the canal. Through time, the Feeder canal will not remain free of fishes, as observed in irrigation schemes worldwide, fishes are colonizing canals.

The passage from the Feeder canal to Middle Shire

The passage is probable since gravity canals will have very gentle slopes and the water intake is a passive mechanism not involving any pumps. Buried siphons and inverted siphons, regardless of their slopes are not fish proof since, in case if the water intake closes, the water will remain still in the siphon and fish could simply move up in the water column (the tiger fish is a pelagic fish; it can easily move up and down in the water column).

An example of tiger fish passage in underground and pressurized places was provided by M. Tweddle (personal communication, 2016):

“The Fisheries Offices in Katima Mulilo (Namibia) contain a fish hatchery. The reservoir for the hatchery is a large pond filled by a narrow pipe directly from the town’s water supply, which is pumped directly from the Zambezi River. The offtake to the hatchery pond lies between the pump and the purification plant. The pond contains several species from the river, including a few small tigerfish”.

Middle Shire to Upper Shire and Lake Malawi

Several elements support the statement that other than Kapichira falls, there are no absolute and proven impassable obstacles for fish upstream movement along the Shire:

- **Physical characteristics.** None of Middle and Upper Shire falls are as high as Kapichira falls, they also do not have sudden drops such as those found at Kapichira falls. They are not physical impassable obstacles especially at time of high flows because the falls are not very high at any given point (no sudden drop), therefore they could be transformed into rapids during high flows. In addition, some of these falls have gentle “bypass” channels where water flows more quietly. The following is the path and obstacles that fishes may face after Kapichira falls when moving upstream, rapids are not presented because they are not obstacles to fish movement :
 - After Kapichira falls, going upstream there is Mpatamanga gorge. During the rainy season, falls become rapids as depth of water increases in the gorge without an increase in river width.
 - The next obstacles going upstream are Tedzani and Nkula falls both located in by-passed stretches of Shire River where Escom is generating hydropower (two hydropower stations). Nkula falls are rather small and Tedzani falls look more like a long series of rapids.
 - After the powerstations, there are two other falls: close to Zalewa where, during the rainy season, side channels have gentle slopes and by-pass the falls; and close to Malope which appear to be more difficult to pass. However, these falls are in gorges, thus during the rainy season water level goes up transforming the falls into rapids.
 - the Kamuzu Barrage is not a barrier.
- **Human barrier.** Since both sides of the Kapichira falls and the reservoir are restricted access areas, Kapichira falls are also a “human barrier” to the accidental release of fish upstream. On one side, Escom prohibits all access to the reservoir and on the other side, Majete Wildlife Reserve restricts access to paying visitors only. Both organizations take restricted access to the reservoir very seriously.
- **Proven barriers.** This argument is the most important of the three and the only one that can hardly be scientifically questioned (as there will probably never be any consensus whether other falls are passable or impassable solely based on their physical properties). To really assess whether other falls along the Middle and Upper Shire are impassable or not would require some evidences in terms of differences in fish diversity and the fish fauna “assemblage” is the same along the stretch of Middle Shire and Upper Shire. The only absolute fact is that the barrier between Lower Zambezi fish fauna and Upper Shire fish fauna is, based on extensive fish surveys, Kapichira falls (Tweddle, 1979, 1994). None of other falls can be proven barriers to stop upstream migration since they are all located upstream of Kapichira falls where the “separation” in fish fauna has already taken place.

WHAT IS AT STAKE ?

Lake Malawi shelters rich aquatic biodiversity and fishery, it is a source of livelihood for communities. It is also a World Heritage site.

- **Biodiversity:** more than 800 species in Lake Malawi are endemic (from the cichlid family). They are therefore unique to Lake Malawi. The lake has more known fish species than any other lake in the world (Lewis, 1988). The risk of having new species of fishes in the Middle and Upper Shire is also a concern as Kapichira falls have always separated two distinctive fish fauna assemblages (Upper and Lower Shire).
- **International waterbody:** Lake Malawi is shared between three countries: Malawi, Mozambique and Tanzania.
- **Fisheries:** fisheries in Lake Malawi is an important source of livelihoods. In addition, cichlids from Lake Malawi are exported as aquarium fishes.
- **Tourism:** Lake Malawi is an important touristic spot and a diving spot for the colorful cichlid fishes.

WHY IS THE TIGER FISH A RISK ?

- **It is a piscivorous predator and an opportunistic feeder:** the Tiger fish is a piscivorous predator and an opportunistic feeder which preys upon the most abundant prey species (it does not have a strict food regime). Its prey size can reach up to 46% of its body lengths, far beyond the size of cichlids (Lewis, 1988 and Dalu et al., 2012).
- **It preys on cichlids** (fish family found in Lake Malawi): it has been proven by research of stomach contents that the Tiger fish, in other countries such as Zambia and Zimbabwe, preys on cichlids. In Lake Kariba, the Tiger fish takes a substantial toll on the juveniles of commercially important cichlids (Lewis, 1988). In Zimbabwe, a study demonstrated that cichlids are the most important diet of the Tiger fish in a reservoir lake (Dalu et al., 2012).
- **It is a large and powerful fish:** the Tiger fish is known to jump out of the water to catch birds (barn swallows) (O'Brien et al., 2013). It is common in the fast flowing stretches below Kapichira falls (Tweddle et al., 1979).
- **It likes open water with few vegetation** (Langerman, 1984 quoted by Lewis, 1988) which is the typical environment found in Lake Malawi or a canal.
- **It is an aggressive species** and spawning of the Tiger fish takes places earlier than most fishes, juvenile Tiger fish could easily prey on eggs of endemic upstream fishes causing damages to Upper Shire fish fauna.
- **It has never been observed upstream from Kapichira falls:** as the Kapichira falls are effective barriers to passage of all fishes (Tweddle et al., 1979).

If the tiger fish were to reach Lake Malawi, it would lead to a decline in native fish population and in fishery activities of Lake Malawi. The extent of the decline is not predictable, however in some areas in Africa, the Tiger fish, when introduced, had a significant impact on native fish population (Dalu et al., 2012).

Figure 84 The tiger fish



Source: Angle Zambia, 2016

CONCLUSION

The following conclusion summarizes our assessment, the statement in italic is shared by M. Denis Tweddle, renowned fish expert in the Southern Africa Region and highest reputed fish expert of the Shire River.

Kapichira falls are the only proven and absolute barriers to the upstream migration of the Tiger fish. Other falls along the Shire have characteristics that makes them difficult to pass, but are not all-year around absolute barriers to fish. In addition, due to their locations upstream from Kapichira falls they were never proven to be reliable physical barriers to Tiger fish migration.

Regardless of the characteristics of other falls, the impact of the Tiger fish (and other Lower Zambezi fishes) moving to a new ecoregion in the Middle and Upper Shire also needs to be taken into account. Allowing non-native fishes to move up the Middle and Upper Shire, one step closer to Lake Malawi, is also a risk because any future development along the River could provide new paths for fish movement (for example: a new gravity irrigation scheme using another hydropower reservoir, etc.).

