State of the Basin Report for Shire River Basin
June 2016

Prosperous families
Green catchments
Healthy waterways
Foreword

The Lake Malawi–Shire River hydrological system represents Malawi’s single most important natural resource system. The Shire provides water for a number of productive purposes, including: hydropower, agriculture, fisheries, transport, tourism, urban water supply and rural water users along the length of the river, in addition to various environmental functions. On the other hand, much of the land and forest resources of the basin are being degraded and depleted at a rapid rate, its population is increasing at close to 3% per year, and climate change poses threats of worsening droughts and more intense rainfall leading to increased flooding.

The Malawi Development and Growth Strategy (MGDS-II – now being updated) aims to address these problems. It outlines plans to stimulate economic growth and development including a series of large-scale infrastructure investments in the Shire River Basin (irrigation, hydropower plants, and restoration of transport links, flood mitigation works and mining). Such large scale investments may generate long-term and cumulative adverse environmental, social and economic impacts if the interlinked challenges of increasing population pressure on a degraded natural resources base, declining agricultural yields, rapid urbanisation (driving demand for charcoal), unreformed land ownership, and weak institutional capacity to promote sustainable land and water management, are not addressed in an integrated, multi-sectoral fashion. For the Shire River Basin, a comprehensive, integrated and robust plan is critical to the success of achieving the goals of the MDGS.

The Shire River Basin Management Project (Phase I) – SRBMP – is funded by the World Bank and has the primary objective to develop a Shire River Basin planning framework and improve land and water management for ecosystem and livelihood benefits in the basin. The project aims to: (a) strengthen the institutional capacities and mechanisms for Shire Basin monitoring, planning, management and decision support systems; (b) invest in water related infrastructure that sustainably improves water resources management and development; (c) reduce erosion in priority catchments and sedimentation and flooding downstream, while enhancing environmental services, agricultural productivity and improving livelihoods; (d) improve flood management in the Lower Shire and provide community level adaptation and mitigation support; and (e) protect and enhance ecological services in the basin.

This State of the Basin Report, prepared under Subcomponent A1 of SRBMP, provides a comprehensive situation analysis of the Shire River Basin, its people, economy and natural resources. It provides a valuable reference document to inform basin planning and ongoing management decision making by the relevant agencies. It includes indicators that can be updated regularly to enable monitoring of the progress being made towards achieving the Vision of the Shire River Basin:

*Prosperous families*
*Green catchments*
*Healthy waterways*

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# Abbreviations

<table>
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<th>Description</th>
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<tbody>
<tr>
<td>AfDB</td>
<td>African Development Bank</td>
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<tr>
<td>AFIDEP</td>
<td>African Institute for Development Policy</td>
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<tr>
<td>AIDS</td>
<td>Acquired Immune Deficiency Syndrome</td>
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<tr>
<td>BOD</td>
<td>Biological Oxygen Demand</td>
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<tr>
<td>CIA</td>
<td>Central Intelligence Agency</td>
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<tr>
<td>CITES</td>
<td>Convention on International Trade in Endangered Species</td>
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<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
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<tr>
<td>CRIDF</td>
<td>Climate Resilient Infrastructure Development Facility</td>
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<tr>
<td>DCCM</td>
<td>Department of Climate Change and Meteorological Services</td>
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<tr>
<td>DEA</td>
<td>Department of Environmental Affairs</td>
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<tr>
<td>DNPW</td>
<td>Department of National Parks and Wildlife</td>
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<td>DOE</td>
<td>Department of Energy</td>
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<tr>
<td>DOEDP</td>
<td>Department of Economic Development Planning</td>
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<tr>
<td>DOMM</td>
<td>Department of Mines and Minerals</td>
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<tr>
<td>DWAF</td>
<td>Department of Water Affairs and Forestry. South Africa</td>
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<tr>
<td>ERP</td>
<td>Economic Recovery Plan</td>
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<td>ESCOM</td>
<td>Electricity Supply Commission of Malawi</td>
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<tr>
<td>$ET_0$</td>
<td>Evapotranspiration</td>
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<tr>
<td>FAO</td>
<td>Food and Agriculture Organisation</td>
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<tr>
<td>FEWS NET</td>
<td>Famine Early Warning Systems Network</td>
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<tr>
<td>FISP</td>
<td>Farm Input Subsidy Program</td>
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<tr>
<td>FRIM</td>
<td>Forest Research Institute of Malawi</td>
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<tr>
<td>GCM</td>
<td>Global Circulation Model</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<tr>
<td>GHG</td>
<td>Greenhouse gas</td>
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<tr>
<td>GOM</td>
<td>Government of Malawi</td>
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<td>GVC</td>
<td>Global value chain</td>
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<td>ha</td>
<td>Hectare</td>
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<tr>
<td>HH</td>
<td>Household</td>
</tr>
<tr>
<td>HIV</td>
<td>Human Immunodeficiency Virus</td>
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<tr>
<td>IFMIS</td>
<td>Integrated Financial Management System</td>
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<tr>
<td>IHS</td>
<td>Integrated Household Survey</td>
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<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
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<tr>
<td>IUCN</td>
<td>International Union for Conservation of Nature</td>
</tr>
<tr>
<td>JICA</td>
<td>Japan International Cooperation Agency</td>
</tr>
<tr>
<td>kg</td>
<td>Kilograms</td>
</tr>
<tr>
<td>$km^3$</td>
<td>Cubic kilometres (billion cubic metres)</td>
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<tr>
<td>$m^3$</td>
<td>Cubic metres</td>
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1 Introduction

1.1 Purpose of this Report

The Shire River Basin Management Program (Phase I) Project (SRBMP), funded by the World Bank, aims to increase sustainable social, economic and environmental benefits by effectively and collaboratively planning, developing, and managing the Shire River Basin’s natural resources.

This report has been prepared by the consultants NIRAS, DHI and Bua Consulting Engineers as part of Subcomponent A1 of the SRBMP. It presents an overall assessment of the present state of the Shire River Basin and emerging trends and challenges for the future. It also includes relevant indicators for key basin characteristics that can be tracked over time. It is anticipated that the State of the Basin Report will be updated by the Shire River Basin agency, yet to be established.

This report also summarises the findings of the various sector and thematic assessments that have been prepared and submitted by the consultants, as follows:

**Sector Assessments**
- Agriculture, livestock and fisheries
- Hydropower and energy
- Water supply and sanitation
- Navigation and other transport
- Tourism
- Mining
- Industry

**Thematic Assessments**
- Climate change\(^2\)
- Surface water assessment
- Groundwater assessment
- Catchment management and biodiversity assessment
- Water quality and pollution management assessment
- Information and data assessment
- Institutional assessment
- Transboundary water management assessment
- Demographics assessment

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\(^1\) It is the intention of the Government of Malawi to establish a Shire River Basin agency and part of the TOR to assist the Ministry responsible for water to do so. This will (or should) be the agency to update the SOB report on a regular basis.

\(^2\) Note that, due to the importance of the climate change analysis assessment, this report was submitted in July 2015.
- Environmental flow assessment
- Water licensing and regulation assessment

Collectively, these assessments will inform the development of the Shire River Basin Plan (SRBP). These reports should be consulted for more detailed information and can be found in the Knowledge Portal developed by NIRAS and DHI. It can be found at: http://shirebasinplanning.wris.info/

In this report, the numerous basin characteristics that are of importance are described under the following broad headings:

- The People
- The Economy
- Agriculture, Livestock, Fisheries and Forestry
- Energy
- Industry and Mining
- Tourism
- The Land
- Water Resources
- Climate Change
- Water Quality
- Biodiversity

The main purpose of this work is two-fold: first, it will inform the formulation of the Shire River Basin Plan – also to be done by the consultants under SRBMP Subcomponent A1; and second, it will be a reference document for government and private sector decision makers in the water sector.

NIRAS has also produced a companion document – the Shire River Basin Atlas – that covers the same themes as this report. It contains more detailed maps, with only summary information describing each theme.

1.2 Developing Indicators

1.2.1 Need for indicators in the Shire River Basin

A strong indicator framework is critical for measuring progress towards defined goals, outcomes and targets. This is one of the lessons learnt from the implementation of the first Malawi Growth and Development Strategy (MGDS) and the MDGS II. MDGS III is now under preparation and it may be that, once finalised, it can provide information to update the indicators presented in this report.

The SRBMP needs indicators in order to reduce down to its simplest form the large quantity of data associated with catchment and biodiversity management while retaining the essential meaning of the data for the questions that are being asked. Indicators are needed to make sense of the complex environmental systems in which we live.

In general, the main reasons for using indicators include:

- They allow the synthesis of large volumes of data;
- They show the current status in relation to desirable states;
- They demonstrate trends and progress towards goals and objectives; and
They communicate current status to stakeholders so that effective management decisions can be taken that lead towards achieving targets. Indicators are therefore a means of summarising the current status, trend and rate of change of progress towards a particular goal or objective. As with any summary, the greater the degree of aggregation of the information, the more of the original picture is lost. If indicators are to be useful to decision-makers, they have to be simple enough to allow for ease of processing and comprehension. The number of indicators used should be kept to a minimum as too many indicators may reduce the ability of an organisation (including a government agency) to use the information effectively.

1.2.2 Characteristics and functions of indicators

The key characteristic of indicators is being able to ‘track progress and performance and act as a guide to decision making’ (OECD. 2003). Indicators have two defining characteristics, in that they:
- quantify information so that its significance is more readily apparent;
- simplify information about complex phenomena to improve communication (Wright. 2010).

The Organisation for Economic Cooperation and Development (OECD) terminology points to two major functions of indicators:
- They reduce the number of measurements and parameters that normally would be required to give an exact presentation of a situation. As a consequence, the size of an indicator set and the level of detail contained in the set need to be limited. A set with a large number of indicators will tend to clutter the overview it is meant to provide;
- They simplify the communication process by which the results of measurement are provided to the user.

Due to this simplification and adaptation to user needs, indicators may not always meet strict scientific demands to demonstrate causal chains. Indicators should therefore be regarded as an expression of "the best knowledge available".

Indicators can measure inputs, outputs, outcomes, processes and structures (facilities). These indicators can be identified for programs, sub-programs, agencies, and multi-unit/agency initiatives. These types are discussed in more detail in the following sections.

1.2.3 Types of indicators

Input indicators

Input indicators measure resources, human and financial, that are devoted to particular program or intervention (for example, amount of money invested). Input indicators can also include measures of characteristics of target populations (for example, number of people qualified to operate hydroelectric facilities). They are generally only of limited use in the ongoing monitoring of the performance of river basin management programs.
Output indicators

Output indicators measure the quantity of goods and services produced and the efficiency of production (for example, number of reports prepared, speed of response to reports). Output indicators are being developed and managed by the SRBMP Subcomponent A4: Consolidated Monitoring and Evaluation of Shire River Basin Management. While these are useful for monitoring the implementation of programs like SRBMP, they by themselves do not reflect the results of the program – that is, what impact is the program having on the stakeholders (including the environment) to which it is targeted.

Outcome indicators

In recent years, natural resources and environmental management agencies have increasingly recognised that reliance on input and output indicators alone does not account for qualitative differences in the effectiveness of various interventions, investments and other activities. This trend is part of a more general tendency to focus compliance assurance on environmental outcomes (OECD. 2011).

Outcome indicators measure the broader results achieved through the provision of goods and services. These indicators can exist at various levels: population, area, agency, and program.

Population-level indicators measure changes in the condition or well-being of children, families or communities (for example, rate of access to clean drinking water). Changes in population level indicators are often long-term results of the efforts of a number of different programs, agencies and initiatives. In some cases, rather than providing information about the outcomes achieved by interventions, population-level indicators may provide information about the context in or assumptions under which these interventions operate. For example, the overall level of water in aquifers provides important contextual information for farmer irrigation schemes. In this case, monitoring the availability of water in aquifers and the recharge rate allows stakeholders to correctly interpret program outcomes. Area-level – that is, catchment or sub-catchment level – indicators measure outcomes of activities within the area of interest. Agency-level indicators measure outcomes for which an agency is responsible; program-level indicators measure the results for which a program or sub-program is responsible. Area, agency and program-level outcome indicators are often defined more narrowly than those pertaining to the population as a whole. For example, they may measure farmers practicing irrigation versus rainfed agriculture. Identification of appropriate indicator levels ensures that expectations are not set unrealistically high.

“Stressor” indicators

In long-term programs, such as the SRBMP, it may be desirable to not only monitor factors that can be influenced by the program, but also “non-attributable” factors that relate to the driving forces that lead to the need for the program. These are commonly called “stressors”. For the Shire River Basin, population density and growth is a primary driving factor for the SRBMP – in the sense that it is population pressures that have led to significant environmental impact, need for increased energy and water supplies, and so on. Other relevant indicators of this type might be poverty levels, energy demand, hydro-meteorological factors (such as annual
rainfall) and others. These indicators are related to “external\textsuperscript{3} scenarios” such as climate change, population growth and so on. These are discussed in NIRAS’ report on the use of scenarios for Shire River Basin planning (NIRAS 2015b).

The purpose of monitoring these indicators is primarily to allow decision-makers to understand the change in the program “drivers” over time in order to change relevant policies, plans and actions to suit the circumstances. In addition, these indicators will facilitate the identification of adverse trends that may require new projects or programs to be implemented over time.

1.2.4 Indicators, targets and objectives

The difference between what is commonly understood by “indicators”, “targets” and “objectives” needs to be clarified at this point. In the context of this report, an “indicator” measures a single factor related to the state of a system, program or other activity at a given point in time, and can be used to track the trajectory of the state of that factor over time (see Section 1.2.2). A “target” is a value of an indicator that is desired to be achieved at some (unspecified) point in the future. But adding a timeframe, an “objective” is created.

The following simple example illustrates this concept:

**Indicator** – Proportion of biomass (mainly fuelwood and charcoal) used as a source of energy compared to the total energy consumption of Malawi (the value of this indicator at the present time is around 89\%\textsuperscript{4}).

**Target** - Achieve a value for that indicator of 75\% (say).

**Objective** - Achieve a value for that indicator of 75\% by the year 2025 (say).

1.2.5 Indexes

An index provides a single number (like a grade) that expresses the overall condition or status of a specific factor based on several more specific parameters. The objective of an index is to turn a set of complex indicators into information that is simpler and more understandable and useable.

An example of this is for water quality, where indexes are commonly used\textsuperscript{5}, because water quality has many “dimensions”, usually expressed by a large number of parameters, such as temperature, pH, total dissolved solids, total phosphorus, total nitrogen, chemical oxygen demand (COD), biological oxygen demand (BOD), heavy metals, pesticides and so on. Having a separate indicator for all of these makes for a complex and unwieldy description of the water quality as a whole.

It must be said that the use of an index to define a water quality indicator is a controversial issue among water quality scientists. A single number

\textsuperscript{3} “External” in the sense that they are outside the scope of influence of the program.


\textsuperscript{5} See, for instance:


cannot tell the whole story of water quality – there are many other water quality parameters that are not included in the index. The index may be specifically aimed at human health, aquatic ecosystems or other situations and therefore may have a very narrow scope of application. Nonetheless, a water index based on some very important parameters can provide a simple indicator of water quality. It can give decision-makers and other stakeholders (particularly the public) a general idea of the possible problems with the water in the basin.

1.2.6 Challenges to defining and implementing indicators

Part of the problem of creating and using indicators for water security, or any other type of resource scarcity, is that many indicators do not specify what the goals of the indicator are and mix a variety of input, output, and state of the resource variables to define the index. The focus is on the ‘objective use’ of the indicator; an indicator has to be directed towards some management control or assessment action (GWP. 2012).

For countries such as Malawi with limited national resources for sustained data collection and analysis, the practical considerations are often the greater challenges to implementing indicators. These practical considerations are presented in Table 1.

In this report, many of the indicator values for the present situation are not known at the time of writing, due to a variety of reasons. However, all the indicators are measurable and processes need to be put in place to collect and analyse the relevant data in order to be able to track them over time. It is envisaged that the indicators marked “To be calculated” are expected to become available in the coming months, as many statistics for 2015 are not collated, analysed and published by the responsible agencies for some time. For those marked “Not available”, it is hoped that the nominated agency can provide the requisite data in the future.

For the Shire River Basin, many of the data that are required for the indicators are collected, or at least published, at national level. These will need to be “downscaled” from national level to basin level. How difficult this might be will depend on the specific indicator, and it may entail going back to raw data sources to extract data for individual collection “units”. Even in this case, those units may be Districts, in which case further disaggregation may be necessary. All this will add greatly to the cost of derivation of the actual indicator values. However, since the Shire River Basin is clearly a priority part of Malawi (as evidenced by the existence of the Shire River Basin Management program), efforts to collect and analyse data at basin level need to be intensified.
Table 1: Practical considerations for operationalisation

<table>
<thead>
<tr>
<th>Practical Considerations</th>
<th>Operationalisation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timeliness:</strong> data need to be assembled, analysed, presented, and disseminated within a time period that users need it</td>
<td>Does it take less than 3 months to assemble and analyse data? Y=1; N=0</td>
</tr>
<tr>
<td><strong>Affordability:</strong> data collection, analysis, and presentation take time and cost money. Measures too costly do not help anyone</td>
<td>Is the cost of acquiring this indicator less than 10 percent of this budget? Y=1; N=0</td>
</tr>
<tr>
<td><strong>Cost effectiveness:</strong> the information for an indicator is available or can be obtained with reasonable cost and effort and provides maximum information per unit of effort</td>
<td>Is ([\text{Total of all considerations marked yes} – \text{practical considerations}] / \text{percent of total budget consumed by measurement}) greater than 1? Y=1; N=0</td>
</tr>
</tbody>
</table>
| **Difficulty level:** ability to obtain expertise to monitor | A. Is a college education not required to collect this data Y=1; N=0  
B. Is a college education not required to analyse and interpret this data? Y/N |
| **Availability:** good information dissemination is key | Is this indicator measure readily available? |


### 1.3 The Shire River Basin

The Lake Malawi–Shire River hydrological system represents Malawi’s single most important natural resource system. The Shire River provides water for a number of productive purposes, including: hydropower, agriculture, fisheries, transport, tourism, urban water supply and rural water users along the length of the river, in addition to various environmental functions. The Shire River originates at Lake Malawi and flows for 520 km through the Southern Region of Malawi. It is joined by numerous rivers and streams, the Ruo River being the largest, and merges with the Zambezi River in Mozambique (see Figure 1).

The part of the Lake Malawi–Shire River basin that is commonly referred to as the “Shire River Basin” is the part of the hydrological basin that is both downstream of the lake and within Malawi. In this sense, it is strictly not a true hydrological basin, but rather a planning unit. It covers an area of 22,430 km².
The Upper Shire is situated at around 470 meters above sea level (masl) and flows on a very shallow gradient through Lake Malombe to the Kamuzu Barrage at Liwonde, constructed in 1965 to partially control the water level and Shire flows to the benefit of hydropower generation in the Middle Shire. After Liwonde, the Middle Shire flows across a broad plain descending only seven meters in 50 km. It then drops steeply by 360 meters over a distance of around 70 km through a series of rapids and falls, some of which have been harnessed to provide hydropower. The Lower Shire emerges below the falls at Kapichira to flow across a wide floodplain with a minimal gradient of 10 meters in 90 km. The river then flows through an expansive floodplain wetland – including the Elephant marshes – that supports extensive dry season agriculture, high levels of biodiversity and a productive fishery. These wetlands also play an important role in reducing downstream sedimentation and flooding. The Lower Shire hosts large areas of traditional and commercial agriculture, and adjacent to the river, more than half a million people live in areas that are vulnerable to droughts and floods.

High population density and poverty have led to significant human pressure on the environment and degradation of the Shire Basin's natural resource base, notably land and forests. The growing population expands land area under cultivation and exploits forests and woodlands for firewood and charcoal production. Deforestation, soil erosion and sedimentation form the most serious threats to the environment and natural resource base in the Shire River Basin, resulting in the increased incidence of erosion and flash floods, as well as downstream sedimentation. High loads of sediment are deposited in riverbeds, reservoirs and floodplain wetlands affecting irrigation canals, fisheries and hydropower generation. Water resources are
increasingly degraded through silt loads, sedimentation, eutrophication, biological contamination and effluents. These problems are a direct result of catchment degradation, unsustainable land use and management practices, and increased use of chemical fertilizers without complementary soil and water conservation measures.

Some years ago⁶, Malawi adopted a system of dividing the country into “Water Resource Areas” (WRAs) with these being further subdivided into “Water Resource Units” (WRUs) for water resource related analyses. The Shire River Basin, as defined, consists of WRA 1 and WRA 14, with a total of 21 WRUs. For planning purposes, the basin has been divided by NIRAS into six sub-basins as shown in Figure 2. These sub-basins are amalgamations of WRUs. The areas of the sub-basins are shown in Table 2.

Table 2: Shire sub-basin areas

<table>
<thead>
<tr>
<th>Sub-Basin</th>
<th>Area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivi Rivi</td>
<td>4,798</td>
</tr>
<tr>
<td>Lisungwe</td>
<td>4,124</td>
</tr>
<tr>
<td>Wamkulumadzi</td>
<td>3,375</td>
</tr>
<tr>
<td>Mwanza</td>
<td>5,147</td>
</tr>
<tr>
<td>Thangadzi</td>
<td>1,467</td>
</tr>
<tr>
<td>Ruo</td>
<td>3,519</td>
</tr>
<tr>
<td><strong>Shire River Basin</strong></td>
<td><strong>22,430</strong></td>
</tr>
</tbody>
</table>

⁶ When this occurred and the rationale behind it is difficult to determine precisely.
Figure 2: Sub-basins of the Shire River Basin
2 The People

2.1 Overview

Malawi is one of the fifteen countries that have been categorised as a population and climate change “hotspot” because of its rapidly growing population, water scarcity and falling food production. Malawi’s population has grown from 6 million in 1966 to about 17 million now and the United Nations Population Division projects that it could more than triple to 50 million by 2050, and reach 129 million by 2100. This population growth is due to high and only slowly declining fertility levels. The number of births per woman is currently estimated at around 5.7. Though there is increasing demand for smaller families, about 26% of all married women who want to postpone or avoid pregnancy still lack modern contraception. Twenty-six percent of all recent births were unwanted while 19% were mistimed.7

Rapid population growth places increased demands on natural resources such as land, forests and water. The wellbeing of the majority of Malawians is dependent on natural resources and highly vulnerable to climate change. Malawi has already been experiencing climate change effects, including reduced and erratic rainfall, floods, droughts, dry spells, strong winds, thunderstorms, land- and mudslides, hailstorms and heat waves. These have resulted in crop failure, disruption of hydroelectric power generation, and water shortages.

2.2 Population

2.2.1 Malawi

The present population of Malawi is around 17,380,000.8 It has increased rapidly from about 3,500,000 in 1961 – that is by about fourfold. Figure 3 shows the population for the period 2000 to 2012. The population growth rate for the same period is shown in Figure 4.

The population density for the period 2000 to 2012 is in Figure 5, while the present distribution of population density across Malawi is shown in Figure 6.

---


8 Source: CIA World Factbook.
Figure 3: Malawi – population 2000 – 2012 (millions)

Source: CIA Factbook (online)

Figure 4: Malawi – population growth rate 2000 – 2012 (percent)

Source: CIA Factbook (online)

Figure 5: Malawi – population density 2000 – 2012 (persons/km²)

Source: CIA Factbook (online)
It should be noted from Figure 6, that the greatest population density occurs in the south, most of which is covered by the Shire River Basin.

The population of Malawi is expected to continue to grow rapidly in the foreseeable future. Population projections up to the year 2100, for three variant scenarios identified by the United Nations Population Fund (UNPF) based on possible fertility rates are shown in Figure 7. For instance, the UN medium variant projects a Malawi’s fertility rate to decline from 5.7 children per woman to 5.1 by 2030 and to 4.0 by 2050. It can be seen that even for this scenario, the population could reach 130 million by the year 2100. In
the extreme case, the population could reach almost 180 million by then. Given the slow pace of fertility decline in Malawi thus far, it is quite possible that high population growth will continue.³

Figure 7: Malawi Population Projections

Malawi’s high population growth is driven by high fertility. Fertility has declined modestly during the past few decades – despite almost half the women in the population having access to contraception, while child mortality declined steadily. Demographic health surveys show that the total fertility rate has declined from 6.7 children per woman in the 1970 to 5.7 children per woman in 2010. The under-five-mortality rate declined from 234 deaths per 1000 live birth in 1992 to 112 in 2010.¹⁰ Therefore, reducing the fertility rate in Malawi is the key to stabilising the population. In other words, the year in which Malawi reaches replacement fertility level¹¹ will have a major impact on its ultimate population size.

Table 3 shows the estimated “stable” population that could be achieved if the replacement fertility rate (around 2.1) could be achieved by various years.

---


¹¹ In simple terms this is the fertility rate (average number of live births per woman) that just balances the mortality rate of a population and is usually about 2.1 in developed countries.
Table 3: “Stable” population versus year replacement fertility rate is achieved

<table>
<thead>
<tr>
<th>Year RFR achieved</th>
<th>Ultimate population size</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>27 million</td>
</tr>
<tr>
<td>2040</td>
<td>44 million</td>
</tr>
<tr>
<td>2060</td>
<td>63 million</td>
</tr>
<tr>
<td>2080</td>
<td>88 million</td>
</tr>
</tbody>
</table>

Source: Adapted from Population Dynamics, Climate Change and Sustainable Development in Malawi, AIFDP, Nairobi, Kenya, November 2012

2.2.2 Population age structure

The “population pyramid” illustrates the age and sex structure of a country’s population and may provide insights about political and social stability, as well as economic development. The shape of the population pyramid will gradually evolve over time based on fertility, mortality, and international migration trends. For Malawi the present-day age structure is shown in Figure 8.

Figure 8: Age structure for present day Malawi

Source: CIA Factbook (online)
In Figure 9 (with estimates from 2012) it can be seen that with high fertility rates that have persisted over the last decade, the age structure among the poorest 20 percent of the population was extremely youthful with the median age being 13. During the same time period, the wealthiest 20 percent began to experience a fertility rate decline, increasing the median age of this group to 17.

**Figure 9: Age structure and wealth**

Source: Malawi Population Data Sheet 2012. USAID

### 2.2.3 Shire River Basin

The population density in the Shire River Basin in 2012 is shown in Figure 10. It could be expected that the distribution of population in 2015 is very similar, even though the densities will have increased.

The population estimates within the Shire River Basin by district in 2015 (calculated using district population increase rates from Figure 11) is shown in Table 4.
Figure 10: Shire River Basin population distribution (2012)
Table 4: Population within the Shire River Basin by district

<table>
<thead>
<tr>
<th>District</th>
<th>Area of district within Shire Basin (km²)</th>
<th>Population density (per km²)</th>
<th>Estimated population in 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balaka</td>
<td>2,134</td>
<td>179</td>
<td>382,900</td>
</tr>
<tr>
<td>Blantyre Rural</td>
<td>1,794</td>
<td>226</td>
<td>405,900</td>
</tr>
<tr>
<td>Blantyre City</td>
<td>221</td>
<td>3665</td>
<td>809,900</td>
</tr>
<tr>
<td>Chikwawa</td>
<td>4,892</td>
<td>107</td>
<td>521,000</td>
</tr>
<tr>
<td>Chiradzulu</td>
<td>453</td>
<td>454</td>
<td>205,800</td>
</tr>
<tr>
<td>Machinga</td>
<td>1,313</td>
<td>145</td>
<td>190,100</td>
</tr>
<tr>
<td>Mangochi</td>
<td>1,769</td>
<td>142</td>
<td>251,600</td>
</tr>
<tr>
<td>Mulanje</td>
<td>1,766</td>
<td>313</td>
<td>552,900</td>
</tr>
<tr>
<td>Mwanza</td>
<td>743</td>
<td>151</td>
<td>112,200</td>
</tr>
<tr>
<td>Neno</td>
<td>1,576</td>
<td>82</td>
<td>129,500</td>
</tr>
<tr>
<td>Nsanje</td>
<td>1,962</td>
<td>144</td>
<td>283,400</td>
</tr>
<tr>
<td>Ntcheu</td>
<td>1,739</td>
<td>178</td>
<td>309,400</td>
</tr>
<tr>
<td>Phalombe</td>
<td>141</td>
<td>267</td>
<td>37,600</td>
</tr>
<tr>
<td>Thyolo</td>
<td>1,643</td>
<td>430</td>
<td>706,600</td>
</tr>
<tr>
<td>Zomba Rural</td>
<td>592</td>
<td>227</td>
<td>134,400</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>22,738</strong></td>
<td></td>
<td><strong>5,033,200</strong></td>
</tr>
</tbody>
</table>

Source: Adapted from Final Report of Component 1 (Water Resources Assessment) of the National Water Resources Investment Strategy Project (April 2011)

Within the country, the annual population growth rates were highest (above the national average of 2.8%) in the districts of the less densely populated Northern and Central regions. Growth has been slower in the districts of the more densely populated Southern Region, including the Shire River Basin (see Figure 11).

Based on projected population growth rates (for Malawi) implicit in Figure 7, the population projections have been calculated as in Table 5.
Figure 11: Population growth rates by District

Source: Malawi Population Data Sheet 2012. USAID

Table 5: Shire River Basin population projections to 2100

<table>
<thead>
<tr>
<th>Year</th>
<th>Low Variant</th>
<th>Medium Variant</th>
<th>High Variant</th>
</tr>
</thead>
<tbody>
<tr>
<td>2050</td>
<td>12,400,000</td>
<td>13,800,000</td>
<td>15,200,000</td>
</tr>
<tr>
<td>2100</td>
<td>25,400,000</td>
<td>35,900,000</td>
<td>49,200,000</td>
</tr>
</tbody>
</table>
Notwithstanding the slower than average growth rates being experienced in the Shire River Basin, it is projected that population densities will generally remain at higher levels than for the northern and central parts of the country (see Figure 12, which shows population densities by District projected to the year 2030).

**Figure 12: Population densities by District to year 2030**

2.3 Access to Water Supply and Sanitation

2.3.1 Water supply

Malawi’s institutional framework for the urban, semi-urban and rural water supply is (as of 2016) managed by the Ministry of Agriculture, Irrigation and Water Development and five parastatal Water Boards. The Department of Water Supply Services of the Ministry is responsible for the development of rural water supply, whereas the water boards have the control and responsibility of all urban and semi-urban waterworks, the management of the supply and distribution of such water in accordance with the Waterworks Act (1995). The water boards operating inside the Shire River Basin are Blantyre Water Board, Central Regional Water Board and Southern Regional Water Board serving a total population of over 1.14 million.

A common type of rural water supply scheme in Malawi is the so-called gravity fed scheme that started to be developed around 1968. Currently, within the Shire River Basin, 39 gravity fed piped water supply schemes of various sizes are in operation. These 39 schemes serve a total population of approximately 477,000 people. The Mpira-Balaka water supply scheme that covers four districts is the largest in the Shire River Basin and the only rural water supply scheme with a large dam as the raw water source. This scheme is presently suffering stress due to increasing population and deterioration of the water supply infrastructure. The town of Balaka, which takes most of its water from the scheme, is seen by many rural dwellers dependent on the scheme as taking more than its share of the water supply.

There are about 13,000 boreholes in the Shire (see Figure 13), around 1,500 shallow wells and 130 spring sources covering approximately 1.3 million.

Figure 13: Typical rural water source
The present (2015) access to safe water supply (piped water into dwelling, yard, or plot; public tap or standpipe; tubewell or borehole; protected dug well; protected spring; or rainwater collection) in the Shire River Basin is estimated to be approximately 58%. Presently more than 2.1 million people (42%) are without proper and adequate safe water supply (refer to Table 6).

There is a significant difference to what is reported nation-wise in 2011 (88%) and the estimated coverage in Shire River Basin above. It should be noted that the 42% not covered (the 2.1 million in the table above) is being supplied by water but receiving less than the design norms and also most likely of an inferior quality. These sources could be unprotected dug wells; unprotected springs; carts with small tank or drum; tanker trucks; surface water, which includes rivers, dams, lakes, ponds, streams, canals or irrigation channels; or bottled water. In addition, the number of people with reliable access is affected by hand pumps being broken, leaving no choice but to go back to unsafe (unimproved) water sources.

Table 6: Water supply coverage in the Shire River Basin (2015)

<table>
<thead>
<tr>
<th>Sub-basin</th>
<th>Population 2015</th>
<th>Access to safe water supply</th>
<th>No access to safe water supply</th>
<th>No access to safe water supply (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivirivi</td>
<td>949,490</td>
<td>576,410</td>
<td>373,080</td>
<td>39%</td>
</tr>
<tr>
<td>Lusungwe</td>
<td>553,800</td>
<td>218,760</td>
<td>335,040</td>
<td>60%</td>
</tr>
<tr>
<td>Wamkulamadzi</td>
<td>1,186,000</td>
<td>1,113,840</td>
<td>72,170</td>
<td>6%</td>
</tr>
<tr>
<td>Mwanza</td>
<td>726,600</td>
<td>390,930</td>
<td>335,670</td>
<td>46%</td>
</tr>
<tr>
<td>Ruo</td>
<td>1,429,760</td>
<td>521,120</td>
<td>908,640</td>
<td>64%</td>
</tr>
<tr>
<td>Thangadzi</td>
<td>187,540</td>
<td>92,720</td>
<td>94,820</td>
<td>51%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,033,190</strong></td>
<td><strong>2,913,780</strong></td>
<td><strong>2,119,420</strong></td>
<td><strong>42%</strong></td>
</tr>
</tbody>
</table>

Based on the information received from the water boards and the previous reports, the total daily “abstraction/used” in Ml/day of water by the water boards, gravity schemes and boreholes is provided in Table 7.