The question of which falls other than Kapichira Falls are also absolute barriers is therefore irrelevant, since Kapichira Falls are the only proven barriers to fish passage (there is a clear difference between upstream and downstream fish diversity). Risking the introduction of a non-native fish upstream of Kapichira Falls would go against all precautionary principles since there is no proof that the falls further upstream are absolute barriers. It is the Consultant's opinion that the issues at stake call for serious measures, and should not be influenced by any assessment of physical properties of other smaller falls in the Middle or Upper Shire.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Risk of Tiger fish invasion in the upper Shire. The water intake could lead to Tiger fish invasion of Middle and Upper Shire and Lake Malawi
Value of the affected component	Highly valued
Intensity	High
Extent	Regional
Duration	Permanent
Significance	Major
Occurrence probability	Potential occurrence

14.7.1.3 Reduction of suitable habitat for fish in the Elephant marsh

During operation, reduction of flow will lead to reduction of habitat suitability in the marsh. With flow reduction, especially at Phase II, many areas will be less submerged, leading to reduction of suitable fish habitats. In addition, slower water may lead to more silt being deposited in the marsh, which will further degrade the habitat. The correlation between flow and fish catch was proven to be highly significant, whenever there was a flow reduction, the number of fish declined (Tweddle et al., 1994).

The DRIFT report (Ecosystem Functional Model by Southern Waters in association with Streamflow Solutions, Anchor Environmental and MRAG for the SRBMP, 2016) does not foresee a reduction of open water surface (but depth) in the marsh (where most fishery takes place) however it foresees a reduction in rooted vegetation where spawning takes place.

Lastly, the increase drainage of pollutants (fertilizers and pesticides) will impact aquatic habitats.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Reduction of suitable habitat for fish in the Elephant marsh. Reduction of flow will lead to reduction of habitat suitability in the marsh
Value of the affected component	Highly valued
Intensity	Low
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	High probability

14.7.2 Mitigation measures

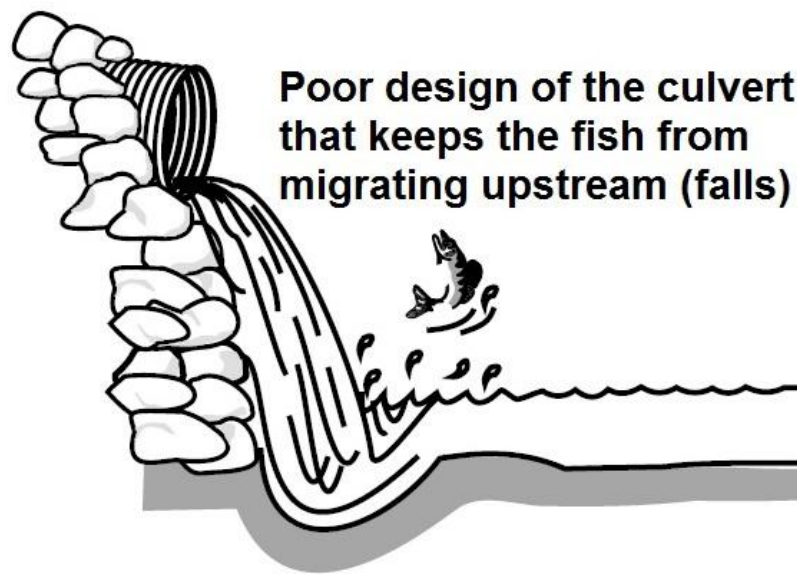
14.7.2.1 Disturbance to fish migration to spawning sites

In order to reduce impact on fishes during construction, it is highly recommended to:

- Design appropriate permanent river crossings instead of earth dikes. The goal would be to foresee needs before the Project is operational and to install permanent crossings;
- Forbid ford crossings of rivers to avoid destroying banks. In case where ford crossing is the best option, banks shall be stabilized and the ford crossing and ramp shall be made of concrete.
- When installing a temporary dike to cross river (for machinery and construction vehicles), the following measures shall be implemented:
 - Install super sized box culverts that allow for hydraulic transparency (see section on hydraulic transparency).
 - Install box culverts with natural bottoms to allow for fish passages by :
 - ensuring that all culverts are installed partially under the river bed level;
 - avoiding creating water falls (perched culvert) or having a steep slope in the culvert;
 - avoiding increasing flow to a point where some fishes can no longer swim;
 - stabilizing the culvert embankment with large riprap or gabion (given the strength of flash floods);
 - avoiding crossing at areas rich in vegetation (trees and tall grasses) or with shallow rocky areas as they often are valued spawning areas.
- All work in temporary rivers shall be prohibited from November to March and shall be concentrated between July and October to minize impacts on migrating fishes.

Regarding the potential chanelization of watercourses inside command areas to become drainage canals or to avoid floods, the FS has identified the Nkombedzi Wa Fodya to be channelized to protected lands from floods. On an environmental perspective, it is recommended to avoid chanelizing major seasonal rivers as well as rivers crossing LNP especially Nkombedzi Wa Fodya and Namitalala Rivers. The main reason is that these rivers flooding pattern allow riparian thickets to grow (see previous section on disturbance of wildlife and vegetation). The Final Design shall exclude training work on Nkombedzi Wa Fodya and Namitalala Rivers, in order to comply with OP 4.04 and generally accepted environmental good practice standards.

Figure 85 Poor design of a culvert



Source : Bibliothèque nationale du Québec, 1997

14.7.2.2 Risk of Tiger fish invasion in the upper Shire

"If there is one thing the history of evolution has taught us it's that life will not be contained. Life breaks free, it expands to new territories and crashes through barriers, painfully, maybe even dangerously..." Professor Ian Malcom, quote from the movie Jurassic Park (1993).

Although the invasion is only potential, the seriousness of the consequences both for fisheries and biodiversity of Lake Malawi in case of a Tiger fish invasion calls for real effective measures (Precautionary Principle). It is therefore recommended to install a fish barrier.

Self-reliant and low maintenance are the two principles that should govern the infrastructure that will be built to stop migration of Lower Shire fish species upstream.

Physical barriers will be more effective than behavioral barriers. This ESIA presents 3 options, all of which shall be studied in depth at Design stage to select the most appropriate option.

Electric fish barrier, sending pulses through the water, is not recommended, as it would involve having a constant electric current in a stretch of the canal, with regular power outages it will not be efficient.

The following options are not based on any return of experience on Tiger fish barriers as this situation is unique. It is only based on bibliographical analysis on invasive fish issues in North America. In addition, the FS report does not provide reliable assessment on canal or siphon infrastructures that are planned and that could be modified to design a physical barrier. The following description of options has been carried out with these limitations and take into account that the Tiger fish is known to jump out of the water to catch birds (barn swallows), it is also known to gain speed deeper before surfacing out of water (O'Brien et al., 2013).

OPTION 1: FISH SCREENS: HIGH RISK IF BUILT BY THE SCHEME CONSTRUCTION CONTRACTOR

Technical aspects

Fish screens are actual screens with small mesh size that retain fishes from moving along a canal or water intake. Fish screens should remain outside of the Shire flood risk zone (this is valid for all options). The following figure overlays flood assessment maps (BRLi, Wems, Aurecon, 2015) with the Project layout to show the area prone to floods. From this map, it is obvious that, in order to minimize the risk of floods overlapping fish screens, they have to be installed upstream from Mwanza River (this is valid for all fish barrier options). Installing fish screens upstream of the scheme reduces the risk of sabotage as people could be tempted to stock fish in the canal, a fish screen could be seen as an obstacle to fisheries. It is not recommended to install the screens along a canal since there is a probability that people use the canal as a waste dumpster (it is observed in many countries where the consultant has worked) blocking the flow at screen location and creating localized floods leading to potential Tiger fish passage around the fish screens;