In total approximately 160 Ml/day or 58,500 Ml/year is presently being used in the Shire River Basin for domestic/institutional and commercial purposes. The future demand for water supply for domestic purposes will depend upon population growth and increase in service levels. The forecast future demand has been estimated as shown in Table 8.
Table 7: Water production in the Shire River Basin

<table>
<thead>
<tr>
<th>Sub-basin</th>
<th>Blantyre Water Board</th>
<th>Southern Water Board</th>
<th>Central Water Board</th>
<th>Gravity Schemes</th>
<th>Rural Water Supply (BH)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivirivi</td>
<td>0.00</td>
<td>5.57</td>
<td>0.00</td>
<td>7.08</td>
<td>9.46</td>
<td>22.11</td>
</tr>
<tr>
<td>Lusungwe</td>
<td>74.43¹²</td>
<td>0.00</td>
<td>1.01</td>
<td>2.20</td>
<td>5.52</td>
<td>83.16</td>
</tr>
<tr>
<td>Wamkulamadzi</td>
<td>8.28</td>
<td>1.82</td>
<td>0.00</td>
<td>0.00</td>
<td>3.72</td>
<td>13.82</td>
</tr>
<tr>
<td>Mwanza</td>
<td>0.00</td>
<td>1.84</td>
<td>0.00</td>
<td>2.42</td>
<td>11.29</td>
<td>15.55</td>
</tr>
<tr>
<td>Ruo</td>
<td>0.00</td>
<td>3.82</td>
<td>0.00</td>
<td>5.17</td>
<td>12.80</td>
<td>21.79</td>
</tr>
<tr>
<td>Thangadzi</td>
<td>0.00</td>
<td>0.95</td>
<td>0.00</td>
<td>0.03</td>
<td>2.91</td>
<td>3.89</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>82.71</strong></td>
<td><strong>14.00</strong></td>
<td><strong>1.01</strong></td>
<td><strong>16.90</strong></td>
<td><strong>45.70</strong></td>
<td><strong>160.32</strong></td>
</tr>
</tbody>
</table>

Note: Figures are in Ml/day.

Table 8: Projected water demand

<table>
<thead>
<tr>
<th>Sub-basin</th>
<th>2015 Ml/day</th>
<th>2020 Ml/day</th>
<th>2035 Ml/day</th>
<th>2050 Ml/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivirivi</td>
<td>36.18</td>
<td>42.22</td>
<td>67.14</td>
<td>106.90</td>
</tr>
<tr>
<td>Lusungwe</td>
<td>95.80</td>
<td>110.50</td>
<td>172.02</td>
<td>274.26</td>
</tr>
<tr>
<td>Wamkulamadzi</td>
<td>16.54</td>
<td>18.97</td>
<td>28.89</td>
<td>44.57</td>
</tr>
<tr>
<td>Mwanza</td>
<td>28.21</td>
<td>31.93</td>
<td>46.56</td>
<td>68.37</td>
</tr>
<tr>
<td>Ruo</td>
<td>56.05</td>
<td>60.70</td>
<td>77.22</td>
<td>98.55</td>
</tr>
<tr>
<td>Thangadzi</td>
<td>7.47</td>
<td>8.41</td>
<td>12.00</td>
<td>17.12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>240.24</strong></td>
<td><strong>272.73</strong></td>
<td><strong>403.83</strong></td>
<td><strong>609.77</strong></td>
</tr>
</tbody>
</table>

These figures may need to be adjusted upwards depending upon the assumptions for service level improvements between 2015 and 2050 as result of increased standard of living of consumers.

2.3.2 Sanitation

The majority of the population in Malawi use on-site systems to dispose of their sewage. The common on-site facilities used in Malawi are: pit latrine; improved pit latrine; and flush toilet with septic tank and soil adsorption field. In the urban areas of the basin, the following types of sewage disposal are utilised: sewerage; septic tank; improved pit latrine; pit latrine; and no facility (open defecation). As for rural areas, the most used type is basic pit latrine or (unfortunately) open defecation.

Malawi faces serious health threats from the inadequate maintained sanitary facilities and domestic wastewater is a serious cause of pollution

¹² Water abstracted in Lusungwe for urban population in Wamkulamadzi sub-basin
for potable water sources – both surface and groundwater. There seems to be a need to define and improve the overall responsibility for sanitation and sewerage management in Malawi.

The sanitation coverage (households) and type of toilets/latrines in the six sub-basins for 2015 has been estimated\textsuperscript{13} and is shown in Table 9.

Table 9: Estimated sanitation coverage in households (2015)

<table>
<thead>
<tr>
<th>Sub-basin</th>
<th>Flush to sewer</th>
<th>Flush to septic tank</th>
<th>Improved Latrine</th>
<th>VIP\textsuperscript{14}</th>
<th>Eco-San</th>
<th>Basic Latrine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivirivi</td>
<td>1,213</td>
<td>3,517</td>
<td>3,082</td>
<td>599</td>
<td>4,783</td>
<td>212,053</td>
</tr>
<tr>
<td>Lusungwe</td>
<td>673</td>
<td>1,798</td>
<td>2,388</td>
<td>228</td>
<td>2,219</td>
<td>124,524</td>
</tr>
<tr>
<td>Wamkulamadzi</td>
<td>699</td>
<td>5,660</td>
<td>5,991</td>
<td>376</td>
<td>890</td>
<td>75,943</td>
</tr>
<tr>
<td>Mwanza</td>
<td>2,181</td>
<td>23,250</td>
<td>11,700</td>
<td>340</td>
<td>756</td>
<td>123,448</td>
</tr>
<tr>
<td>Ruo</td>
<td>1,453</td>
<td>2,028</td>
<td>43,302</td>
<td>1,286</td>
<td>3,471</td>
<td>296,006</td>
</tr>
<tr>
<td>Thangadzi</td>
<td>206</td>
<td>577</td>
<td>453</td>
<td>0</td>
<td>206</td>
<td>39,766</td>
</tr>
<tr>
<td><strong>Total SRB (HH)</strong></td>
<td><strong>6,425</strong></td>
<td><strong>36,830</strong></td>
<td><strong>66,917</strong></td>
<td><strong>2,829</strong></td>
<td><strong>12,327</strong></td>
<td><strong>871,741</strong></td>
</tr>
<tr>
<td><strong>Total SRB (%)</strong></td>
<td><strong>0.64%</strong></td>
<td><strong>3.69%</strong></td>
<td><strong>6.71%</strong></td>
<td><strong>0.28%</strong></td>
<td><strong>1.24%</strong></td>
<td><strong>87.44%</strong></td>
</tr>
</tbody>
</table>

With the present very limited coverage of safe piped sanitary disposal in urban and peri-urban areas (Blantyre) and the general low coverage in rural areas – there is an obvious substantial demand to sanitation. In particular – the lack of facilities in working condition in urban and peri-urban areas cause already severe environmental and health problems – and this will only be exacerbated in the future by the population growth and possible rural to urban migration.

In rural areas in the Shire River Basin – the coverage of “improved” sanitation (anything other than basic latrine/open defecation) is assessed to be still around 13% in 2015. So even in 2015, approximately 870,000 households are today in need of improved sanitation facilities (instead of the present basic latrine/open defecation).

In addition to these 870,000 households and taking into account the population growth, the following addition demand for improved sanitation (shown as number of improved latrine facilities in households) in SRB can be estimated.

An economic study\textsuperscript{15} has shown that impacts resulting from poor sanitation and hygiene costs the economy of MWK 8.8 billion (US$ 57 million) per year, or the equivalent of 1.1% of annual GDP.

With the continued dependency of surface water as source for domestic potable water supply – the present sanitation situation in the Shire River Basin (and in Malawi in general) is seriously alarming and needs to be addressed in the very near future.


\textsuperscript{14} Ventilated improved pit latrine.

\textsuperscript{15} World Bank. Water and Sanitation Program. 2012.
Table 10: Additional and total demand for improved sanitation

<table>
<thead>
<tr>
<th>Sub-basin</th>
<th>Anticipated demand (Improved latrines)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2020 No. HH</td>
</tr>
<tr>
<td>Rivirivi</td>
<td>37,645</td>
</tr>
<tr>
<td>Lusungwe</td>
<td>20,040</td>
</tr>
<tr>
<td>Wamkulumadzi</td>
<td>12,509</td>
</tr>
<tr>
<td>Mwanza</td>
<td>21,177</td>
</tr>
<tr>
<td>Ruo</td>
<td>28,830</td>
</tr>
<tr>
<td>Thangadzi</td>
<td>5,184</td>
</tr>
<tr>
<td>Additional SRB</td>
<td>125,386</td>
</tr>
<tr>
<td>Present coverage</td>
<td>870,000</td>
</tr>
<tr>
<td>Total, including present demand</td>
<td>995,386</td>
</tr>
<tr>
<td>Total demand, rounded</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>

Thus, under the population growth scenario underlying the calculations the total service gap – or total demand – for improved sanitation is close to 1.0 million households in 2020, increasing to 1.5 million in 2035, and to 2.2 million households in 2050 (refer to Table 10). Based on the present stock of 125,000 improved sanitation installations the required additional number of installations to satisfy increasing shares of the total demand in selected years is illustrated in Table 11.

Table 11: Required additional sanitation installations under different assumptions

<table>
<thead>
<tr>
<th>Assumption</th>
<th>2020</th>
<th>2035</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present coverage</td>
<td>125,000</td>
<td>125,000</td>
<td>125,000</td>
</tr>
<tr>
<td>Total demand, rounded</td>
<td>1,000,000</td>
<td>1,500,000</td>
<td>2,200,000</td>
</tr>
<tr>
<td>Additional number of installations required for:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction of 20% of total demand</td>
<td>75,000</td>
<td>175,000</td>
<td>315,000</td>
</tr>
<tr>
<td>Satisfaction of 40% of total demand</td>
<td>275,000</td>
<td>475,000</td>
<td>755,000</td>
</tr>
<tr>
<td>Satisfaction of 60% of total demand</td>
<td>475,000</td>
<td>775,000</td>
<td>1,195,000</td>
</tr>
<tr>
<td>Satisfaction of 80% of total demand</td>
<td>675,000</td>
<td>1,075,000</td>
<td>1,635,000</td>
</tr>
<tr>
<td>Satisfaction of 100% of total demand</td>
<td>875,000</td>
<td>1,375,000</td>
<td>2,075,000</td>
</tr>
</tbody>
</table>

Note: It is assumed that the present stock of improved sanitation installations stays constant.

16 From Table 8.
To satisfy 20% of the total demand for improved sanitation facilities by 2020 would require an additional number of 75,000 installations. By 2035 the required additional number would have grown to 175,000, and by 2050 the required number would be 315,000.

To satisfy 40% of the total demand for improved sanitation facilities by 2020 would require an additional number of 275,000 installations. By 2035 the required additional number would have grown to 475,000, and by 2050 the required number would be 715,000.

### 2.4 Poverty

#### 2.4.1 Overview

As in many developing countries, poverty reduction is a primary development goal in Malawi. Up until 2015 the country was committed to the Millennium Development Goals (MDGs). These sought, among other things, to eradicate extreme poverty and hunger. Over the years, the Malawian government has pursued poverty reduction efforts through various strategies emphasizing economic growth, infrastructural development, and the provision of basic social services. These strategies have included: the Poverty Alleviation Program (1994); the Malawi Poverty Reduction Strategy (2002–2005); and, more recently, the Malawi Growth and Development Strategy (MGDS) (2006–2011 and 2011–2016) – with MDGS III in the process of development. Despite these various policies and measures, poverty remains widespread in Malawi and the Shire River Basin in particular (see Figure 14).

Malawi has now committed to the Sustainable Development Goals (SDGs), which were developed in September 2015 within the United Nations arena.\(^\text{17}\)

\(^{17}\) Officially known as *Transforming our world: the 2030 Agenda for Sustainable Development*, the SDGs are an intergovernmental set of aspiration Goals with 169 targets. The Goals are contained in paragraph 54 United Nations Resolution A/RES/70/1 of 25 September 2015.\([1]\) The Resolution is a broader intergovernmental agreement that, while acting as the Post 2015 Development Agenda (successor to the Millennium Development Goals).
2.4.2 Poverty profile

Table 12 shows poverty headcount rates measured at two poverty lines distinguishing “poor” and “ultra-poor” individuals. Results are shown for rural/urban areas as well as across the three regions of Malawi, and are based on: the Welfare Monitoring Surveys (WMS) (2005-2009), and two waves of the Integrated Household Survey (1998 or IHS1, and 2005 or IHS2), all conducted by the National Statistical Office (NSO) in Malawi.
Table 12: Poverty Rates In Malawi (1998 – 2009)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Percentage Poor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National</td>
<td>54</td>
<td>52</td>
<td>50</td>
<td>40</td>
<td>39</td>
</tr>
<tr>
<td>Urban</td>
<td>19</td>
<td>25</td>
<td>24</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Rural</td>
<td>58</td>
<td>56</td>
<td>53</td>
<td>44</td>
<td>43</td>
</tr>
<tr>
<td>Northern Region</td>
<td>56</td>
<td>56</td>
<td>51</td>
<td>46</td>
<td>31</td>
</tr>
<tr>
<td>Central Region</td>
<td>48</td>
<td>47</td>
<td>46</td>
<td>36</td>
<td>41</td>
</tr>
<tr>
<td>Southern Region</td>
<td>68</td>
<td>64</td>
<td>60</td>
<td>51</td>
<td>51</td>
</tr>
<tr>
<td><strong>Percentage Ultra-Poor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National</td>
<td>24</td>
<td>22</td>
<td>21</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Urban</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Rural</td>
<td>26</td>
<td>24</td>
<td>23</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Northern Region</td>
<td>25</td>
<td>26</td>
<td>21</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>Central Region</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>Southern Region</td>
<td>35</td>
<td>32</td>
<td>30</td>
<td>22</td>
<td>23</td>
</tr>
</tbody>
</table>

Figures are not collected specifically for the Shire River Basin but note that in Table 12, the figures for the Southern Region represent a close approximation to the situation for the basin. In particular, it can be seen that the prevalence and severity of poverty is greater than the other regions of Malawi.

Unlike the more comprehensive IHS, the WMS does not collect consumption expenditure data, a standard metric for measuring poverty; instead, consumption is imputed. Comparisons between WMS and IHS should therefore be made with caution. Nevertheless, the series does suggest a sharp decline in poverty, from 52 to 39%, and in ultra-poverty from 22% to 15% over the implementation period of the Farm Input Subsidy Program (FISP) that dominated the policy front from about 2004 to 2010. Table 12 further reveals a much higher incidence of poverty in rural areas compared to urban areas. Since 85% of the Malawian population lives in rural areas, the vast majority of the poor are in fact located in rural areas (96%). Both rural and urban areas have experienced significant reductions in poverty; for instance, urban poverty reduced from 25% to 14% between 2004 and 2009, while rural poverty declined from 56 to 43% over the same period.

Table 12 also disaggregates rural poverty rates across Malawi’s three regions. Poverty rates in the rural south (which in effect is the Shire River Basin) have historically been highest, while those in the north are lowest. The relative disadvantage of southerners relates in part to land constraints in the face of high population density: the 2008 Population Census puts the population density in the south at 184 persons per km² compared to only 63 in the north. The differences can be discerned from Figure 12.
Plot sizes are thus smaller in the south, which results in lower agricultural output per capita. Although not reported in Table 12, poverty in Malawi takes on a distinct gender dimension. Data from the IHS2 indicate that in rural areas, about 55% of people in male-headed households are poor, compared to 60% in female-headed households. One in four people in male-headed urban households are poor, compared to about a third of those in female-headed urban households\textsuperscript{18}.

Finally, poor households in general tend to be larger than non-poor ones and have higher dependency ratios. Household heads in poor households typically have little or no education, and have a lower likelihood of being in salaried employment or of working in a household enterprise. Instead, heads of poor households often rely on household farming, fishing activities, and\textit{ ganyu} (informal off-farm labour) for income.

2.4.3 Vulnerability and the determinants of poverty

Malawian households are vulnerable to a number of shocks that may increase their likelihood of being poor. A World Bank study in 2006 lists four major shocks that are deemed to be important by households.

First, given the prominence of rain-fed agricultural production systems in Malawi, climatic shocks have potentially severe implications for household welfare; second, animal and plant diseases may lead to major crop and livestock losses; third, price volatility of maize, tobacco and fertiliser is a major source of vulnerability to households; finally, health shocks mostly due to HIV/AIDS, malaria, tuberculosis, and anaemia are pervasive in Malawi. The economic implications of poor health are wide-ranging, for example household income may be negatively affected by illness and death of productive adults due to medical and funeral costs incurred by family members and time lost caring for the sick.

A number of studies have looked at the determinants of poverty in Malawi. In summary, the studies find that human capital, physical infrastructure, ownership of productive assets, access to wage employment, and participation in agriculture all tend to lower the likelihood of being poor. Having additional children on the other hand is found to increase monetary poverty but reduces subjective poverty. Severe weather shocks often drag households below the poverty line and limit the extent to which they can invest in inputs for the next production cycle. In addition to this, Malawi’s high import intensity means real exchange rate fluctuations or international price shocks have a significant impact on the domestic economy.