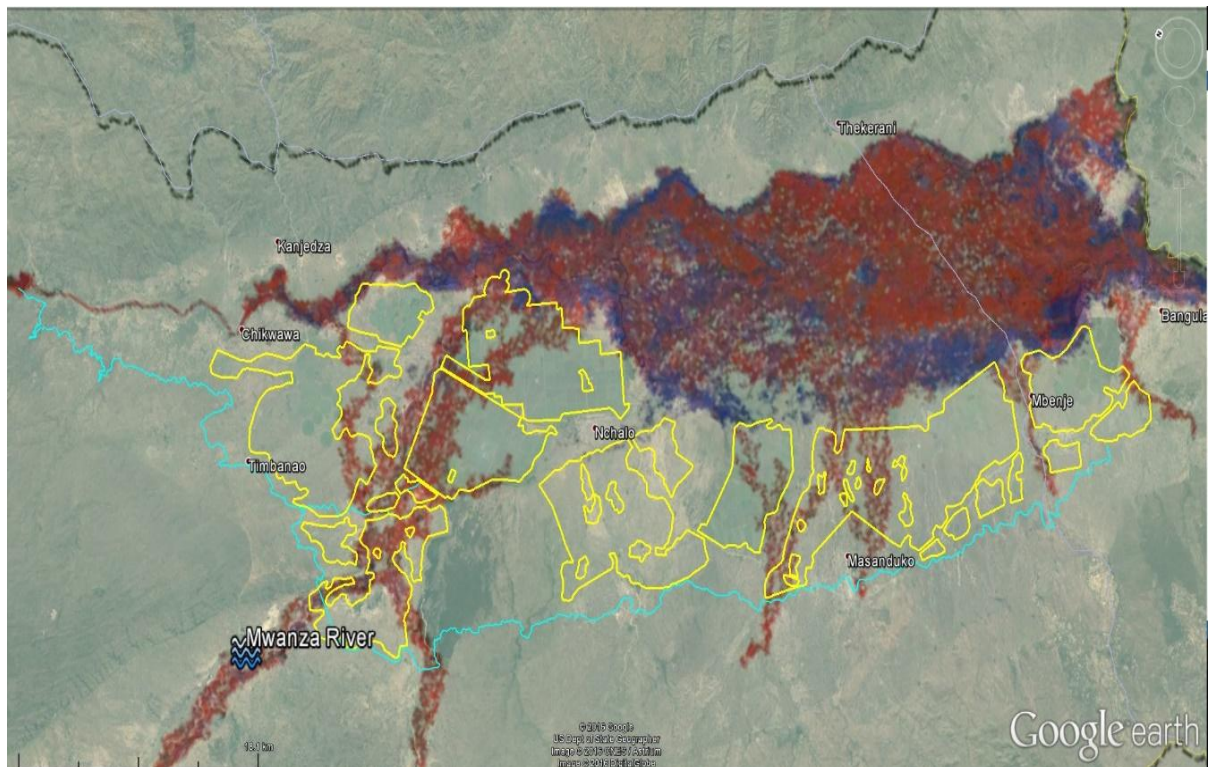
The mesh shall be small enough to exclude all tiger fish life stages except for eggs as tiger fish is not likely to spawn in the canal (especially in the buried canal) and that the risk of passage is based on movement (fish swimming upstream) and not flow (eggs do not swim).

- Fry sizes at hatching varies from 5-8 mm but fry grows very fast in warm temperatures (above 28°C) to reach 15mm in length within 2-3 days (with good nutrition).
- Adult size is up to 1,050mm (standard length, i.e., exclude the caudal fin, only the body) in the wild, in captivity they grow up to 750 mm ; their life span is 10 to 15 years and can weigh up to 28 kg. Males are larger than females.

Fish screens with 5 mm mesh size could be installed at the water intake.

The cost for fish screens varies greatly, but the average price in the US is about 35,000 USD per m³/s (Oregon Department of Fish and Wildlife Fish Screening Program: Fish Screen Types and Costs, 2016). A cost estimate for a fish screen with automatic cleaning device was provided by an USA based firm; based on current design of the Project, the cost of a fish screen would be 1.2 million USD including installation and shipment to South Africa of the screens (IWS International Water Screens, 2016) but excluding land transport to Malawi, which would cost around 25,000 USD (quotation from Savino Del Bene, 2017). Custom fees are unknown. Each replacement screen is 75,000 USD.

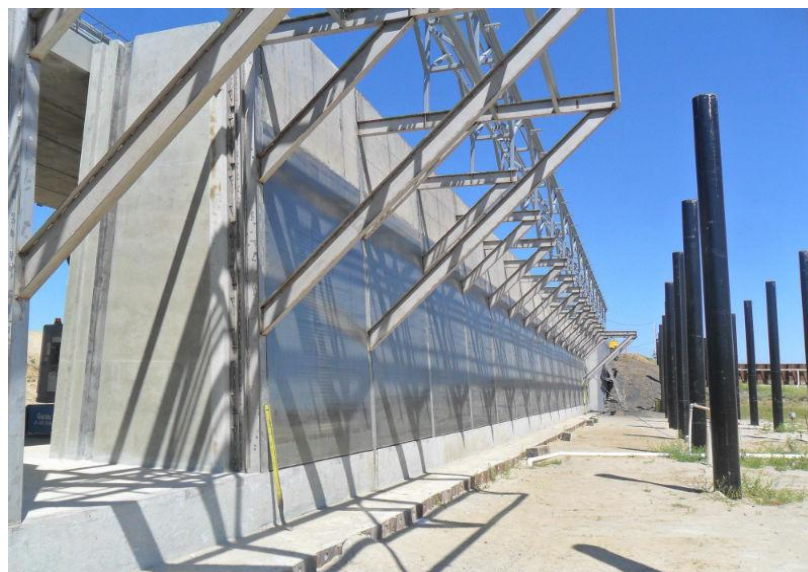
Figure 86 Flood risk area (in red)



Source: BRLi, 2016

The fish screens shall have automatic cleaning mechanism to remove debris using a traveling belt, with the belt moving in an endless loop powered by electricity. In front of the traveling belt a trash rack would be installed removing larger debris (logs, etc.). An inspection and maintenance plan shall be developed to ensure that the screens are operating well and that there is no breach.

Figure 87 Example of under construction large fish screen for water intake (left)