2.4.4 Poverty trends

Projections of future poverty levels appear to be very difficult to find. It is clear though that poverty levels have been falling in recent times. According to World Bank statistics\textsuperscript{19}, the percentage of people below the national poverty line was 65.3% in 1997, but fell to 50.7% by 2010\textsuperscript{19}. More work needs to be carried out in order to determine forecasts for the future.

\textsuperscript{18} More discussion of gender differences is in Section 2.7.
\textsuperscript{19} Source: http://data.worldbank.org/country/malawi
It is clear that efforts to reduce poverty will be hampered by increasing population (see Figure 7). Even for the "low growth" projection of around 45 million people for Malawi and more than 12 million people in the Shire River Basin (Table 4), without a significant move away from reliance on subsistence agriculture (particularly in the face of the likely adverse impacts of climate change) and significant increase in GDP (which is presently in decline – see Figure 24) through industrialisation, it is difficult to see how the various indicators of poverty can be improved.

### 2.5 Food Security

Under average conditions, Malawi is a self-sufficient maize producer. However, crop performance was poor in the 2014-15 growing season due to a late and erratic start to the season, followed by damage from severe flooding in the Shire River Basin and periods of extended dryness across most of the country for the latter half of the season. As a result, maize supplies for the 2014-15 agricultural year were well below the five-year average. Prices increased by more than 10% during the harvest and post-harvest period, providing an early indication of limited market supplies.

Rainfed maize production for the 2014-15 season decreased by approximately 25% to 30% compared to the previous season and the five-year average. In contrast, the latest irrigated maize production estimates indicate that this year’s production is above average; however, irrigated production usually contributes only 15% to 20% of total maize production. Other cereals, including millet and sorghum also registered at below-average levels. The Famine Early Warning Systems Network (FEWS NET) has estimated that the national maize deficit was approximately 500,000 tonnes during 2015. The FEWS NET estimate for food security for southern Malawi, based on maize deficit, is shown in Figure 15.20

In the Shire River Basin in 2015 some markets reported low maize supplies as early as June. However, in the traditionally surplus central and northern areas maize market supplies are normal. Average national prices are higher than normal in the post-harvest period. Some maize prices are as much as 60% above the three-year average. The June Consumer Price Index (CPI) dropped slightly between May and June, but still indicates that the cost of living is high in Malawi.

During 2015, households typically sold some of their food and cash crops as necessary. Households also participated in some agricultural labour for wetland cultivation in some areas. On average, wages from a day of labour are worth 4 kg of maize, while selling a chicken is worth 15 kg of maize.

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20 The Integrated Food Security Phase Classification (IPC) is a set of standardised tools that aims at providing a “common currency” for classifying the severity and magnitude of food insecurity. This evidence-based approach uses international standards that allow comparability of situations across countries and over time. It is based on consensus-building processes to provide decision makers with a rigorous analysis of food insecurity along with objectives for response in both emergency and development contexts.
For the 2015-16 season, the situation has become even worse. Due to the effects of a major El Niño event, much of Malawi has suffered severe drought. Production has been estimated to be 2,431,313 tonnes, down from 2,776,277 in the 2014/15 growing season, representing a 12.4% decrease. It is estimated that as much as 1,650,000 tonnes is required to meet Malawi’s needs. No specific figures for the Shire River Basin are available.

2.6 Health

2.6.1 General

As with many African countries, common diseases in Malawi are HIV/AIDS, malaria, measles, tuberculosis and pneumonia. Over the last decade, the government has worked towards providing basic healthcare for all with emphasis on immunisation programs, reproductive health and nutrition.

There are four main public hospitals, located in the cities of Lilongwe, Blantyre, Zomba and Mzuzu, and a network of district hospitals (as well as a number which are run by missionary societies). However, healthcare in

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21 Briefing to journalists by the Minister of Agriculture, Irrigation and Water Development on 29 April 2016 and reported in The Daily Times newspaper on 3 May 2016. But official figures vary.
Malawi suffers from a shortage of medical supplies and an acute lack of doctors and nurses.

Village life is still very traditional. Most homes have a thatch roof and are made of mud (because cement and the wood needed to fire bricks are both scarce and costly). Few houses have piped water or electricity – fewer than one in ten Malawians have access to electricity. Villagers collect water from wells or streams and cook over an open fire.

As a result of endemic poverty and the many threats to health, the average life expectancy is 58.1 years for males and 61.1 for females\(^{22}\). While no statistics for the Shire River Basin are available, it could be expected that these figures are less there, due to the higher poverty rates (see Table 12).

### 2.6.2 HIV/AIDS

While not specifically related to land and/or water management HIV/AIDS are nonetheless an important health issue. HIV/AIDS has an impact on a country’s mortality rate and therefore on population growth. HIV/AIDS is a major public health concern and cause of death in many parts of Africa including Malawi.

In Malawi, the HIV/AIDS pandemic has aggravated the burden and incidence of other diseases such as malaria, tuberculosis and other opportunistic infections due to compromised immunity in those infected. High disease burden slows down development efforts as most resources are diverted to health sector leaving other sectors inadequately supported. The high prevalence of these diseases has grossly affected the human capital development, welfare and health care service delivery system. This causes a big challenge in attaining a healthy nation and seriously impedes development efforts. The high prevalence of these diseases has grossly affected the health service delivery system and subsequently the health status of the country’s population.

However, Malawi is considered a success story in reducing HIV infection rates, passing the tipping point – when the number of people starting treatment exceeds the number of new infections. According to UN figures, between 2001 and 2011, the rate of new HIV infections dropped by 73%. This was helped in part by the introduction of anti-retroviral drugs in 2003, which have slashed death tolls from about 92,000 to less than 45,000 over the past decade. But with an HIV prevalence of about 10% among people aged 15 to 49, Malawi has the ninth highest HIV rate in sub-Saharan Africa, according to UN-Aids estimates. More than 40% of new infections are among 10 to 19 year olds.

The HIV/AIDS adult prevalence rate gives an estimate of the percentage of adults (aged 15-49) living with HIV/AIDS. Adult prevalence rates by region are shown in Table 13, while Figure 16 shows the decline in the statistic over the period 1999 to 2009.

Figure 17 shows the annual number of deaths from HIV/AIDS. These peaked in 2003 at more than 80,000 but have reduced progressively since that time.

\(^{22}\) Based on 2014 estimates. See: http://www.worldlifeexpectancy.com/malawi-life-expectancy
Table 13: HIV/AIDS prevalence by region

<table>
<thead>
<tr>
<th>Region</th>
<th>Adults aged 15-49 with HIV/AIDS (%)</th>
<th>Youth aged 15-24 who have been tested for HIV and received results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Women</td>
</tr>
<tr>
<td>Malawi</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>Rural</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Urban</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>North</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Central</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>South</td>
<td>15</td>
<td>18</td>
</tr>
</tbody>
</table>

Source: Malawi Population Data Sheet 2012. USAID

Figure 16: Malawi HIV/AIDS adult prevalence rate in percent (1999-2009)

Source: CIA Factbook (online)

Figure 17: Malawi HIV/AIDS deaths ('000. 1999-2009)

Source: CIA Factbook (online)
The current spatial prevalence of HIV/AIDS in the Shire River Basin is shown in Figure 18.

Figure 18: Prevalence of HIV/AIDS
2.6.3 Water-Borne and Vector-Borne Diseases

Malawi experiences water borne diseases and health problems connected with polluted watercourses and drinking water sources. flooding and catchment degradation. The diseases in question include chronic conditions associated with diarrhoea and cholera as well as Malaria. A direct connection between deforestation and human health was shown in the Zomba vector disease outbreak of 2006, as described in the Malawi State of Environment and Outlook Report. In 2013, the *simulium* black fly population exploded on the Zomba plateau following the ‘rampant careless cutting of trees on mountain slopes’ some years earlier, leading to siltation and favourable conditions for the fly, with the consequence that vector-borne diseases increased significantly when the flies started to bite human beings in large numbers.

The water-borne diseases (including water-related vector-borne diseases) with the greatest incidence in Malawi are cholera, malaria and bilhazia (schistosomiasis). Others of importance include lymphatic filariasis and onchocerciasis, but although the importance of these is widely recognised among health workers, the onset and increase of these diseases are poorly documented.

Cholera is generally associated with poor water supply and sanitation and its prevalence is correlated with water quality.

On the other hand, malaria, onchocerciasis and schistosomiasis are the major parasitic diseases associated with the ecological and social changes in and around water resources projects. The most significant reported increases in disease prevalence and public health importance attributable to water development schemes concern schistosomiasis. Although this disease is not associated with mortality, as is malaria, nor with the dramatic morbidity of elephantiasis due to lymphatic filariasis in affected communities, it is always recognised as a major health problem to which people attribute much of their misery.

The prevalence (endemicity) of malaria in the Shire River Basin is shown in Figure 19.
Gender

The Constitution of Malawi upholds the principle of equal rights for men and women and prohibits any discrimination based on gender or marital status. The unequal status of women in Malawi is highly influenced by the interrelated factors of poverty, discriminatory treatment in the family and public life and a vulnerability to HIV/AIDS. Both matrilineal and patrilineal systems operate in Malawi’s ethnic groups and it is reported that both systems
perpetuate discrimination against women in the family with respect to control over resources. Women in Malawi generally fare worse than their male counterparts on most social and economic indicators including wage equality, political participation, secondary and tertiary education enrolment and literacy. However, Malawi has achieved gender parity with respect to primary school enrolments, which indicates an improvement in attitudes towards girls’ education.

While data specific to the Shire River Basin on gender-related trends, some national-level statistic can be assumed to illustrate the present situation and trends in the basin. These are shown in Figure 20, Figure 21 and Figure 22, which show indicators of economic opportunities, education and participation in public life and decision making in Malawi respectively.

**Figure 20: Ratio of female to male labour force participation rate (%)**

Figure 21: Ratio of female to male lower secondary completion rate (%)


Figure 22: Seats held by women in national parliament (%)

### 2.8 Indicators

The following indicators are proposed for key characteristics related to “the People”.

#### Table 14: Indicators – The People

<table>
<thead>
<tr>
<th>Key Area</th>
<th>Indicator</th>
<th>Estimated Value for 2015</th>
<th>Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>Population</td>
<td>5.033.200</td>
<td>NSO</td>
</tr>
<tr>
<td></td>
<td>Annual rate of population growth (averaged across districts)</td>
<td>2.1-3.9%</td>
<td>NSO</td>
</tr>
<tr>
<td>Water Supply</td>
<td>Percentage of people with access to safe water supply</td>
<td>59.7%</td>
<td>NSO</td>
</tr>
<tr>
<td></td>
<td>Annual demand for potable water supply to urban areas</td>
<td>58.500 Ml/year</td>
<td>Water Boards</td>
</tr>
<tr>
<td>Sanitation</td>
<td>Percentage of population with/without access to adequate sanitation</td>
<td>87.4/%</td>
<td>NSO</td>
</tr>
<tr>
<td>Health</td>
<td>Percentage of population with HIV/AIDS</td>
<td>9%</td>
<td>MoH</td>
</tr>
<tr>
<td></td>
<td>Average malaria endemicity</td>
<td>48%</td>
<td>MoH</td>
</tr>
<tr>
<td></td>
<td>Average life expectancy (years)</td>
<td>47 years</td>
<td>WHO (2009) MoH</td>
</tr>
<tr>
<td>Poverty</td>
<td>Proportion of people living on less than one US dollar a day (Poverty Head Count)</td>
<td>63</td>
<td>MDG Report for Malawi 2014</td>
</tr>
<tr>
<td></td>
<td>Incidence of depth of poverty as measured by the poverty gap (average distance separating the poor from the poverty line expressed as a percentage of the poverty line)</td>
<td>26%</td>
<td>MDG Report for Malawi 2014</td>
</tr>
<tr>
<td></td>
<td>Proportion of population below minimum level of dietary energy consumption</td>
<td>35%</td>
<td>MDG Report for Malawi 2014</td>
</tr>
<tr>
<td>Food Security</td>
<td>Phase of acute food insecurity&lt;sup&gt;23&lt;/sup&gt;</td>
<td>3 (Crisis)</td>
<td>FEWS NET</td>
</tr>
</tbody>
</table>

<sup>23</sup> See: http://www.ipcinfo.org
3 The Economy

3.1 Structure of the Economy

Malawi’s national accounts data reveal strong growth across all economic sectors during 2005–2011, with per capita GDP growth averaging 3.5% per annum. Growth was particularly robust in the agricultural sector, which can probably be ascribed to the Farm Input Subsidy Program (FISP). Since many of the poor are engaged in farming as smallholders, and since about half of smallholders were targeted by the program, the expectation was always that Malawi’s growth trajectory during this period would be highly pro-poor.

However, despite strong growth, and despite the various anti-poverty strategies listed above, poverty seemingly remains widespread in Malawi (see Section 2.4).

Like other countries with agrarian-based economies, Malawi typically has an erratic growth rate (see Figure 23). Weather and price fluctuations are a major cause of agricultural growth volatility, especially since rain-fed smallholder maize production accounts for around one quarter of agricultural GDP, while the agricultural sector, in turn, accounts for about 30% of the Malawian economy.

Figure 23: Change in Malawi’s GDP 1980 to 2015

Source: World Bank
Malawi’s overall growth in GDP is barely keeping up with population growth (see Section 2.2.1). Since 1980, there has been little more than 10% increase in GDP per capita (see Figure 24). It is sobering to note that Malawi has fallen far behind all other African countries in this measure. To illustrate this, Figure 24 shows that in 1997, Malawi, Mali and Madagascar all had GDP per capita figures of around USD 270. However, currently both Mali and Madagascar have improved their economies at much greater rates than Malawi, despite facing many of the same challenges.

**Figure 24: Malawi GDP per capita (USD)**

Since 2005-06 favourable weather combined with the introduction of the FISP, which targeted roughly half of Malawian smallholders, has led to strong and persistent agricultural growth led by rapidly rising maize yields. In fact, the success of Malawi’s FISP created renewed interest globally in fertilizer subsidies as a tool for promoting growth while at the same time ensuring food security and poverty.

Figure 25, based on official crop estimates, shows the improvement in maize yields in 2005-06 when FISP was first implemented and again in 2006-07 when the program was expanded further. While the southern region of Malawi (in effect, the Shire River Basin) still lags behind in terms of yield performance, mostly due to more frequent floods and periods of deficit rain in this region, yields in general have almost doubled from around one tonne per hectare during the pre-FISP years to around two tonnes per hectare thereafter, as shown by Figure 25.

Expansion in agricultural production contributed to the revival in manufacturing output activities, especially agro-processing. For 2014, Malawi’s real GDP growth in 2014 was about 5.5% after a slump over the period 2010 to 2012 (see Figure 23). It is expected to accelerate further in the immediate future. However, this positive growth outlook presupposes continued macroeconomic stability, high tobacco prices, adequate availability of foreign exchange, favourable weather conditions and improvement in the business climate. The evidence is that it appears unlikely that these suppositions will be realised. For instance, as far as weather conditions are concerned, the 2014-15 and 2015-16 growing seasons were greatly affected by droughts and floods (see Section 2.5).
It is difficult to obtain specific economic data for the Shire River Basin alone. The basin provides more than 50% of Malawi’s GDP, and so the general conclusions drawn regarding the national economy are applicable to the basin’s economy as well.

### 3.2 Cost of Living

The cost of living for Malawians is rising due to the weakening kwacha (see Figure 26) and high dependence on imported goods.

As far as the Consumer Price Index (CPI) and inflation (annual increase in CPI) is concerned, the inflation for September 2015 stood at 24.1% compared to the inflation of 23.7% for the same period in 2014. The urban and rural rates were at 19.6% and 27.4% respectively. Overall, food inflation was 27.2% (see Figure 27). These figures show that Malawians are presently suffering a rapid increase in the cost of living.
Mobile phone and Internet services are very expensive in Malawi. In fact, a report by the International Telecommunications Union says on average Malawians use more than $12 a month on mobile phones. This is more than half of what an ordinary Malawian earns in a month. In neighbouring Mozambique, consumers spend just more than a quarter of their incomes...
using their mobile phones. The figure in Kenya and South Africa is significantly lower, amounting to less than 5% of average monthly earnings. This makes Malawi one of the most expensive countries in the world to use mobile phones.

### 3.3 Development Strategies and Trends

The macroeconomic reforms pursued by Malawi under the Economic Recovery Plan (ERP) began to yield results as evidenced by improved foreign exchange availability and better incentives for producers of export commodities. In spite of the gains, the country has continued to face macroeconomic pressures. These include inflation, exchange rate volatility and excessive government domestic borrowing. To curb inflation, the Reserve Bank of Malawi (RBM) maintained a tight monetary policy stance. While inflation has started to decline, the pace of disinflation has been slower than expected because of the sharp depreciation of the Malawian kwacha (Figure 26) and in fact is now increasing.

The macroeconomic challenges faced by Malawi were exacerbated by the revelation in September 2013 of the looting of public funds through the Integrated Financial Management System (IFMIS), known as "Cash-gate". Donors suspended budget support, leading to a widening of the fiscal gap. In response to the scandal, the government is implementing with the support of donors a comprehensive action plan to correct weaknesses in public finance management. The financial scandal has underscored the urgent need for Malawi to redouble efforts to improve accountability and transparency in the public sector.

### 3.4 Threats to the Economy

Primary commodities dominate Malawi’s exports, but with globalisation opportunities for exports of processed products have emerged. The country has not yet re-positioned itself to exploit opportunities to integrate into global value chains (GVCs). Obstacles to integration into GVCs include poor infrastructure, low skills and a weak business climate. The government is implementing the national export strategy with a view to enhancing export competitiveness and promoting exports of processed agro-products to feed into regional and global value chains.

With rapidly increasing population, and commensurate decrease in the size of land holdings, plus little in the way of mineral resources that could boost exports, Malawi needs to look to industrial development to grow the economy and provide employment opportunities for future generations. Improving agriculture and processing of agricultural products, while necessary, is highly unlikely to provide the solution. However, at present, plans for new industrial development are very limited in scope and greater attention needs to be paid to industrial development.

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24 See NIRAS (2015d)
3.5 Indicators – the Economy

The following indicators are proposed for key characteristics related to the Economy.

Table 15: Indicators – the economy

<table>
<thead>
<tr>
<th>Key Area</th>
<th>Indicator</th>
<th>Estimated Value for 2015</th>
<th>Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Productivity</td>
<td>Annual increase in Gross Basin Product</td>
<td>5.5%</td>
<td>MoF</td>
</tr>
<tr>
<td></td>
<td>Gross Basin Product per capita</td>
<td>USD 226 (based on national average)</td>
<td>MoF</td>
</tr>
<tr>
<td>Inflation</td>
<td>Consumer Price Index inflation</td>
<td>26%</td>
<td>MoF</td>
</tr>
</tbody>
</table>
4 Agriculture. Livestock. Fisheries and Forestry

4.1 Rainfed and Irrigated Agriculture

Figure 28 shows the types of smallholder irrigation in the Shire River Basin as of 2010.

Figure 28: Types of smallholder irrigation in the Shire Basin (2010)

![Pie chart showing types of smallholder irrigation]

Source: Adapted from Final Report of Component 1 (Water Resources Assessment) of the National Water Resources Investment Strategy Project (April 2011)

Figure 29 comprises pie charts illustrating the areas given over to smallholder crops (mainly rainfed) where it can be seen that although characterised by a range of crops the rainfed sub-sector is dominated by maize, cotton, sorghum, pulses and millet, which among them occupy 90% of the area planted. Irrigated crops are fewer and are dominated by maize, pulses and sweet potatoes.

Table 16 makes the best use of such data that is available to assess the situation.
Figure 29: Smallholder cropping in the Shire Basin

Table 16: Commercial agriculture in the Shire Basin (2010)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Production Model</th>
<th>Area (ha)</th>
<th>Summer</th>
<th>% irrigated</th>
<th>Winter</th>
<th>% irrigated</th>
<th>All year</th>
<th>% irrigated</th>
<th>Irrigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee</td>
<td>Estate</td>
<td>150</td>
<td>100%</td>
<td></td>
<td>150</td>
<td></td>
<td></td>
<td></td>
<td>150</td>
</tr>
<tr>
<td>Cotton</td>
<td>Estate</td>
<td>190</td>
<td>100%</td>
<td></td>
<td>190</td>
<td></td>
<td></td>
<td></td>
<td>190</td>
</tr>
<tr>
<td>Maize</td>
<td>Estate</td>
<td>709</td>
<td>30%</td>
<td></td>
<td>213</td>
<td></td>
<td></td>
<td></td>
<td>213</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>Estate</td>
<td>13,800</td>
<td>90%</td>
<td></td>
<td>12,420</td>
<td></td>
<td></td>
<td></td>
<td>12,420</td>
</tr>
<tr>
<td>TOTALS</td>
<td></td>
<td>899</td>
<td></td>
<td></td>
<td>13,950</td>
<td></td>
<td></td>
<td></td>
<td>12,973</td>
</tr>
</tbody>
</table>

With respect to overall cropping intensity the nature of the available data does not permit an accurate estimate of the current situation. Nonetheless, based on an amalgamation of such data that is available it is reasonable (at this stage) to suggest that the cropping intensity (harvested area/available area) is around 110%.

Unfortunately, the available data cannot be used for estimating the irrigated cropping intensity because it does not link specific irrigation scheme with both summer and winter crops. Nonetheless, irrigated cropping intensity is a very useful indicator regarding the utility of and possible demand for irrigation service coverage. To this end, it is noted that the Irrigation Master Plan states that country-wide, the irrigation cropping intensity is around 170%\(^{25}\).

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\(^{25}\) IMP Logframe Outcome 2. 1\(^{st}\) indicator.
In terms of agricultural productivity, yields (per hectare) are set out in Table 17 where yields are rendered in kilograms per hectare. Unfortunately, data are only available for smallholder systems.

Table 17: Smallholder crop yields in the Shire Basin

<table>
<thead>
<tr>
<th>Crop</th>
<th>Rainfed</th>
<th>Irrigated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (ha)</td>
<td>Production (kg)</td>
</tr>
<tr>
<td>Maize</td>
<td>40,205</td>
<td>48,924</td>
</tr>
<tr>
<td>Rice</td>
<td>5,480</td>
<td>12,932</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>3,590</td>
<td>2,199</td>
</tr>
<tr>
<td>Cotton</td>
<td>38,453</td>
<td>42,465</td>
</tr>
<tr>
<td>Sorghum</td>
<td>33,330</td>
<td>35,556</td>
</tr>
<tr>
<td>Millet</td>
<td>22,732</td>
<td>22,393</td>
</tr>
<tr>
<td>Pulses</td>
<td>25,752</td>
<td>18,086</td>
</tr>
<tr>
<td>Paprika</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sesame</td>
<td>2,867</td>
<td>969</td>
</tr>
<tr>
<td>Cassava</td>
<td>1,351</td>
<td>20,164</td>
</tr>
<tr>
<td>Sweet potatoes</td>
<td>4,013</td>
<td>48,979</td>
</tr>
</tbody>
</table>

Source: Ministry of Agriculture\(^\text{26}\) (2014)

\(^\text{26}\) Now part of the Ministry of Agriculture, Irrigation and Water Development.
In every case the rainfed yields are low and the irrigated yields are significantly below reasonable expectations. Although the Ministry of Agriculture data of 2014 does not include sugar cane as a smallholder crop, data included in the Irrigation Master Plan suggests that some 1,750 ha is grown as a rainfed crop by smallholders, who get an average yield of 90 tonnes (cane weight/ha). This is commendable and may reflect extension support by the processors (but this has yet to be confirmed).

With respect to irrigation coverage, Figure 31 indicates the location of the main irrigation areas.

**Figure 31: Location of main irrigation areas**

![Map of irrigation areas](image-url)
Information with respect to ownership/management issues and types of irrigation information is limited and coarse grained. It is nonetheless possible to identify three basic scheme ownership/management models concerning full or supplementary irrigation in the Shire River Basin:

1. Private estates producing crops which include sugar, coffee, tea and tobacco and which are operated by large-scale commercial farmers and enterprises on freehold and leasehold land;

2. Government-run smallholder schemes established to give irrigation opportunities to local farmers who are allocated irrigated plots in addition to their dryland holdings in the vicinity of schemes. These include rice schemes located along the lakeshores. Water is generally diverted from rivers under gravity to a system of canals (mostly unlined) and bunded fields; and

3. Self-help smallholder schemes usually designed and constructed by government with the support and participation of farmers who manage and maintain the schemes with minimum government support. The irrigation layouts of these schemes usually consist of simple headworks and unlined canals with simple diversion and drop structures. Basin irrigation is typical. Rice is the dominant rainy season crop while both rice and maize are mainly grown during the dry season.

The 2014 Irrigation Master Plan includes a table listing the 30 best-ranked potential public irrigation schemes. Information provided in the table includes unit development costs and Economic Internal Rates of Return. Using this information Figure 32 illustrates the percentage of the potential irrigable area that could be developed with an expectation of a given EIRR value.

**Figure 32: Economic performance of top 30 IMP schemes compared with area**

![Figure 32: Economic performance of top 30 IMP schemes compared with area](image)

This confirms that in terms of economic performance, schemes in the Shire Basin are not especially different from elsewhere in Malawi – at least with respect to potential economic performance.
Regarding *scheme status/condition* discussions with representatives of the Irrigation Department confirmed that the public and self-help schemes are generally in a poor condition due to a lack of capacity (skills and finance) at user level.

Unfortunately, limitations of data and information have meant that it has not measured how well the Basin’s irrigation facilities are performing in terms of physical water use efficiency, land use factors and distribution efficiency. Nonetheless, the same representatives of the Irrigation Department were unanimously of the opinion\(^{27}\) that:

- **physical water use efficiency** generally varies between 20% and 30%;
- **land use factors** are around 70% (and is inversely proportional to scheme size); and
- **distribution efficiencies** are typically high at between 90% and 100%.

### 4.2 Livestock Husbandry

Table 18 provides an indication of livestock populations in the Shire River Basin, along with estimated rangeland and fodder areas where relevant or available.

<table>
<thead>
<tr>
<th>Livestock Type</th>
<th>Estimated Population</th>
<th>Percentage of National Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>222,500</td>
<td>25%</td>
</tr>
<tr>
<td>Goats</td>
<td>658,000</td>
<td>21%</td>
</tr>
<tr>
<td>Sheep</td>
<td>15,000</td>
<td>8%</td>
</tr>
<tr>
<td>Pigs</td>
<td>131,500</td>
<td>11%</td>
</tr>
<tr>
<td>Chickens</td>
<td>1,875,000</td>
<td>4%</td>
</tr>
</tbody>
</table>


In more detail\(^{28}\):

- In terms of high input production systems:
  - The majority of Malawi’s large-scale beef feedlots are located in the Shire Basin. The animals involved are fed intensively using crop residues, agricultural by-products and concentrates. There are also a limited number of smallholder zero-grazed systems in the “southern region”, which can be assumed to include the Shire River Basin.
  - High input dairy systems, large and small are found all over the country, presumably including the Shire Basin. The farms involved typically grow fodder maize and Napier grass, but also use supplemental feeds based on groundnut, cotton seed cake

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\(^{27}\) Opinions expressed during consultation meetings.

\(^{28}\) Mainly sourced from: *Overview of the Malawian Livestock Industry* – various authors, date of publication unknown.
and soybeans, all mixed with mineral additives.

- Sheep are not a major component of the high production systems.
- Concentrate-fed pigs are widely produced on a peri-urban basis in Malawi, including the Southern Region.
- Commercial poultry production also produced on a peri-urban basis.

• In terms of medium input systems, the available data is very coarse grained and is adequate to confirm only that dairy cows, pigs and poultry characterise the sub-sector and all are fed on locally procured food stuff such as cut and carry fodder (cattle); refuse (in the case of pigs) and free range source (poultry). All such animals are occasionally provided with concentrates.

• In terms of low input production systems:
  - Beef is produced on multiple-ownership herds grazed on common land.
  - Small ruminants, mainly goats, are raised in small flocks by some 15% of all families, of which those in the Southern Region use tethering rather than free range basis.
  - In the majority of cases, pigs, which mainly comprise local breeds are simply left to scavenge for their food.
  - Poultry is almost entirely free range – one notable exception being the chicken production and processing complex operated by Crown Chicken Agro-Limited in Ntcheu and Balaka.

With respect to the value of livestock activity, livestock production and its appurtenant activities is an important contributor to Malawian GDP. Historical data suggests that at the national level livestock alone contributes to around 9.9% of agricultural GDP and 3.3% of total GDP29. But if the value of manure and draught power were quantified and added, it is estimated that livestock’s contribution would increase to somewhere around 4.6% of GDP.

Hence for 2013 (see above) the livestock sector would be worth 3.3% of $3.705 billion. Excluding the value of manure and draft power, this equates to approximately $122.27 million. It has not been possible to find data on livestock activity specifically for the Shire River Basin. However, on the reasonable assumption that there is a direct relationship between area and scale of livestock operation, it is noted that the basin comprises 16% of Malawi’s total land area and hence that the value of livestock activities in the basin are approximately 16% of the national value; that is $19.56 million without manure and draft power, and $27.4 million with them.

4.3 Fisheries

Recent data and information concerning Malawi’s fisheries industry is limited. Nonetheless from the data and information that is available it is noted that although a considerable range of fish species are caught or

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29 Malawi "Livestock Sector Brief" FAO 2005 – this appears to be the latest estimate available.
raised in Malawi, according to the Fisheries Department\textsuperscript{30} the \textit{types of fish} caught in the Shire Basin (actually the Lower Shire which is where most of the basin’s fishery reportedly takes place) are effectively limited to catfish and tilapia. The activity – as it is encountered in the Lower Shire – is dominated by artisanal capture fisheries whose \textit{typical gear} comprises: fish traps; hook and line, baskets and spears.

At the national level fisheries production falls into three categories: capture, aquaculture and aquarium. Although of high value, the last is understood to be effectively irrelevant to the Shire River Basin and is hence not considered here. Moreover, the data and information sources regarding fisheries activities in the Shire River Basin are not well defined geographically. Some sources refer only to the Lower Shire, while others refer to the whole basin and other still refer to Upper and Lower Shire.

Data is only available for capture fisheries. Tonnage figures are set out and compared with national statistics in Figure 33. The value of the capture in the Shire Basin is present in Figure 34, and again compared with national figures. Figure 33 shows a decline in Shire tonnages compared with national capture; Figure 34 – which, it should be noted, is presented logarithmically because of the great different between Shire and national values – shows not only that the value of the Shire fisheries not only represents a small percentage of the national catch, but also indicates a declining value in recent years, even when the national value is increasing. No explanation has so far been identified to account for this, although over-fishing in the waterways of the Shire would seem a likely culprit.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure33}
\caption{Capture fisheries tonnages in the Shire Basin 1987 to 2012}
\end{figure}

\footnote{F J Njaya. 2006: “Overview of Fisheries and Aquaculture in Malawi”. Fisheries Department.}
In terms of *livelihoods (direct and indirect)*, according to the FAO, in 2005\(^3\) 62,000 people’s livelihoods derived directly from fisheries activities, and 350,000 indirectly in Malawi as a whole. The same source states that 6% of the Basin’s livelihoods derive from fisheries activities. However, with a basin population in 2005 of 3.55 million this would mean that some 213,000 livelihoods were involved, and as such is not compatible with national totals. Other sources\(^3\) suggest that between 4% and 5% of the national fishery livelihoods play out in the Shire Basin. If so this would mean that in 2005 there were around 3,100 direct and 17,500 indirect fishery-related livelihoods. Put another way, FAO states that within the agricultural and natural resources sector fisheries is the second largest employer after the crop sector and has the largest number of employees per enterprise (4.0 as compared with 3.8 in crop production) and generates the largest profit per employee per hour\(^3\). The literature, however, is not clear on whether these livelihoods relate to capture fisheries or aquaculture – except to say that some 7,000 fish farms and 800 reservoirs that can be used for fishery purposes are distributed all around the country, although the sources are silent on how many of these are to be found in the Shire River Basin\(^3\). However, the current National Fisheries Policy (2012-2017) notes that 90% of all fisheries livelihood (direct or indirect) derives from the small-scale sector.

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32  Including the SRBMP Subcomponent A1 Inception Report, which states that the Lower Shire accounts for some 4% of the national total and that the Upper Shire accounts for 5%.
33  This statement is historical Current values are not available and not withstanding this. The “National Fisheries Policy 2012-2017” does question the profitability of aquaculture: “one of the major problems identified with commercial aquaculture is that the species cultured are slow growing and have a poor feed conversion, making the products of aquaculture expensive to produce”.
34  FAO *ibid*
In addition, the FAO source suggests that value added between the point of production and point of consumption is some 400%. Although the actual parameter is not quantified, it is reasonable to assume that much of this added value comprises labour. In addition to its value as a source of livelihood, the value of the value of the industry is significant in both nutritional and monetary terms. Almost the entire catch is consumed in Malawi where it is an important source of protein, especially among the poor. But as far as the Shire River Basin is concerned, it is highly variable because, according to the 2006 overview, in the last 40 years or so, production has varied between lows of around 3,000 tonnes to highs of some 11,000 tonnes.

The monetary value of this can be estimated as follows: The FAO source states that fisheries account for some 4% of GDP (see above). This means that fisheries GDP, at 4% of total GDP, would have been around $150 million of which 5% – or $7.5 million – is accruable to fisheries in the Shire. Taking 5% of this, it is reasonable to surmise that the value of the fisheries industry to the Shire River Basin is around $7.5 million/year.

4.4 Challenges Facing the Agriculture and Fisheries Sectors

The need for water-competitive agriculture and indeed “water-smart” agriculture is an emerging theme among the many members of the global water management community that are concerned about the widely encountered gulf between agriculture and water policies. This gulf is becoming ever more threatening in the context of ongoing population growth, economic diversification, climate change, and catchments that are beginning to close – all of which are relevant to the Shire River Basin.

In this context it should be noted that the Shire River Basin has some of Malawi’s highest population densities – see Figure 6. Ideally, as population densities continue to increase in the Basin, the economy will have to diversify in order to provide livelihoods for the burgeoning proportion of the population that will need off-farm livelihoods – and food.