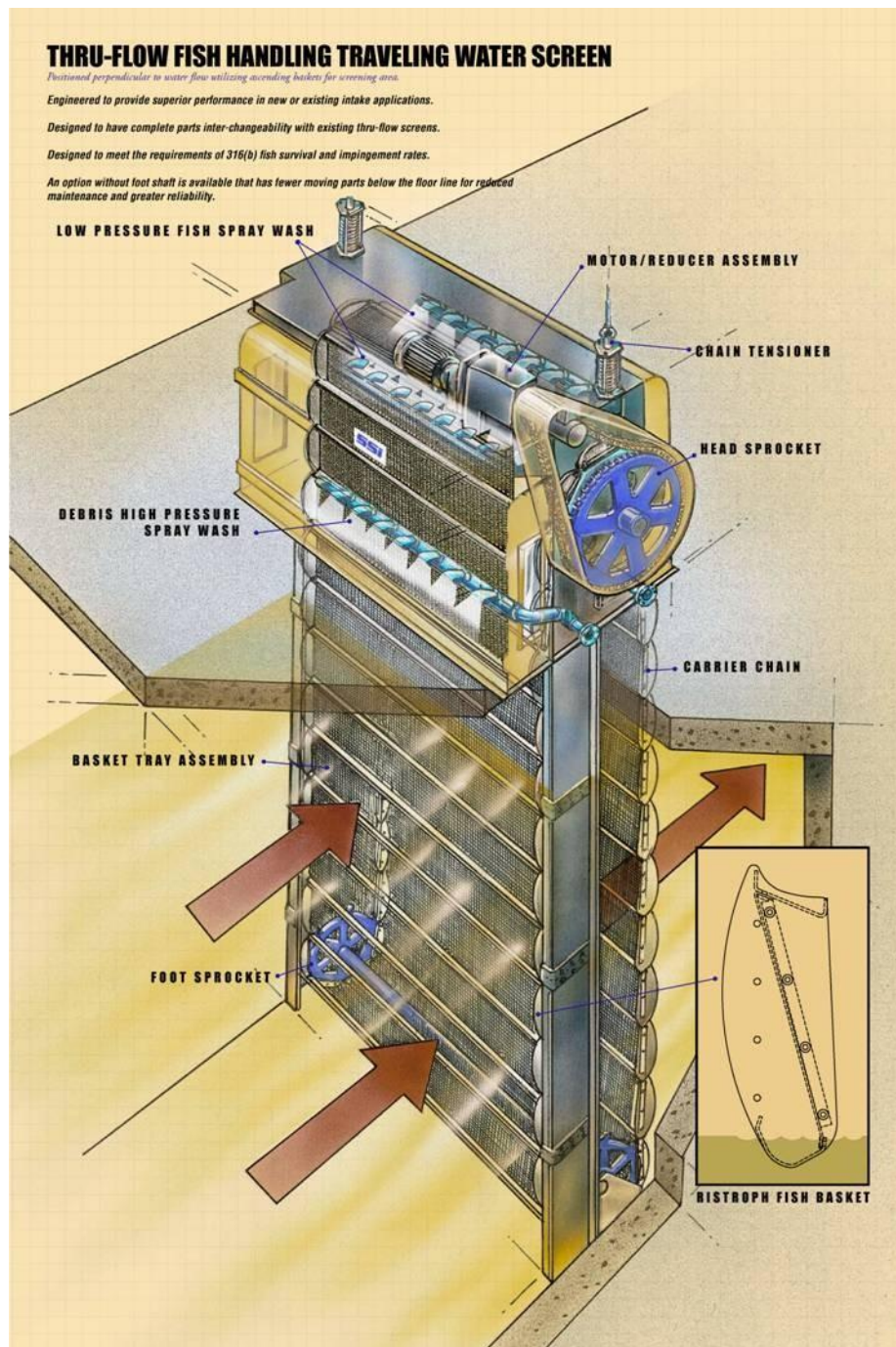
Source: Hendrick Screen Company, Fish diversion screen, 2016

Figure 88 Small scale automatic debris removal screens



Source: IWS International Water Screens, 2016

Figure 89 Large-scale automatic debris removal (traveling belt screen)



Source: Screening Systems International, 2016

Pros

Installing fish screens will have lesser economic impact on the Project than option 1 (due to option 1 head loss) because it will lead to insignificant head loss (about 30 cm head loss, based on actual calculations from IWS with a fish screen at the SVIP water intake, 2016). It will be efficient to prevent the Tiger fish from moving upstream only if a specialized firm is involved in designing and installing the screen.

Cons

The risk of defect, breach or obstruction of the screens is very important for the following reasons:

- There is a high risk of water hyacinth bloom in the Kapichira reservoir leading to blockage of screens at the water intake, unless a reliable trash rack is installed;
- Unless a specialized firm is involved in designing, producing and installing the screen, it will probably have defects and will not prevent fish passage (in fact in many countries such as the US, fish screens have to follow regulations and norms and must be built by certified firms). Many specialized firms are located on the Pacific coast of North America where there are issues with invasive migratory fishes. This expertise is absent in Africa and there is no return of experience in Africa.
- The fish screen is not a simple civil engineer infrastructure and will require constant effort and maintenance. Maintenance of this technology may fail in the medium term for a number of reasons (change in the scheme operator, budgets cut back, lack of spare parts, etc.). Maintenance of the screen at the water intake would require to remove debris (water hyacinth), logs, etc. in an area crawling with crocodiles. A self-cleaning device is highly recommended.

OPTION 2: A LOW CONCRETE WALL WITH A RACK AND AN APRON

This infrastructure shall not be installed outside MWR otherwise people will use it as area to wash clothes (on the apron) to bring cattle to drink and to bath. This will lead to damages to the infrastructure.

To be efficient, the fish barrier shall have the following characteristics from upstream to downstream:

- A waterfall high enough to keep the fish from jumping over. This wall shall be vertical and made of concrete. The height shall be at least 1 meter high.
- A long area of shallow water of about 30 cm deep (called an apron) to keep fish from gaining speed and energy to jump. The length of the apron shall be a few meters. To convey 50m³/s, the apron will need to be several hundred meters wide.
- An area of gradual slope leading to the canal which, at this point, will have its normal shape.
- A rack to offer additional security against jumping fishes

The fish barrier shall be installed in Majete Wildlife Reserve for the following reasons:

- To intercept all risks as the further downstream the structure is installed, the higher the risk of invasion;
- To take advantage of the buried canal or inverted siphons exit and available land to install the fish barrier;
- To take advantage of an area with lesser population density and to avoid having people using it to wash clothes (on the apron), bringing cattle to drink and to bath.
- To rely on African Parks as a well-managed organization for surveillance.

The following figures show two tested fish barriers with their wall and apron.

Figure 90 Smaller scale examples of fish barriers



Source left to right: The Verde Independent | Cottonwood, Arizona (2015) and Trout Unlimited (2013)

Pros

The low wall could be compensated by a rack (fence) along it to keep adult fish from jumping, the height of the wall would still be efficient to keep adults, fry and juveniles away and the apron will keep Tiger fish from gaining speed to jump. The fence could be either vertical or horizontal (as shown in the following pictures). This option is economically advantageous while ensuring high efficiency. However, as the wall is low, any damages to the structure would reduce its efficiency. The fence could simply be repaired in case of damages.

Cons

For this option, the Design or FS consultant has to decide what is an acceptable head loss, canal slope reduction, width augmentation and flow reduction. The height shall however not be lower than one meter.

The rack (fence) shall be designed, produced and installed by a specialized firm.

Figure 91 Examples of fish weir and rack



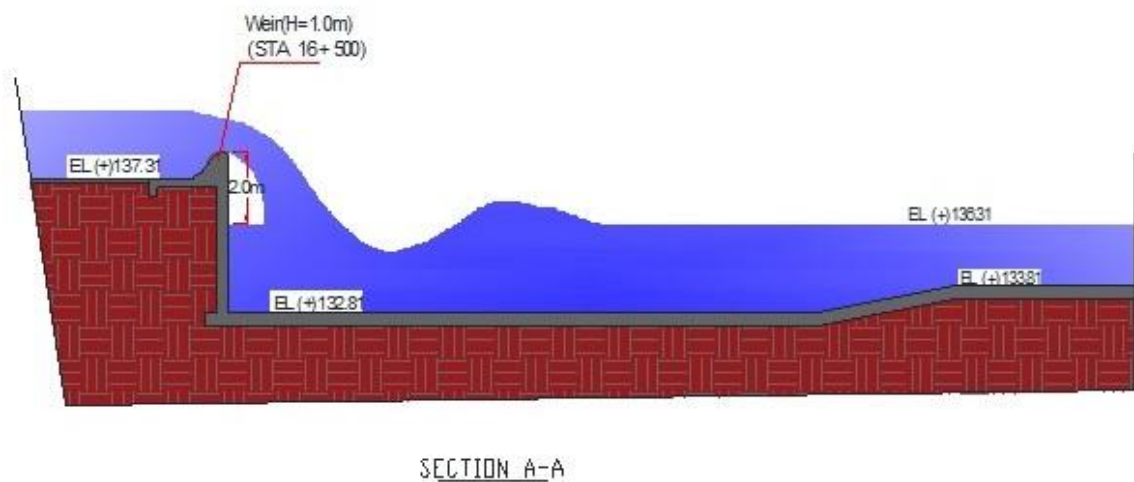
Source: New Zealand department of conservation, 2016

OPTION 3: A HIGH WALL, THE TIGER FISH WEIR DESIGNED BY KRC

Several discussions were held after the ESIA Mitigation Workshop (November 2016) on measures to avoid invasion of the Tiger fish upstream of Kapichira falls. In March 2017, a document called “Second proposal for mitigating the Tiger Fish Issue” was produced by the FS consultant presenting an infrastructure to stop Tiger fish migration upstream. This section presents the infrastructure and its main characteristics.