In 2004, Malawi reportedly had the world’s highest urbanisation rate – a trend expected to continue: “The study35.... has tipped Malawi to score highly in urbanisation in the next 15 years”. Yet despite this “Malawi’s economy depends on agriculture and shortages of land have in recent years contributed to perennial food shortages. which refuse to ease”.

This is likely to mean that, instead of being a residual user of water, agriculture may have to compete with other sectors for water – other sectors whose growth is needed to absorb urban labour. One way to do this is to leave politically cheap, but economically/environmentally costly self-sufficiency objectives behind and begin to invest water not into household food stores but rather into value chains that increase both the number and diversity of “jobs-drop”, and in so doing blur the grey line between agriculture and industry.

35  http://www.ipsnews.net/2004/07/development-malawi-rapid-urbanisation-looks-irreversible/
For fisheries, it is clear that in the future there will be decline in fish stocks—a trend that is already apparent in the Basin. This again is driven by increasing population pressures, leading to overfishing of the limited resources.

In addition, many rivers are ecologically degraded by invasive species, sedimentation, cultivation and deforestation, which reduce the habitat for fish species. For the Elephant Marsh in particular, high sediment loads in the rivers feeding the wetland system are leading to extensive siltation of the waterways, again reducing fish habitat and also restricting access to fisheries areas.

### 4.5 Indicators – Agriculture, Livestock and Fisheries

The following indicators are proposed for key characteristics related to agriculture, livestock, fisheries and forestry.

#### Table 19: Indicators – agriculture, livestock, fisheries and forestry

<table>
<thead>
<tr>
<th>Key Area</th>
<th>Indicator</th>
<th>Estimated Value for 2015</th>
<th>Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>Annual reliability of supply to irrigation (%)</td>
<td><em>Yet to be calculated</em></td>
<td>DoI</td>
</tr>
<tr>
<td></td>
<td>Annual value of irrigated agricultural production</td>
<td><em>Data not available</em></td>
<td>DoA</td>
</tr>
<tr>
<td></td>
<td>Percentage of households dependent on subsistence agriculture</td>
<td>78%</td>
<td>DoA</td>
</tr>
<tr>
<td>Livestock</td>
<td>Animal husbandry, annual value of production</td>
<td><em>Data not available</em></td>
<td>MoA</td>
</tr>
<tr>
<td>Fisheries</td>
<td>Annual fisheries production value</td>
<td><em>Data not available</em></td>
<td>MoA</td>
</tr>
</tbody>
</table>
5 Energy

5.1 Overview of the Energy Sector

Malawi’s energy needs are met by biomass, electricity, petroleum products and coal with small contributions of renewable energy in the form of solar and wind in the approximate proportions shown in Table 20. It should be stressed here that the energy sector must be considered in a national context and cannot be conveniently isolated to the Shire River Basin.

Table 20: Energy sources in Malawi

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>89%</td>
</tr>
<tr>
<td>Petroleum</td>
<td>6%</td>
</tr>
<tr>
<td>Electricity</td>
<td>3%</td>
</tr>
<tr>
<td>Coal</td>
<td>2%</td>
</tr>
<tr>
<td>Renewables</td>
<td>Less than 1%</td>
</tr>
</tbody>
</table>

Source: Department of Energy Affairs

Households account for some 84% of consumption, with agriculture consuming 8%, transport 4%, industry and mining 2%, and social services accounting for approximately 2%.

The Department of Energy Affairs\(^\text{36}\) (DoEA) within the Ministry of Natural Resources, Energy and Mining is responsible for all aspects of the energy sector in Malawi. The Department oversees the activities of the Malawi Energy Regulatory Authority (MERA) and the Electricity Supply Corporation of Malawi (ESCOM) and was responsible for the development of the 2003 National Energy Policy.

The National Energy Policy sets out the objectives for improvement and future management of the energy sector through \textit{inter alia} DoEA and MERA.

A key objective of the policy is to “reduce the dependency on the Shire River for power generation by exploiting other hydropower sites and developing coal and biomass thermal plants”. This is a critical consideration for the development of the Shire River Basin Plan.

An update and revision of the policy is currently in draft form and is scheduled for release sometime in 2016.

\(^{36}\) Commonly referred to as the Department of Energy.
ESCOM is solely responsible for the generation, transmission and distribution of electricity in Malawi - almost entirely by means of hydroelectric power plants with a total installed capacity of 350.8 MW. Wvowe Hydro-power Plant in Malawi’s Northern Region provides 4.5 MW of this capacity with the remainder provided by hydropower stations at Nkula, Tedzani and Kapachira on the Shire River. Details of the Shire hydropower stations are shown in Table 21.

### Table 21: Existing Shire River hydropower stations

<table>
<thead>
<tr>
<th>Name</th>
<th>Date of Installation</th>
<th>Installed Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nkula A</td>
<td>1966</td>
<td>24 MW</td>
</tr>
<tr>
<td>Nkula B</td>
<td>1980 - 1992</td>
<td>100 MW</td>
</tr>
<tr>
<td>Tedzani 1</td>
<td>1973</td>
<td>20 MW</td>
</tr>
<tr>
<td>Tedzani 2</td>
<td>1977</td>
<td>20 MW</td>
</tr>
<tr>
<td>Tedzani 3</td>
<td>1996</td>
<td>52.7 MW</td>
</tr>
<tr>
<td>Kapachira I</td>
<td>2000</td>
<td>64 MW</td>
</tr>
<tr>
<td>Kapachira II</td>
<td>2014</td>
<td>65.6 MW</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>346.3 MW</strong></td>
</tr>
</tbody>
</table>

Transmission is by a 132 kV and 66kV network with distribution via 33 kV 11 kV and 400/230V networks. These networks are heavily loaded and are poorly maintained, resulting in frequent failures and interruptions to supply.

The Shire hydropower stations experience clogging of intake screens by aquatic weed, siltation of headponds, flood damage and low river flows, which also cause generation outages and load shedding.

As a result of these difficulties, the supply of electricity is unreliable and in 2013 ESCOM reported a decrease in generating output, transmission and distribution, resulting in a revenue loss in 2013 of MK 1.18 billion. ESCOM reported an increase in the number of new connections although there was a backlog of some 17,000 new connections. Only 9% of the population receive electricity and only 1% of the rural population are able to access an electricity supply.

### 5.2 Opportunities Provided by Energy Resources

#### 5.2.1 Hydropower resources

The constrained development of the Malawi energy sector has inhibited economic growth and uncertainties about future development of the sector continue to adversely affect necessary private investment in the country.

Existing hydropower schemes in the Shire River Basin are shown in Table 22.
Table 22: Existing Hydropower stations on Shire River

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Date of Installation</th>
<th>Machines</th>
<th>Installed Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nkula A</td>
<td>1966</td>
<td>3 x 8 MW</td>
<td>24 MW</td>
</tr>
<tr>
<td>Nkula B</td>
<td>1980 - 1992</td>
<td>5 x 20 MW</td>
<td>100 MW</td>
</tr>
<tr>
<td>Tedzani 1</td>
<td>1973</td>
<td>2 x 10 MW</td>
<td>20 MW</td>
</tr>
<tr>
<td>Tedzani 2</td>
<td>1977</td>
<td>2 x 10 MW</td>
<td>20 MW</td>
</tr>
<tr>
<td>Tedzani 3</td>
<td>1996</td>
<td>2 x 25 MW</td>
<td>52.7MW</td>
</tr>
<tr>
<td>Kapichira I</td>
<td>2000</td>
<td>2 x 32 MW</td>
<td>64 MW</td>
</tr>
<tr>
<td>Kapichira II</td>
<td>2014</td>
<td>2 x 32 MW</td>
<td>65.6 MW</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>346.3 MW</td>
</tr>
</tbody>
</table>

Opportunities for development of the sector include: power generation by means of hydropower, coal and renewables, and interconnection with the Southern African Power Producing (SAPP) network.

The untapped hydropower potential in Malawi is estimated at almost 2000 MW and a number of potential sites have been identified for development. The most viable sites are currently considered to be Lower Fufu (90-180 MW) on the South Rukuru River, Mpatamanga (100-150 MW) and Kholombidzo (100 MW) on the Shire River, and Chimgonda on the Dwambadzi River. Feasibility and other studies for these schemes are being progressed through World Bank funding.

In addition, construction of Tedzani 4 (22 MW) is scheduled to commence in 2015 with JICA funding and Millennial Challenge Corporation (MCC) funded refurbishment of the existing machines at Nkula A will provide an additional 12 MW. The Songwe multi-purpose project, being implemented jointly by Malawi and Tanzania will provide 80 MW of hydropower capacity in the first phase.

The location of these priority schemes, together with existing hydropower stations is shown in Figure 35.

It should be noted that the National Energy Policy has one of its key objectives to reduce the country’s reliance on hydropower in the Shire River Basin. Constructing additional hydropower schemes on the Shire River and its tributaries will therefore need to be considered carefully. This is especially so because of the increasing competition for water from proposed irrigation schemes (such as the Shire Valley Irrigation Scheme), additional demands for water supply (the greatest of which will be for Blantyre) and other uses. The water available for use in the Shire is largely constrained by net inflows\(^7\) into Lake Malawi. Releases from the Kamuzu Barrage must, on average, be less than the “freewater” – otherwise lake levels will decline.

\(^7\) “Net inflows” means the sum of inflows to the lake (from surface and groundwater) plus rainfall on the lake surface, minus evaporation from the lake surface. This is often referred to as the “freewater” from the lake.
Based on ESCOM figures, current water demand for hydropower alone in the Shire River is 233 m$^3$/s (released from Kamuzu Barrage) and is expected to reach 268 m$^3$/s by 2022. While present demands (from the Shire River) for urban and rural water supply, irrigation and other uses is around 5 m$^3$/s or less, new projects already planned, such as the Shire Valley Irrigation Scheme, and future development scenarios, are likely to increase the demands for releases from Kamuzu Barrage significantly.

It should be noted that, according to the consultants NORPLAN, who have studied the hydrology of Lake Malawi and its relationship to flows in Kamuzu Barrage and flows into the Shire River in some detail, the
estimated “freewater” available from Lake Malawi for the period 2010-2016 is around 70 m$^3$/s. This is reflected in lowering of Lake Malawi levels over recent years. Climate change may sustain or even exacerbate lake level decline in the future and possibly cause the outflow from Lake Malawi to cease altogether.

**5.2.2 Other resources**

Coal has the potential to contribute further to power generation in Malawi. In particular, a scheme for importing coal by rail from Moatize in Mozambique to a new coal fired power station at Kamwamba, with a Phase 1 capacity of 100 MW, currently awaits finance.

A 400 kV interconnector from Mozambique has been identified which would feed into the ESCOM transmission system with a capacity of up to 300 MW. A Memorandum of Understanding for the Power Interconnector Project has been signed between the governments of Malawi and Mozambique with a view to pursuing its development. The interconnector would reduce the dependency on the Shire River for power generation although the existing Malawi transmission system will need reinforcing.

The potential for the harnessing of renewable energy sources – wind, solar, geothermal and mini-hydro – is increasingly being considered. Through MERA, opportunities for involvement of Independent Power Producers (IPPs) have been progressed, including the establishment of feed-in tariffs and Power Purchase Agreements. Also, there is IPP interest in development of hydropower projects at Mbongodzi and Mulanje and a coal fired power station at Pamodzi. Opportunities for development of small, non-grid energy sources also exist that are applicable, particularly to the supply of electricity to rural communities.

**5.2.3 Summary of potential future resources**

A summary of currently planned enhancements to Malawi’s generating capacity, showing status and estimated completion dates is shown in Table 23.

**Table 23: Future potential power generation projects**

<table>
<thead>
<tr>
<th>Project</th>
<th>Potential Capacity</th>
<th>Funding</th>
<th>Status</th>
<th>Possible Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NORTHERN REGION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Fufu Hydro</td>
<td>140 MW</td>
<td>WB (studies)</td>
<td>Studies due 2016</td>
<td>2024</td>
</tr>
<tr>
<td>Songwe Hydro Phase 1</td>
<td>90 MW</td>
<td>To be found</td>
<td>Studies completed</td>
<td>2022</td>
</tr>
<tr>
<td>Lweya Hydropower</td>
<td>15 MW</td>
<td>?</td>
<td>?</td>
<td>2019</td>
</tr>
<tr>
<td>Standby Diesel Mzuzu</td>
<td>6 MW</td>
<td>ESCOM</td>
<td>Being procured</td>
<td>2017</td>
</tr>
<tr>
<td>Karonga Coal Fired PS</td>
<td>200 MW</td>
<td>?</td>
<td>Feasibility study underway</td>
<td>2021</td>
</tr>
<tr>
<td>Project</td>
<td>Potential Capacity</td>
<td>Funding</td>
<td>Status</td>
<td>Possible Completion</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------</td>
<td>---------------------</td>
<td>---------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td><strong>CENTRAL REGION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chizuma Hydro (Bua)</td>
<td>50 MW</td>
<td>Government (studies)</td>
<td>Feasibility study completed?</td>
<td>2019</td>
</tr>
<tr>
<td>Chasambo Hydro</td>
<td>50 MW</td>
<td>Government (studies)</td>
<td>Feasibility study completed?</td>
<td>?</td>
</tr>
<tr>
<td>Chimgonda Hydro</td>
<td>50 MW</td>
<td>WB (studies)</td>
<td>Feasibility study completed?</td>
<td>?</td>
</tr>
<tr>
<td>Mbongodzi Hydropower</td>
<td>41 MW</td>
<td>IPP (hydrpower)</td>
<td>Studies completed</td>
<td>2019</td>
</tr>
<tr>
<td>Malenga Hydropower</td>
<td>60 MW</td>
<td>Unknown</td>
<td>Unknown</td>
<td>?</td>
</tr>
<tr>
<td>Pamodzi Coal Fired</td>
<td>120 MW</td>
<td>IPP</td>
<td>Govt discussions</td>
<td>?</td>
</tr>
<tr>
<td>Dwangwa Bagasse</td>
<td>11 MW</td>
<td>Illovo/ESCOM</td>
<td>Studies due 2016</td>
<td>2017</td>
</tr>
<tr>
<td>Standby Diesel Lilongwe</td>
<td>20 MW</td>
<td>ESCOM</td>
<td>Commissioned</td>
<td>2016/18</td>
</tr>
<tr>
<td><strong>SOUTHERN REGION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tedzani 4 Hydro</td>
<td>22 MW</td>
<td>JICA</td>
<td>Started</td>
<td>2019</td>
</tr>
<tr>
<td>Nkula “A” Hydro Upgrade</td>
<td>12 MW</td>
<td>MCC</td>
<td>Started</td>
<td>2018</td>
</tr>
<tr>
<td>Mpatamanga Hydro</td>
<td>350 MW</td>
<td>WB (studies)</td>
<td>Studies due 2016</td>
<td>2022</td>
</tr>
<tr>
<td>Kholombidzo Hydro</td>
<td>200 MW</td>
<td>AfDB (studies)</td>
<td>Studies due 2016</td>
<td>2020</td>
</tr>
<tr>
<td>Kapichira III</td>
<td>50 MW</td>
<td>Awaited</td>
<td>Shelved</td>
<td>?</td>
</tr>
<tr>
<td>Mulanje Hydropower</td>
<td>40 MW</td>
<td>IPP (Kuwale)</td>
<td>Feasibility study underway</td>
<td>?</td>
</tr>
<tr>
<td>Ruo (Zoa Falls) Hydro</td>
<td>23 MW</td>
<td></td>
<td>Feasibility study awaited</td>
<td>2023</td>
</tr>
<tr>
<td>Tedzani 3 Hydro Upgrade</td>
<td>10 MW</td>
<td>EPC Contract</td>
<td></td>
<td>2022</td>
</tr>
<tr>
<td>Kamwamba Coal FPS</td>
<td>300 MW</td>
<td>Chinese Government</td>
<td>Feasibility study being redone</td>
<td>2019/20/21</td>
</tr>
<tr>
<td>Nchalo Bagasse</td>
<td>40 MW</td>
<td>Illovo/ESCOM</td>
<td>Studies due 2016</td>
<td>2018</td>
</tr>
<tr>
<td>Standby Diesel Blantyre</td>
<td>20 MW</td>
<td>ESCOM</td>
<td>Being procured</td>
<td>2018</td>
</tr>
<tr>
<td><strong>OTHERS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mozambique Interconnector</td>
<td>300 MW</td>
<td>WB ?</td>
<td>Studies underway</td>
<td>2019</td>
</tr>
<tr>
<td>Zambia Interconnector</td>
<td>TBA</td>
<td>WB (studies)</td>
<td>Studies underway</td>
<td>2017</td>
</tr>
<tr>
<td>Tanzania Interconnector</td>
<td>TBA</td>
<td>WB (studies)</td>
<td>Studies underway</td>
<td>?</td>
</tr>
</tbody>
</table>
5.3 Challenges Facing the Energy Sector

5.3.1 Future Demands for Energy

Generating capacity is less than the current demand estimated at 430 MW. Various estimates have been made of Malawi’s future energy demand. Using the demand estimate presented by MCC and “best guesses” of commissioning dates of future projects listed above, the shortfall in future generating capacity has been estimated in Table 24.

Table 24: Estimated generating capacity shortfall in Malawi

<table>
<thead>
<tr>
<th>Project</th>
<th>Potential Capacity</th>
<th>Funding</th>
<th>Status</th>
<th>Possible Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV</td>
<td>30 MW</td>
<td>IPPs (JCM C)</td>
<td>Government discussions</td>
<td>?</td>
</tr>
<tr>
<td>Demand Side Management</td>
<td>40 MW</td>
<td>ESCOM</td>
<td>System reductions</td>
<td>?</td>
</tr>
</tbody>
</table>

Other future demand forecasts are available from ESCOM and the Malawi Energy Demand Assessment (MEDA) Report, both of which show different shortfalls. These differences emphasise the need for preparation of an up to date, reliable demand forecast taking account, particularly of industrial demand.
5.3.2 Operation of existing Shire hydropower stations

Shire River flows are dependent on the level of Lake Malawi. The Kamuzu Barrage at Liwonde regulates river flow to meet the requirements of downstream users. The barrage is currently being rehabilitated and an improved model for operation of the barrage has been developed.

Specific, significant challenges exist in the current and future operation of the existing hydropower stations on the Shire River. Weed infestation (blocking of intake screens causing station closure – see Figure 36) and siltation of headponds (causing interruptions to flow requirements and erosion and damage to turbine moving parts by suspended silt – see Figure 37) have presented costly and practical problems to ESCOM and caused lengthy interruptions to supply.

Although estimates of climate change indicate that the level of Lake Malawi will rise towards the end of the century, periods of low flow from the lake into the Shire can be expected. This means that on occasions there will be insufficient water to meet the requirements of the downstream hydropower stations and other users.

Figure 36: Weed at Tedzani trash rakes. January 2015
Together, these problems raise concerns about the reliability of the Nkula, Tedzani and Kapachira power stations to maintain output in the future and raise doubts about the viability of future proposed hydropower development on the Shire.

Currently, 99% of Malawi’s generating capacity is dependent on the Shire River. Development of further power stations on the Shire will continue the risk of shut-downs and power outages in the future. Indeed, continued dependence on the Shire will risk total failure of electricity supply causing disruption to households and industry and damage to Malawi’s economy.

Also important in the context of the Shire Basin is the use of biomass in the form of firewood and charcoal for cooking and its contribution to catchment degradation and soil erosion. Both urban and rural households must be encouraged to move to alternative energy sources, such as electricity that will be cleaner and healthier, and will help to reduce soil erosion, which is causing siltation at the Shire power stations. Thus, removal of dependency on the Shire power stations – in accordance with the Energy Policy objective - and of dependency on the use of biomass as a fuel for cooking can be expected to improve the future reliability and sustainability of the supply of electricity to all users in Malawi.
5.4 Indicators – Energy

The following indicators are proposed for key characteristics related to Energy.

Table 25: Indicators – energy

<table>
<thead>
<tr>
<th>Key Area</th>
<th>Indicator</th>
<th>Estimated Value for 2015</th>
<th>Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>Percentage of total energy sourced from biomass (firewood, charcoal)</td>
<td>89% (all Malawi)</td>
<td>NSO</td>
</tr>
<tr>
<td></td>
<td>Total annual hydropower generation from the Shire Basin</td>
<td>90% (all Malawi)</td>
<td>ESCOM</td>
</tr>
<tr>
<td></td>
<td>Total annual hydropower as percentage of installed capacity [346.3 MW]</td>
<td>72%</td>
<td>ESCOM</td>
</tr>
<tr>
<td></td>
<td>Dependence of Malawi on Shire River Basin hydropower schemes for electricity (%)</td>
<td>99%</td>
<td>ESCOM</td>
</tr>
<tr>
<td></td>
<td>Number of trading centres supplied by the electricity grid</td>
<td>Yet to be calculated</td>
<td>DoEA</td>
</tr>
</tbody>
</table>

38 Trading centres have been included in this indicator as progress is easier to measure than actual households. They provide a good surrogate measure of electricity availability across the basin.
6 Mining and Industry

6.1 Mining

6.1.1 Present status of the mining sector

Mining is a small but growing industry in Malawi. In 2013, mining accounted for 5.2% of GDP and the following commodities were mined for domestic consumption: brick clay, coal, crushed stone, lime, limestone and sulphuric acid. The country also mined and exported uranium (from Kayelekera which has since closed), and gemstones (amethyst, garnet, ruby, sapphire and tourmaline) and ornamental stone (agate and rose quartz).

Most of the mining and mineral processing operations in Malawi are privately owned, including the cement plants, the coal mines, and the Nyala ruby and sapphire mine. Malawi’s mineral industry also includes several artisanal and small-scale mining operations that produce aggregate, brick clay, gemstones and lime. Available data on production figures are presented in Table 26.

Table 26: Malawi minerals production

<table>
<thead>
<tr>
<th>Commodity</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>20131</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bentonite</td>
<td>8,050</td>
<td>2,100</td>
<td>2,450</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Brick Clay</td>
<td>N/A</td>
<td>960,405</td>
<td>1,015,200</td>
<td>1,400,000</td>
<td>1,500,000</td>
</tr>
<tr>
<td>Coal (bituminous)</td>
<td>59,201</td>
<td>65,006</td>
<td>72,300</td>
<td>91,910</td>
<td>98,000</td>
</tr>
<tr>
<td>Gemstones (kg)</td>
<td>306,700</td>
<td>190,340</td>
<td>215,000</td>
<td>285,000</td>
<td>310,000</td>
</tr>
<tr>
<td>Lime</td>
<td>25,900</td>
<td>45,851</td>
<td>93,549</td>
<td>95,543</td>
<td>115,000</td>
</tr>
<tr>
<td>Ornamental Stone</td>
<td>241</td>
<td>5,300</td>
<td>4,434</td>
<td>7,200</td>
<td>7,800</td>
</tr>
<tr>
<td>Stone:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crushed for Aggregate</td>
<td>970,550</td>
<td>965,600</td>
<td>1,039,237</td>
<td>1,338,600</td>
<td>1,450,000</td>
</tr>
<tr>
<td>Dimension Stone:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude</td>
<td>N/A</td>
<td>201</td>
<td>277</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Worked</td>
<td>N/A</td>
<td>116</td>
<td>167</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Limestone (for cement)</td>
<td>47,150</td>
<td>27,122</td>
<td>33,701</td>
<td>41,150</td>
<td>190,000</td>
</tr>
<tr>
<td>Sulphuric Acid2</td>
<td>6,400</td>
<td>37,000</td>
<td>56,000</td>
<td>73,000</td>
<td>75,000</td>
</tr>
<tr>
<td>Uranium U3O8</td>
<td>115</td>
<td>790</td>
<td>998</td>
<td>1,298</td>
<td>1,335</td>
</tr>
</tbody>
</table>

1Estimated data 2Used for uranium process. Gypsum and salt production is not reported.
Note: Figures quoted in metric tonnes unless otherwise indicated.
Data on mineral production within the Shire River Basin are presented in Table 27. In 2010 (the latest year for which data are available), employment in the mineral industry amounted to about 21,000 people, with the biggest employer being the aggregate subsector (about 12,000).

A map of the main mineral occurrences in southern Malawi is presented in Figure 38.

**Table 27: Shire River Basin minerals production**

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Main Companies</th>
<th>Location</th>
<th>Annual Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension Stone</td>
<td>Granite Ltd</td>
<td>Mzimba District</td>
<td>n/a</td>
</tr>
<tr>
<td>Fertilizer (P)</td>
<td>Optichem Ltd</td>
<td>Blantyre</td>
<td>120,000</td>
</tr>
<tr>
<td>Gemstones (kg)</td>
<td>Mzimba Gemstone Mining Cooperative Soc. Ltd</td>
<td>Mzimba District</td>
<td>n/a</td>
</tr>
<tr>
<td>Aquamarine (kg)</td>
<td>Silver Hill Gems</td>
<td>Mzimba District</td>
<td>7,000</td>
</tr>
<tr>
<td>Aquamarine (kg)</td>
<td>Aquasmart (Pty) Ltd</td>
<td>Mzimba District</td>
<td>n/a</td>
</tr>
<tr>
<td>Rose Quartz</td>
<td>Artisanal miners</td>
<td>Mzimba District</td>
<td>56</td>
</tr>
<tr>
<td>Ruby/Sapphire (kg)</td>
<td>Nyala Mines Ltd (Columbia Gem House Ltd)</td>
<td>Chimwadzulu Hill</td>
<td>450</td>
</tr>
<tr>
<td>Lime</td>
<td>Zalewa Agric Lime Co.</td>
<td>Blantyre</td>
<td>21,000</td>
</tr>
<tr>
<td>Lime</td>
<td>Balaka Limeworks Supply Co.</td>
<td>Balaka</td>
<td>21,000</td>
</tr>
<tr>
<td>Lime</td>
<td>Lirangwe Lime Makers Assoc.</td>
<td>Lirangwe</td>
<td>n/a</td>
</tr>
<tr>
<td>Limestone</td>
<td>Cement Products Ltd</td>
<td>Mangochi</td>
<td>45,000</td>
</tr>
<tr>
<td>Limestone</td>
<td>Artisanal Miners</td>
<td>Mangochi</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Note: Figures quoted in metric tonnes unless otherwise indicated.

The Lengwe and Mwabvi coalfields are preserved in a down-faulted graben in the far southwest of the country along the border with the Tete Province of Mozambique, within the Districts of Chikwawa and Nsanje. These coalfields were the subject of evaluation by BRGM between 1987 and 1991. The Mwabvi coalfield extends over 400 km² and has an identified resource of 2.2 million tonnes between surface and 50 m depth, and a further 2.5 million tonnes between 50m and 100m. Coal quality is reported to improve with depth.

The Lengwe coalfield extends over 350 km² but is of much lower quality than Mwabvi.
6.1.2 Opportunities provided by mining resources

Coal
Coal is an important and underused source of energy in Malawi. It offers a more reliable source of energy than renewable sources such as hydroelectric power generation and could be a substitute for wood charcoal, which is creating rapidly increasing environmental stress on the Shire River Basin.
Niobium and tantalum

The coltan metals columbite ([(Fe. Mn) Nb_2O_6]) and tantalite ([(Fe. Mn) Ta_2O_6]) are important ores of Nb and Ta which are used in specialist steels (for example, surgical instruments), superconductors, nuclear reactors, capacitors, mobile phones, and digital cameras. Pyrochlore ([(Na.Ca)_2 Nb_2O_6 (OH.F)]) is a major source of Nb.

Coltan, pyrochlore, zircon and uranium minerals are associated with alkaline magmatism (chiefly carbonatite intrusions) and the weathering products of these rocks in southern Malawi.

Phosphate

Phosphate is an important component of phosphate-based fertilizers. Many of the Carbonatite complexes in southern Malawi (particularly Tundulu, Chilwa island and Kangankunde) contain hard rock phosphate concentrations in the form of apatite (Ca_{10}(PO_4)_6(OH.F.Cl)). At Tundulu, a resource of 2 million tonnes of hard rock phosphate grading at 17% P_2O_5 has been delineated, with a high grade zone of 0.9 million tonnes grading 22% P_2O_5. Despite potential to mine other minerals simultaneously, this resource may be too small to be economic.

Limestone

Limestone is an important commodity for the development of Malawi. A number of limestone occurrences are known and there are currently two significant cement factories within the Shire Basin.

Graphite

Graphite currently has a small global demand of approximately 500,000 tonnes, and is used chiefly in the steel industry. However, it is widely considered to be on the brink of a major growth in demand based on new battery technologies (chiefly automotive) and applications in the smelting of aluminium. As the technologies become established, graphite demand is expected to grow dramatically.

Iron ore

The global iron ore price has fallen recently, and low cost producers in Australia and Brazil now dominate the market. The 100 million tonnes Nthale iron ore project in Malawi is unlikely to be developed in the short term, since the deposit is far from infrastructure to export the iron ore. Nevertheless, it may represent a future opportunity.

Rare earth elements

Rare earth elements (REE) play a vital and increasing role in a wide range of consumer electronics, environmental technologies and military applications. REE’s are typically divided into two groups: the light REE’s (neodymium, praseodymium, lanthanum, cerium, samarium, promethium) and the heavy REE’s (dysprosium, europium, yttrium, terbium, gadolinium, holmium, erbium, thulium, lutetium, and ytterbium). However a new group has recently been outlined as “critical rare earths” based on the applications they feed into (neodymium, europium, dysprosium, terbium and yttrium).
The Songwe Hill deposit in southern Malawi is at an advanced stage of project development and is likely to become a mine.

### 6.1.3 Challenges facing the mining sector

The challenges facing the mining sector in Malawi can be classed into three main areas, namely: (i) attracting investment to develop projects; (ii) capacity development within the Department of Mines and Minerals; and (iii) lack of infrastructure to export bulk commodities (such as iron ore, coal or graphite).

Investment in mineral projects is a competitive business and Malawi is competing for exploration budgets from public and private companies who will spend their money where there is mineral potential and where the Government is stable and the investment climate attractive and predictable. Malawi has an opportunity to be seen as an attractive destination for exploration investment with the new Mining Law.

The Department of Mines and Minerals (DOMM) faces a lack of skills (only 50% of posts filled according to a 2009 World Bank study) in order to meet the requirements of an efficient administration of the mining industry. Malawi would require:

- Establishment of a computer-based mineral licensing system supported by institutional setup, administrative process design, equipment, training and IT systems. This process can be largely outsourced.

- Strengthening of monitoring, evaluation and enforcement functions within relevant government agencies relating to mineral operations performance and planning (including rehabilitation and closure), mine health and safety And, environmental and social management. Again, this needs to be supported by institutional setup, administrative process design, Equipment, training and IT systems,

- Design and implementation of programs of education and skills development in mining-related disciplines to be undertaken by suitable institutions in Malawi in the sub-region or further afield.

The inefficiency and high cost of available routes (mainly road) to provide access to ports is a barrier to the export of bulk commodities and hence to the economic development of Malawi. Export routes to ports in Mozambique or Tanzania, such as the Lower Shire / Zambezi Waterway Project (still at feasibility stage) and rail links to Nacala and Beira in Mozambique are possibilities but unlikely to be developed in the short term.

### 6.2 Industry

#### 6.2.1 Overview of the industry sector

Although a small and under-developed sector in Malawi, industry is nevertheless an important contributor to the country’s GDP. But the burdens it struggles under are substantial. Hampered by the variability of the agricultural sector on which it is based, high transport costs, a small domestic market, and a poorly skilled work-force being undermined by HIV/AIDS, Malawi’s industries must also contend with a dependence on imported resources. This dependence largely robs the industrial sector of any benefit from successive depreciations of the kwacha and means Malawi’s goods, despite low wage rates, often do not fare well against regional competitors.
The majority of Malawi's industrial activity (85%) comes from manufacturing, a sector that in the year 2000 generated around 14% of GDP, and by 2013 had risen to almost 19%. The main sub-sectors are food processing, construction, consumer goods, cement, fertilizer, ginning, furniture production and cigarette production. Industrial production growth rate was estimated in 2013 as 2.8% per year.

Manufactured products account for only a small proportion of Malawi's export income, as shown in Figure 39. Most of the products shown are agricultural, with tobacco being the dominant export earner. This narrow productive and export base has left Malawi significantly vulnerable to shocks such as commodity prices fluctuations, aid shocks and importer lobbies – who have an interest in overvaluing the exchange rate, inadvertently disincentivising exports.

Malawian manufacturing is carried out by only about 100 companies involved in agricultural processing, textiles, clothing, and footwear production.

Most fruits and vegetables are exported raw, while processed food is imported mainly form South Africa. Carlsberg opened its first brewery outside of Denmark in Blantyre in 1965. The brewery also bottles Coca-Cola products under licence. A mango processing plant for the export of fruit concentrate opened in Salima in 2013. Universal Industries operates several food factories in Blantyre, where it produces sweets, crisps, biscuits, milk powder, soy products and baby food. Coffee and tea are processed by half a dozen of different companies in the regions of Thyolo, Mulanje and around Mzuzu.

To get an understanding of the historical growth of the industry sector, Figure 40 shows the gross value added (GVA) to Malawi's economy of manufacturing and construction. It can be seen that construction has not increased significantly since the 1970s. Manufacturing grew significantly during the Kamuzu era39, only to decline sharply for more than 10 years thereafter. Since about 2005, there has been another growth phase.

At the present time, Malawi is ranked 166th in the world for construction and 144th for manufacturing. There is clearly a need for better economic performance in the industry sector if the country's overall economic situation and standard of living is to improve significantly.

39 Hastings Banda was Malawi’s President from independence in 1964 until 1994.
Figure 39: Malawi’s main exports by value (million USD)

Source: www.trademap.org
6.2.2 Employment in industry

Industry (for the purposes of this assessment confined to manufacturing and construction, as already noted) is a small, employer in Malawi. It can be seen from Table 28 that employment in Malawi is dominated by agriculture, forestry and fishery (84%), and that in 2009 manufacturing and construction account for only 2% of the total workforce. However, according to the Malawi Labour Force Survey of 2013, this number had increased to 6.7%.