This option has a higher wall but no apron and no rack. The infrastructure involves a fall with a 1 meter high broad crested weir across the Main canal 1 (feeder canal) combined with a 3.5 meters drop structure as shown in the following figure.

Figure 92 KRC proposal for a Tiger Fish barrier



Pros

The height of the fall provide sufficient protection against fishes trying to jump. The fact that the wall is higher than option 1 makes the apron and the rack not useful.

Cons

The proposal from KRC seems to be efficient; however, it will have to be completed by more detailed plans and technical description in order to assess its efficiency. In addition, a ramp must be installed to allow removing deposited silts to keep silt from clogging the weir and having side flow and to maintain the structure.

KRC has provided in its document two location, one inside MWR and one at chainage 16+600 (as shown in the picture). The chainage 16+600 is too far downstream and will not catch all risks. In addition, at this location, there is a risk of damages from people using the falls for domestic use or to bring their cattle to drink. The weir has to be located inside MWR.

Summary of options

The following table is a summary of options to block Tiger fish invasion in the Upper Shire River system and all other Lower Shire fishes.

	Option 1: Fish screens	Option 2: A low concrete wall with an apron and a rack	Option 3: The Tiger fish weir designed by KRC High concrete wall without apron and without a rack
Land	Does not require additional land than the actual canal RoW	Requires additional land to install the wide apron	Does not require additional land than the actual canal RoW
Maintenance	High level of maintenance required to remove the debris and repair damages to the screens. Even if an automatic debris removal screen is installed it would still require maintenance (and energy for automatic debris removal)	Low maintenance necessary, the structure is a long lasting infrastructure. Silt removal could be necessary if not done upstream (at the water intake). The fence could easily be repaired in case of damages.	Low maintenance necessary, the structure is a long lasting infrastructure. Silt removal could be necessary if not done upstream (at the water intake)
Economic	High initial cost but probably the least expensive on economic implication thanks to minimal head loss. However, expensive to maintain and represent a high risk in case of failure to maintain the screens	Cheap to install and leading to less head loss than the high wall.	Additional cost is, according to KRC, 4.3 million dollars if the structure is installed inside MWR
Technical	The fish screen has to be designed, produced and installed by a specialized firm (leading to higher prices) as the structure is technically complicated to install. The call for tender for the firm shall be independent from the main tender for the construction contractor.	The weir could be done by the canal construction contractor as the structure is easy to design. However, the fence requires more technical expertise to sustain the flow	Could be done by the canal construction contractor as the structure is easy to design
		This option would require the feasibility or design consultant to decide on an acceptable head loss to statute on an acceptable wall height. However, less than a meter high is not recommended.	Loss of gravity command area: Dropping the canal by 3.5 meters will keep the following area out of gravity command: 275 ha

	Option 1: Fish screens	Option 2: A low concrete wall with an apron and a rack	Option 3: The Tiger fish weir designed by KRC High concrete wall without apron and without a rack
Efficiency	High efficiency in blocking fish movement (no risk regarding fry and juvenile passage) as long as the screen is design and installed by a specialized firm	High efficiency, but the lowest the wall, the more it represents a risk (in case of damages to the weir or fence)	High efficiency in blocking fish movement (no risk regarding fry and juvenile passage) as long as the weir is inside MWR

CONCLUSION

None of the option shall be installed outside African Parks reserve. African Parks is a reliable organization and the reserve is fenced, this would avoid having damages to the infrastructure.

Investment for mitigation should reflect the issues at stake (invasion of the Tiger fish and other non native fishes in an international lake and world heritage site).

Given the high risk of poor maintenance and clogging of fish screens and the high cost for maintenance for the screens, the ESIA recommends that a weir be implemented, as presented in options 2 and 3) because it is the only realistic infrastructure. Option 2 is only recommended if head loss cannot be compensated by changing the canal slope. **However, option 2 alone represents, on the long-term, a major risk for the future of Lake Malawi if maintenance fails or breaches appear on the screens.**

The wall is therefore the principle to retain, if the wall is low (option 2) it has to be accompanied by a rack and an apron, if the wall is high (option 3), there is no need for a rack and less incentive for an apron. The concept of an apron is interesting but given the volume of water, it is not feasible (it would be 500m wide).

This report highly recommends that the fish barrier be installed inside MWR for the following reasons:

- the fish barrier must catch all risks and be located as far as possible upstream.
- to eliminate the risk of tributary rivers flooding the feeder canal upstream from the fish barrier (such as Mwanza River and other rivers with flash floods) leading to potential colonization of fishes. Tributary Rivers flooding canals is a real risk and has been observed by the consultant in other regions of Africa (most of the time it is caused by the absence of culverts across canals or the improper sizing of culverts).
- outside MWR there is a real risk of damages from people using the falls for domestic use (washing their clothes on the fall, as observed in Illovo) or to bring their cattle to drink.
- inside MWR, there is a better chance that defects or breaches in the fish barrier be detected early enough, thanks to good management of African Parks.

It is not recommended that a fish barrier be installed in the underground section of the canal because of maintenance issues; any breaches would remain undetected for long periods of time. In addition, underground fish barriers were never designed nor tested. An underground fish screen is not feasible neither due to high risk of breaches for debris.

In all cases, further assessment shall be done at Design study stage to ensure that the infrastructure blocks all Tiger fish from moving upstream, the Design study has to prove that at all time and at all flow (especially at high flow), the weir drop is higher than the jumping ability of the Tiger fish which is about 1 meter. The World Bank will contract a Panel of Experts to review in depth the design and specific location of this fish barrier to ensure that it would function effectively, with little or no required maintenance over the long term. This expert review will be conducted in parallel with the final design of the Main Canal, and well before the start of canal construction.

14.7.2.3 Reduction of suitable habitat for fish in the Elephant marsh

In order to mitigate the impact on Elephant marsh not much could be done in terms of civil engineer infrastructures. Installing weirs or dikes to maintain a level of water at some key locations is not recommended as important floods would destroy them. The current study under the SRBMP called “Climate resilient livelihoods and sustainable natural resources management in the Elephant Marshes, Malawi” provides more details on institutional measures to implement to ensure adequate natural resources management which will help to improve biodiversity in the marsh as well. Once again, adaptation of Kamuzu barrage to provide for an environmental flow would be useful.

15. IMPACT ASSESSMENT CONCLUSION

This Impact assessment report is based on several bibliographical researches and consultations with various stakeholders as well as external experts on wildlife behavior.

This report has highlighted several significant impacts all of which can however be mitigated to acceptable levels as long as adequate budget is dedicated to mitigation measures.

Mitigation revolves around four challenging topics:

- the tender process for a construction contractor ;
- work in MWR;
- the type of canal and associated wildlife infrastructures in MWR and LNP;
- the type of fish barrier

These five topics shall be given priority by project financiers in case if budget for mitigation is limited. Although mitigation workshops have revealed that additional release from Kamuzu is not feasible on the short term, the rationale for an environmental flow is still detailed in this section.

TENDER PROCESS FOR A CONSTRUCTION CONTRACTOR

The selection of a construction contractor and the inclusion of appropriate mitigation measures in call for tender and contract is a crucial step as many contractors are not environmentally and socially proactive and most have no experience in working in sensitive areas.

Therefore, the selection of the construction contractor will require a conscious decision by project proponent and financing agencies prior to tendering. In addition, many measures proposed in this ESIA involve costs for the construction contractor, call for tender shall be clear on the requirement to quantify measures in the Bills of Quantities.

It is highly recommended to require that the contractor has experience in work in wildlife parks but most important of all, his reputation must be assessed.

WORK IN MWR

This ESIA has highlighted the need to implement many highly specific mitigation measures inside MWR, some of which should be included in the bills of quantities of the construction contractor. The quality of some mitigations inside the reserve cannot be compromised, and the risk that the contractor intentionally tries to replace highly specific mitigation by cheaper infective measures can be managed by providing funds directly to African Parks prior to work inside the reserve so that some site preparation works can be done by African Parks trusted contractors. This way, African Parks could prepare the site according to its quality standards and manage impacts associated with the “heavily impacted area”. The following mitigation could be done by African Parks’ regular contractors (and not by the Project construction contractor):

- Construction of the diverted road.
- Purchase and management of certified sound barriers.
- Purchase and installation of the temporary fences and all other infrastructures along the “heavily impacted area”.
- Animal containment and transportation outside the temporary fences (including the cost for a veterinary).
- Improvement of existing watering points to provide for water further inside the reserve (because wildlife will be startled by construction noise).

- Funds for monitoring studies on the effect of construction on wildlife.
- Any other activities, equipment or mitigation to completely confine the heavily impacted area during the time of work. It will not be realistic trying to continue any touristic activities during work in the “Heavily impacted area”, as the number of trucks traveling along the Mkulumadzi road across MWR will be very high and constant (mainly due to sediment dredging at the water intake, every few minutes a truck will pass). Therefore, it would be better to completely confine this area at once from Mkulumadzi Road to the Shire River. Mobile sound barriers shall be installed along the road close to the entrance gate and shall surround MWR offices (as offices will have excavating activities in the back and traveling trucks in front in addition to dust). Funds for confinement shall be provided to African Parks before work.

Phasing the work inside or near MWR in three distinctive confined areas so that no work takes place in several areas is absolutely necessary to maintain the reserve integrity:

- “Heavily impacted area” (first phase)
- Mwembezi lodge private property (also called Ng'ona lodge) (right outside MWR) (second phase)
- Southern MWR (third phase) from Siphon #2 to Siphon #3

Phasing the work shall be mentioned in the call for tender of the construction contractor so all interventions are planned.

This ESIA has engaged in many discussions with African Parks and provides cost estimates in the ESMP. However, since the Design is not available yet, this ESIA also suggests that the compensation package be updated once the final layout is known.

TYPE OF CANAL AND ASSOCIATE INFRASTRUCTURE IN MWR AND LNP

In order to achieve maximum efficiency in mitigation while remaining economically feasible (and realistic), we recommend that the canal in MWR shall follow the shortest distance outside MWR. According to the FS, some sections of the canal inside MWR will remain open, in this case, to avoid animal and children drownings; walls shall be built on both side of the canal. This is particularly relevant given the fact that recently African Parks has decided to develop the area where the open canal will pass. The development will consist of a small fenced park with non-dangerous mammals (antelope, etc.) aiming at children (schools trips, etc.). African Parks has also requested that a small wetland be built at this location instead of small troughs (as a compensation measure).

Regarding LNP, in case if an earth canal is feasible, this ESIA recommends that slopes remain gentle (1/2 or 1/3 rather than 1/1.5) and that the option of prefabricated concrete mats made of flexible matrix of cellular concrete blocks be studied at Design phase. These mats would give wildlife a good grip to exit the canal and would safe canal banks from erosion and bank destruction from wildlife. The following is a figure illustrating these mats.

Figure 93 Armorflex mats

Source: Infrastructure Specialist Group, 2016

TYPE OF FISH BARRIER

This ESIA recommends that Option 2 or 3 be implemented, as it is simple to maintain, however it will lead to head loss that will have implication for the area of irrigated land. Installing a fish screens at the water intake with a self-cleaning device (traveling belt) is a very interesting option because it will lead to minor head loss (30 cm). The mesh of the screen shall be small enough to exclude all adult and fry tiger fish (5 mm mesh size). However, given the fact that the screen can only be designed and maintained by a specialized firm (and not just by installing a wire mesh across the water intake), this option is less relevant and maintenance risks are high. Any breach in the screen would require importing a new screen from a foreign country leading to delays.

The cost of a fish screen is about 1.2 million USD (based on calculation for SVIP from International Water Screens Co, 2016). This cost exclude maintenance and electricity, each spare screen is 75,000 USD (International Water Screens Co, 2016). This cost also excludes importation fees.

15.1 CONCLUSION ON INFRASTRUCTURES TO BUILD TO MITIGATE IMPACTS

This section presents all civil engineering infrastructures developed in this ESIA and that need to be studied by technical studies (Design).

Self-reliant and low maintenance are the two principles that should govern all infrastructures that will be built.

Additional infrastructures recommended in this ESIA will allow to engage in discussion with various stakeholders but will most likely evolve based on the evolution of the Project. Depending on the financial arrangements for the Project (who will be the end payer for these mitigations), these infrastructures could affect the overall performance of the Project and may influence the water fees.

Costs for mitigation are provided in the ESMP (Vol.3), they are based on return of experience from the consultant or are provided from specialized firms (quotations). However, in depth economic feasibility has to be done by the Design study. Additional cost estimates are provided in the ESMP for non-engineering measures.

CANAL OPTIONS IN LNP

If the canal is an earth canal, the Design shall study the feasibility of installing prefabricated concrete mats along the 14 km of LNP which are flexible matrix of cellular concrete blocks that safeguard canal integrity from animals while ensuring that canals do not represent a drowning hazard. In addition, in case of an earth canal (with or without the Armorflex), walls are not required as an earth canal offers good grip for wildlife to exit the canal.

FENCE OPTIONS IN MWR AND LNP

Wall made of rock in concrete matrix (with a 0.5 cm thickness and a height of 2 meters) to protect the open sections of the Feeder canal in MWR is the selected option by this ESIA and the Design study shall retain this option.

PASSES

The Design study shall assess the economic feasibility of the following options (with current knowledge this will not be required for MWR thanks to buried sections but will be necessary in LNP):

- Unit cost for a wildlife overpass in concrete able to sustain the weight of a herd of buffalos (20+ individuals) with the following dimensions:
 - Slope for the access ramps: 8 Vertical / 1 Horizontal
 - Width : 50 m
 - Height: 2 m above the canal
 - Length to cross Bangula canal: 17 m (without the length of the ramp on both site of the canal)
 - Wall on the pass: 2 m high
 - Supporting poles
- Additional cost to enlarge a box culvert to allow for dry passages of small to medium size animals (wildlife underpass).
- The unit cost for a vehicle bridge across main canals (5 meters wide)
- The unit cost for a footpath across main canals (and branch canals)
- The unit cost for a people/cattle bridge across main canals

WATERING POINTS

The Design study shall design the following measure:

- MWR and LNP : A concrete lined wetland in the small game area of MWR and on the Eastern part of Bangula canal in LNP with the following dimensions:
 - Diameter : 30 m
 - Depth 0.5 m
 - Concrete lining : 10 cm (to avoid seepage) and a geomembrane
 - Type of pipes to convey water (sluice gates, etc.)

- Each wetland would require about 350 m³ of water from the canal, filled every two days, this would be the equivalent of 1230 m³ per week (or 0.002 m³/s) which is negligible in regard to the volume of water in the canal.

CROCODILE FENCE

As highlighted in the report, such fence are not recommended.

TIGER FISH BARRIER

The Design study shall further assess option 4 to ensure that it blocks upstream migration

15.2 RESIDUAL IMPACTS

This section presents residual impacts, if mitigations are implemented impacts can reach an acceptable level.

Table 26 Residual impacts

Impacts	Significance	Residual impact	Explanations
Impacts from water work. During construction, some actions and infrastructures will modify geomorphology of rivers	Negligible	Negligible	Impacts will be reduced with mitigation but not suppressed
Siltation of Elephant marsh. During operation of the scheme, erosion and sedimentation pattern will be modified	Minor	Minor	Reduction of flow cannot be mitigated, the impact will remain
Water abstraction. Up to 50m ³ /s will be extracted from the Shire system	Major (and cumulative)	Moderate	Reduction of the impact can be slightly achieved if pumping stations of Illovo remain shut down and if drainage is efficient. However, they are no provision for an environmental flow from Kamuzu barrage
Hydraulic transparency. When crossing the canal tributary rivers can flood upstream village if culverts are not properly sized	Minor	Negligible	If infrastructures (box culvert, etc.) are properly dimensioned, the impact should be negligible
Impacts from water works. Construction activities will bring silt and other pollutants to rivers	Negligible	Negligible	Impact will be reduced with mitigation but not eliminated
Water quality impairment. Drainage in watercourses will impair water quality	Moderate	Moderate	Impact will remain the same as pesticides and fertilizer will inevitably be used
Impacts from earthwork and land leveling. Construction of the canal system will lead to important earth movement	Moderate	Minor	If mitigations are implemented the impact can be reduced
Changes in soil properties and rising water table. Several changes in soil properties could take place in the command area	Minor	Negligible	Proper soil management will reduce the impact
Village reorganization and resettlement. Major changes are foreseen in terms of land occupation	Major	Minor	The RAP report will address impacts from village reorganization
Workers influx. Land will be necessary and there is a risk that infrastructures do not respect quality standards. Influx could be associated with social impacts	Moderate	Minor	If mitigations are implemented, including the strict application of the Code of conduct, the impact can be reduced
Rapid social changes. There is a risk that people do not	Minor	Minor	Impact will be reduced with mitigation but not eliminated.

Impacts	Significance	Residual impact	Explanations
change their lifestyle and develop skills			The current CCPLTRPF assignment aims to collecting people grievances and communicate about the Project. The Communication strategy report provides a tool to ensure social acceptability of the Project.
Hinterland effect. Increase in human activity and local economy may lead to additional pressure on resources (wood for charcoal, fish, etc.) and land	Moderate	Moderate	Mitigations for this impact are difficult to address in an ESIA
Permanent loss of buildings and other assets. Canals could necessitate to pass through several buildings and assets	Minor	Minor	Impact will be reduced with mitigation but not eliminated, however, the RAP will compensate according to the World Bank OP4.12
Disruption of access. Canals may sever footpaths and cattle paths	Moderate	Minor	If all measures to ensure continuity of access are fulfilled, the impacts will be mitigated
Inadequate maintenance of canals and infrastructures. There is a risk of canals and water intake siltation and invasion of plants in canal and drainage channel	Moderate	Minor	If all measures to ensure proper maintenance of canals and infrastructures are implemented by the scheme operator, the impact will be mitigated
Disturbance to existing agriculture. New lands may not be ready for cropping immediately because of timing, lack of water, or the need for land preparation including levelling, boundaries and drains	Minor	Minor	Impact will be reduced with mitigation but not eliminated, the risk still needs to be addressed
Job opportunities. Work will require unskilled and skilled labour for construction	Minor (positive)	Moderate (positive)	If the employment recruitment policy is implemented, the positive impact can be enhanced
Potential delays in irrigated agriculture development. Any delays in the project completion or skills acquisition could delay the benefits	Minor	Minor	The impact will be reduced with mitigations but not eliminated
Over supply of crops. Increase in production could lower prices and affect rain fed producers	Major	Minor	If this issue is addressed in future studies (agriculture development, agribusiness development), this risk will be significantly reduced
Benefits of irrigated agriculture. The project overall goal is to benefits local communities	Major (positive)	Major (positive)	This major positive impact will be enhanced thanks to training of farmers, creation of water user associations, etc.
Reduction of fisheries. Fishery could be impacted by SVIP	Minor	Minor	Reduction in fishery (if it occurs) will hardly be

Impacts	Significance	Residual impact	Explanations
			mitigable. The SRBMP will develop more good management measures for fisheries
Impacts on livestock rearing. The project will require adaptation of livestock rearing activities	Moderate	Minor	If appropriate mitigations to ensure that livestock owners have access to grazing areas, the impact will be mitigated.
Construction risk and nuisances. The public and workers are at risk from important works along canals	Minor	Minor	Impact will be reduced with mitigation but not eliminated as they will always remain a level of nuisance (noise, dust) and risks of collision
Bilharzias. An increase of bilharzia in the command area is expected	Moderate	Minor	Impact will be reduced with mitigation such as mass treatment but will not be eliminated
Drownings. The presence of main canals may lead to drownings	Major	Moderate	Reduction of the drowning risk can be achieved with sensitization and safety ladders, but never eliminated
Increase workload for women. The Project may become a burden to the workload of women but on the other hand time spent to get water should decrease with Improved access to water	Minor (positive)	Minor (positive)	Gender and Youth Strategy Study (COWI, 2016) has developed a series of measures to mitigate these impacts.
Risk of unfair distribution of benefits. Access to financial services is a strong barrier to women and youth empowerment	Moderate	Minor	
Impacts on vulnerable people. The Project benefits may not reach vulnerable people	Moderate	Minor	
Loss of physical cultural heritage. During construction, excavation of the canal will affect some known and unknown cultural heritage sites.	Minor	Minor	Reduction of the impact can be achieved, however, they will always remain a certain level of impacts as excavation may unveil (or destroy) unknown cultural heritage material
Decision on the type of canal and its alignment. Decisions regarding the canal layout during the design stage will have long term impacts on parks	Major	Minor	If this issue is given consideration and that the canals remain partly buried inside MWR (and remains an earth in LNP), the impact will be reduced.
Decision on the status of canals inside parks. The presence of canals inside parks will require a clear definition of	Moderate	Minor	If this issue is given consideration and that the canals is not alienated from MWR and subject to African

Impacts	Significance	Residual impact	Explanations
their status			Parks access restriction, the impact will be reduced.
Tender process and selection of a construction contractor. The tender process for the selection of the Project construction contractor represent a high risk for parks as it is a crucial step in the development of binding environmental measures	Major	Moderate	If the selection of a high quality construction contractor is given consideration, the impact will be reduced
Impact on tourism. Construction activities in MWR and LNP and close to Ng'ona lodge will have deleterious impacts on tourism	Moderate (MWR) / Minor (LNP and Ng'ona lodge)	Minor	If the construction activity is phased and confined in MWR and its vicinity, the impact will be reduced
Impact on Majete buildings, roads and infrastructures. Infrastructures will be disturbed by construction of the Feeder canal	Moderate	Minor	If the mobile noise barrier, sufficient dust control and other mitigation measures are implemented, impact will be reduced
Impact on Kapichira falls attractiveness. The viability of the falls as a sight to see for tourists may be compromised on long term with reduced flows	Moderate	Moderate	As explained in the report, no realistic mitigation can be implemented
Impact on Lengwe roads and infrastructures. The fence and park roads will be impacted	Moderate	Minor positive	If appropriate infrastructures are implemented close to the canal, they could become an opportunity for LNP
Loss of ownership of park management on the western side of Lengwe. Construction and operation of the Bangula canal will split the park in two, this could be interpreted as a message of weak ownership	Moderate	Minor	If appropriate compensations such as a new ranger scout are funded, the impact will be mitigated
The presence of a canal inside parks will be long-term agent of changes. The presence of canals and other infrastructures inside parks will require additional efforts and inputs from park management in order to maintain parks' integrity	Moderate	Minor	If responsibilities are clearly stated in agreements, the impact will be reduced
Rapid change in land cover. The command area will lead to significant changes in land cover	Moderate	Minor	If set aside lands are implemented at Design, the impact will be reduced
Disturbances of wildlife and vegetation. Forest clearing will permanently destroy valuable habitats and work will startle wildlife	Moderate	Minor	With compensation measures (planting of trees) and mitigation during work are implemented, the impact will be reduced
Habitat fragmentation. Canals	Major	Minor	With a buried canal in MWR

Impacts	Significance	Residual impact	Explanations
will permanently fragmentize habitats especially in parks			and wildlife overpass in LNP, the impact will be reduced
Drowning hazard for wildlife. An open canals represent a drowning hazard for wildlife	Major	Moderate	If the appropriate measure is taken against animal intrusion in the canal (walls on both side of the canal), the impact will be reduced for large animals, however small animals will always be at risk of drowning.
Changes in plant composition in Elephant marsh. Flow reduction will reduce the size of Elephant marsh	Moderate	Moderate	The impact is not mitigable, as they are no provision for an environmental flow from Kamuzu barrage
Wildlife-human conflict. There is a probability that hippos and crocodiles enter the drains and cause wildlife – human conflicts (and casualties). Irrigated field will become very attractive for wildlife.	Moderate	Moderate	The risk is hardly mitigable, however it mainly concerns Phase II as Phase I is far from Elephant marsh
Disturbance to fish migration to spawning sites. Works and infrastructures in temporary rivers could lead to fish migration disturbances	Moderate	Minor	If work is done outside the spawning season and crossings and culverts properly sized, the impact will be reduced
Risk of Tiger fish invasion in the upper Shire. The water intake could lead to Tiger fish invasion of Middle and Upper Shire and Lake Malawi	Major	Nil	If a fish weir is installed upstream from all risks (in MWR and on the Feeder canal), the risk will be nil. Otherwise, the risk will remain
Reduction of suitable habitat for fish in the Elephant marsh. Reduction of flow will lead to reduction of habitat suitability in the marsh	Moderate	Moderate	The risk is hardly mitigable. However, SRBMP may propose measures to mitigate impact

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ANNEXES

ANNEX 1: MINUTES OF MITIGATION WORKSHOPS

Table 27 Minutes of Nsanje Workshop

Questions raised during the workshop	Answers from the Consultant
What will happen if there is a need to cut valuable or protected trees?	At this stage, the ESIA could not identify individual protected trees, the Department of forestry will be involved whenever there is a risk of destruction of protected trees (whenever the canal passes across forested areas). This is added in the ESIA/ESMP in addition to the need to protect woodlands as set aside lands
Will canal be accessible for canoe?	No, canal access will be strictly forbidden for canoe
Water level in the Shire is already going down, is the Project feasible?	Indeed, however the ESIA role is not to assess the feasibility of the Project but to assess impacts. The FS has assessed the feasibility of the Project.
Who will maintain the canals?	The primary canal and branch canals will be under the management of an operator. People will have to maintain their plots, tertiary canals and drains
Could the canal overflow and flood villages?	No, water in the canal is controlled by gates at the water intake
Could the canal be fenced to keep children from drowning?	No, fencing will not withstand (stolen, vandalized, etc.), in addition the length of the canal (160 km) would make this very expensive. However, the ESIA/ESMP recommends regular sensitization in school about the risks for children associated with the canal
Will the water be safe to drink?	No, the objective of the scheme is irrigation. Some pipes may be built to provide with drinking water.
There is concerns over the spread of HIV	Ok, the ESIA/ESMP has highlighted this in the Code of conduct
How to ensure that local people will be hired in the construction process?	An Affirmative Action Recruitment Policy will have to be implemented so that contractor hire local people to work
How will the water fees be collected?	Answer by provided by Boniface Nthakomwa (SVIP) : same as PATHA out grower model (participants related to this example)
Can the canal be buried?	No, in Nsanje it will be open and lined (burying a canal is too expensive)
Will there be any school impacted?	Normally not, however if the canal cannot avoid infrastructures, they will be rebuild to good standards (according to the OP 4.12 from the World Bank)
What about transboundary impact?	Shire River is part of the Zambezi commission, they have been contacted (riparian notification)

Table 28 Minutes of Chikwawa workshop

Question raised during the workshop	Answer from the Consultant
Shire water level is low (same level than in 1997), the barrage is managed by the National Water Authority	Ok, this is taken into account
To compensate for lower water level in the Elephant marsh is it possible to build a pipe to bring water to dimba agriculture?	Dimba agriculture cover a vast area, a pipeline would not solve the issue and would cost a lot
If Kamuzu barrage releases more to compensate for impacts of SVIP it will impact Liwonde National Park (inundations)	Ok, this will be taken into account in the ESIA.
Comment on the PowerPoint : WESM has highlighted that Impact on Majete Wildlife Reserve are not acceptable as African Parks has invested millions in a prime touristic area that is now under threat from construction work and the presence of a canal, in order for the World Bank to comply with their policies, it has to give impacts and mitigation a serious consideration.	Impacts and mitigation on MWR are presented in depth in the ESIA
Comment on the PowerPoint : a participant has highlighted the risk from the Tiger fish	Impact from the Tiger fish is dealt with in the ESIA
Comment on the PowerPoint: How to propose more measures to ensure that a good construction contractor is selected?	The best way to ensure that is to verify the contractor reputation
Comment on the PowerPoint : WESM has highlighted that Elephant poaching was major during work close to Liwonde National Park in 2003, bringing a contractor inside a park is a risk	Ok
The water intake shall have a trash rack with appropriate size to keep juvenile crocodiles from entering	This concern is dealt with in the ESIA/ESMP
Comment from WESM: are local people fully aware of the fact that there will be a water fee?	Yes it was presented as part of the Consultation work from COWI
How will the project mitigate risk during construction of the canal (risk of animal falling in the trench)?	In MWR the work area will be fenced (as described in the ESMP)
Slow moving animal (snakes) shall be protected from persecution from workers	A measure has been added in the ESIA/ESMP
Who will have the authority to stop work in cases on non-compliances?	Details are added in the ESIA/ESMP