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40 Malawi Labour Force Survey 2013 - Key Findings Report, National Statistical Office
Table 28: Employment by sector in Malawi (2009)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Malawi</th>
<th>Male</th>
<th>Female</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry and fishery</td>
<td>84%</td>
<td>77%</td>
<td>90%</td>
<td>24%</td>
<td>90%</td>
</tr>
<tr>
<td>Manufacturing and construction</td>
<td>2%</td>
<td>4%</td>
<td>~0%</td>
<td>9%</td>
<td>2%</td>
</tr>
<tr>
<td>Commerce and hospitality</td>
<td>7%</td>
<td>8%</td>
<td>6%</td>
<td>32%</td>
<td>4%</td>
</tr>
<tr>
<td>Social and community services</td>
<td>4%</td>
<td>6%</td>
<td>2%</td>
<td>18%</td>
<td>4%</td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
<td>5%</td>
<td>1%</td>
<td>13%</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: National Statistical Office

6.2.3 Industry in the Shire River Basin

Most, but by no means all of the industrial activity in the Shire River Basin is located in Blantyre. Other sites include the Illovo sugar mill near Chikwawa a small industrial activity in other centres.

Blantyre is Malawi's centre of finance, commerce and industry, and its second largest city, with an estimated 1,069,000 inhabitants as of 2015. It is sometimes referred to as the commercial capital of Malawi as opposed to the political capital, Lilongwe.

The industrial activity is by far the major employment generator in Blantyre and has the greatest multiplier effect on the urban economy. The city is Malawi's industrial centre with many manufacturing plants. There are eight designated industrial areas: Makata, Ginnery Corner, Maselema, Limbe, Chirimba, South Lunzu, Maone and Chitawira. Of these Makata, Ginnery Corner, Maselema, Limbe, Chirimba and Maone are actively hosting industries whilst South Lunzu is yet to be developed.

The existing industrial sites are further categorised into heavy and light sites. Makata and Limbe, for example, are the sole heavy industrial sites hosting more than thirty companies.

While Chirimba industrial area is designated a heavy industrial area, it is the least developed in terms of number of industries. Apart from Makata, Ginnery Corner industrial site is another active site followed by Limbe and Maselema. The least are Chirimba and Maone industrial sites. Chitawira and Maselema are classic examples of light industrial areas. All the industrial areas are located along the banks of the main rivers or streams of Blantyre city. Makata industrial area lies between Mudi and Nasolo streams whilst Ginnery Corner industrial area is along the Mudi River. Maselema industrial area exists along the Naperi River and Chirimba Stream hosts Chirimba industrial area.
The employment structure includes formal and informal sectors, together offering employment that is estimated to be between 50,000 and 55,000 jobs and absorbing 62% of the labour force. The formal sector employment consists of primary, secondary and tertiary industry subsectors, and the informal sector is principally small-scale business operations. The tertiary or services industry subsector is leading in terms of employment creation and importance to the economy of the city; it employs around 30,000 people accounting for 56.5% of total formal employment. The secondary industry subsector employs about 20,000 people principally in manufacturing and accounts for about 41% of the total employment. Information on informal sector activities is scanty or non-existent.

There are regulations for treatment of wastes in the industries, but disposal of untreated wastewater into drains and, subsequently, into the city's major streams is very common, thus posing a potential health and environmental risk to the people in Blantyre and downstream.

6.2.4 Potential environmental and social impacts of industrial development

While industrial development should be encouraged to ensure reasonable growth of the Malawi economy, the potential environmental and social impacts of such development must be recognised and planned for. Industrial enterprises are significant sources of pollution and unless abatement mechanisms, such as wastewater treatment facilities, are put in place, and wastewater discharge licences issues (importantly) rigorously enforced, then environmental and social problems will arise that may outweigh the benefits of improved economic conditions. These problems are most often exacerbated by the increased urbanisation that follows industrial development as rural workers move to the cities to take up the additional employment being offered.
In the Shire River Basin, the population of the city of Blantyre has grown rapidly (through immigration) over the past few years without keeping pace with the national economy. The surface water sources in the city (rivers, streams and hand-dug wells) are very polluted and hence unsafe and unsuitable for human consumption, mainly due to effluent discharges from industries, domestic and commercial sources and high level content of faecal contaminants; due to poor sanitation combined with seepage from pit latrines and rotting solid waste and suspended solids. An example of a polluted stream in Blantyre is the Mudi River (see Figure 42).

Figure 42: Pollution in Mudi River downstream of Blantyre

6.2.5 Challenges to industry

It is highly unlikely that Malawi can successfully move its economy away from agriculture, especially subsistence agriculture, to a stronger and more stable base without development of a thriving and sustainable industry sector centred around manufacturing and associated construction. While the government appears to be pinning its hopes on other sectors, such as tourism and mining, these simply do not have the potential to lift the economy significantly, mainly through lack of natural resources compared to Malawi’s neighbours. Added to that, the fact that rapid urbanisation and population growth are occurring in Malawi (see Section 4.4) means that employment opportunities need to be provided if increased urban poverty is to be averted. A government strategy that moves the country more rapidly towards a vibrant and robust industry sector is needed if real economic growth is to be achieved.

There would appear to be an opportunity for Malawi to “fill the gap” for some types of manufacturing. As an example, in the textile industry, China once dominated world production, but this dominance is declining due to rising labour costs as the standard of living has increased. Investors have turned to countries such as Indonesia, Viet Nam, and even Central American
countries where labour costs are low, but even these countries are becoming less attractive. Bangladesh has very low labour costs, but consumers are shying away from products made there due to humanitarian concerns based on reports of poor working conditions and cases of child labour. Malawi could provide a good alternative to investors in the textile industry if the right conditions could be achieved. Fair wages could be paid that exceed incomes from subsistence farming, while still being competitive by comparison with other developing countries.

A challenge to the development of the industry sector in Malawi is the lack of skilled and semi-skilled labour required for manufacturing enterprises. According to the Malawi Labour Force Survey of 2013, the percentage of workers employed in the agricultural sector was more than 64% of labour force, while the percentage of plant and machine operators, and assemblers – the type of labour required for manufacturing – was only about 5%. Note that the “employment rate – that is the percentage of the of the population (labour force) age 15 – 65 years who, during the period of the survey were employed to the total working population, was less than 80%.

Clearly, at the present time, investment in manufacturing enterprises is being hampered because of the heavy reliance of Malawi on agriculture and hence lack of technically-oriented labour suited to these enterprises.

The government encourages both domestic and foreign investment in most sectors of the economy without restrictions on ownership, size of investment, source of funds, or the destination of the final product. There is no government screening of foreign investment in Malawi. Apart from the privatisation program, the government’s overall economic and industrial policy does not have discriminatory effects on foreign investors. Since industrial licensing in Malawi applies to both domestic and foreign investment, and is only restricted to a short list of products, it does not limit competition, protect domestic interests, or discriminate against foreign investors at any stage of investment. Restrictions are based on environmental, health, and national security concerns. Affected items are firearms and ammunition; chemical and biological weapons; explosives; and manufacturing involving hazardous waste treatment/disposal or radioactive material. All regulations affecting trade (foreign exchange, taxes, etc.) apply equally to domestic and foreign investors.

While the systems for processing investment proposals are not discriminatory against foreign investors, investments in Malawi require multiple bureaucratic processes, which may include licensing and land use permissions that can be time consuming and may constitute an impediment to investment. The government has made progress in the legislative framework to simplify or streamline the process to attract increased investment, but further reform is required.

At present, Malawi ranks in the bottom 25% of countries for overall ease of doing business. Having good access to imported materials and to international markets is essential for a vibrant and sustainable economy. Unfortunately, Malawi is a land-locked country and so suffers from high costs of transportation that

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41 http://www.doingbusiness.org/data/exploreeconomies/malawi/
impair the economy to a significant extent. Most goods imported from and exported to other countries are shipped by roads connecting Malawi to ports in Dar es Salaam in Tanzania, Durban in South Africa and Beira and Nacala in Mozambique. This adds millions of dollars to the cost of importing and exporting goods each year.

Transport corridors are being developed for roads and railways. The main one is the Nacala corridor project that is planned to link Zambia and Malawi to the port of Nacala in Mozambique (see Figure 43). Development of the Beira transport corridor is also under consideration.

Figure 43: Route of the Nacala transportation corridor

Industrial development is highly dependent on adequate and reliable supplies of power and water. Unfortunately, at the present time this is not the reality in Malawi.

While the motto of the Electricity Supply Commission of Malawi (ESCOM) is "Electricity 24 hours per day, every day", the reality is much different. Less than 10% of the population have access to electricity supply, and most of these are in the cities and larger towns. Even there, electricity outages are commonplace. These outages are caused by lack of capacity of the hydropower plants along the Shire River that supply virtually all the electrical energy for the country. The problem is exacerbated by the siltation of the headponds at the three plants causing blockages of the inlets, which, in turn is caused by high levels of erosion and soil wash off due mainly to deforestation and inappropriate agricultural practices.

42 This issue is covered in detail in NIRAS’ Sector Assessment: Navigation and Transport.
The situation for water supply is little different. Even in Blantyre, which could be expected to be a major centre for future industrial development, a reliable supply of water is not available. At present, rehabilitation works are being carried out at the Walkers Ferry offtake (pump station) that supplies most of Blantyre’s water and expansion works have been designed but at this stage are unfunded.

Note that, while this discussion has focused on Blantyre, being the only urban centre in the Shire River Basin with any significant industrial activity, it applies equally to other industrial centres that may (and should) be developed in the future.

6.3 Indicators – Mining and Industry

The following indicators are proposed for key characteristics related to energy.

Table 29: Indicators – mining and industry

<table>
<thead>
<tr>
<th>Key Area</th>
<th>Indicator</th>
<th>Estimated Value for 2015</th>
<th>Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining</td>
<td>Annual value of production from mining</td>
<td>No data available</td>
<td>DoMI</td>
</tr>
<tr>
<td>Industry</td>
<td>Annual value of production from industry</td>
<td>No data available</td>
<td>DoM</td>
</tr>
<tr>
<td></td>
<td>Percentage of the workforce employed in the industry sector</td>
<td>No data available</td>
<td>NSO</td>
</tr>
</tbody>
</table>
7 Tourism

7.1 Overview

Tourism is Malawi’s third largest foreign exchange earner after tea and tobacco, and a major employer, accounting for more than 5% of the total wage employment. It contributes more than 10% of the country’s GDP.

The principal tourist attraction is Lake Malawi. There are several resort areas on the shores of the lake, which has one of the highest diversities of freshwater fish in the world. Around Cape Maclear there are excellent snorkelling and diving spots.

There are five national parks in Malawi notable for their spectacular scenery and diversity of wildlife. They are:

- Lake Malawi National Park — designated a National Park in 1980 to protect the unique diversity of tropical fish living in Lake Malawi, some not found anywhere else;
- Lengwe National Park — most famed for the nyala antelope, not found in the other northern parks of Malawi, but decreasing in numbers;
- Liwonde National Park — situated 120 km north of Blantyre, on the banks of the Upper Shire River;
- Nyika National Park — the first (certified in 1965), the largest (over 3,000 km²) and the highest (average height 1,800 m);
- Kasungu National Park — situated approximately 165 km north of Lilongwe, this is, at over 2,000 km², the second largest of Malawi’s parks — however, animal numbers are rapidly being depleted.

Birdlife such as African fish eagles, palm nut vultures and Pel's fishing owls are prolific among the flood plains and reed swamps. Malawi is also home to elephants, hippopotamus, waterbuck, reedbuck, sable antelope and other animal species. The country has one of the largest numbers of orchid species in Africa. Zomba Plateau is one of the best places to see orchids and other native flora.

Tourism is included as one of nine ‘key priority areas’ in the Malawi Growth and Development Strategy II. Statistics for tourism in Malawi reveal an annual growth rate approximating 12% over recent years (see Figure 44). And this has out-performed the general trend for Sub-Saharan Africa. According to the statistical database created using departure cards, approximately 25% of visitors are on vacation; a similar number visit for personal reasons; and about 50% travel to Malawi for business-related purposes.

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Note that more recent statistics are not available. This could be because departure cards are no longer required to be filled out.
The tourism industry offers very high water productivity – and it is self-evident that much of the sector depends on the quality of the environment and water resources for its success. This is particularly the case in Malawi, where Lake Malawi and the wildlife assets are major attractions for tourists.

![Figure 44: Numbers of tourists in Malawi between 1994 and 2006](source: Tourism Statistics Report. 2006. National Statistics Office. Malawi.)

### 7.2 Status of Tourism in the Shire River Basin

While Lake Malawi is an important tourist attraction, it lies upstream of the Shire River Basin and so the most popular destinations in the basin are the various protected areas and wetlands that are the habitats of various types of wildlife – that is, ecotourism.

There are seven areas of particular significance in the Shire River Basin in terms of biodiversity and conservation (see Figure 45):

- Liwonde National Park located on the eastern bank of the Shire River above the Kamuzu Barrage;
- Lengwe National Park. situated in the south-west of the sub-basin;
- Majete Wildlife Reserve adjacent to Lengwe. which has been restocked over the last decade and is recording higher numbers of tourists and enhanced revenues;
- Mulanje Mountain ecosystem. to the east of the sub-basin;
- Mangochi Palm Forest Reserve;
- The Shire Marshes (Elephant Marsh and Ndindi Marsh) in the southern reaches of the sub-basin, some 235 km south of the Kamuzu Barrage; and
- Mwabvi Wildlife Reserve. in the extreme south of Malawi.

The conservation of the two National Parks and the Majete Wildlife Reserve has been accorded high priority, and recent reintroductions of various species have been successful in promoting tourism.
SRBMP Subcomponent B4 (Ecological Management) is aimed at strengthening management of remaining key natural habitat areas in the basin to protect and enhancing the delivery of environmental services (such as catchment protection, flood attenuation, biodiversity conservation, carbon sequestration and as a basis for generating revenues from tourism). The main focus areas are:

- Lengwe National Park
- Liwonde National Park
- Mangochi Forest Reserve
7.3 Challenges to Tourism

Investment in tourism is recognised as a mechanism for increasing the magnitude and distribution of economic benefits to the people of impoverished countries such as Malawi, through employment of local people in the tourism industry and other related means. However, little is known about how economic benefits such as increased income of local employees in the tourism industry relate to conditions at the intra-household level, particularly in the least developed countries.

As an example in a study by Gartner and Cukier\textsuperscript{44}, the authors examined the relationship of tourism employment to poverty conditions in Nkhata Bay on Lake Malawi. While this area is not within the Shire River Basin it could be expected that the conclusions of the study are applicable to other locations (including the Shire River Basin) in Malawi.

The findings of the study revealed that while employees of the tourism sector experienced better working and monetary conditions (compared to employees of non-tourism sectors), this group did not exhibit an improved status with respect to other poverty conditions. Most tourism lodge owners were found to adhere to of minimum wage as well as offering fringe benefits, such as paying medical, funeral and education expenses of lodge employees. However, despite this there appears to be little evidence that this translates to a significant improvement in poverty conditions.

Other challenges to tourism development include:

- Illegal hunting of wild animals, leading to depletion of stocks (Figure 46).
- Continued degradation of catchments and landscapes due to deforestation and inappropriate agriculture.
- Lack of maintenance of infrastructure and poor visitor facilities (Figure 47 and Figure 48).
- Competition from neighbouring countries such as Tanzania that already have more established tourism infrastructure.

It should be noted that anecdotal evidence suggests that the number of visitors to the four National Parks in the basin is declining. Presumably this is due to inadequate infrastructure in terms of roads and bridges for access and accommodation and restaurant facilities for visitor comfort.

Figure 46: Capture of crocodiles in the Elephant Marsh

Source: Julian Bayliss

Figure 47: Overgrown access road at Lengwe National Park

Source: Julian Bayliss
7.4 Indicators – Tourism

The following indicators are proposed for key characteristics related to tourism.

Table 30: Indicators – tourism

<table>
<thead>
<tr>
<th>Key Area</th>
<th>Indicator</th>
<th>Estimated Value for 2015</th>
<th>Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tourism</td>
<td>Annual number of visitors to the Shire Basin national parks and game reserves</td>
<td>No data available</td>
<td>DNPW</td>
</tr>
</tbody>
</table>
8  The Land

8.1  Topography

The Shire River Basin is often divided into thirds. The Upper Shire being the exit from Lake Malawi and the relatively flat topography around Liwonde. The Middle Shire is characterised by the steep topography either side of the gorges around the river, leading to hydropower barrages and power stations. The Lower Shire encompasses the flat altitude floodplain wetland system with marshes of wildlife – biodiversity significance and major sugar estates as well as small-scale subsistence agriculture.

A map showing the topography of the basin is shown in Figure 50.

Figure 49: View over the Upper Shire Valley

Source: Børge Storm
8.2 Land Cover and Land Use

The Shire River Basin land cover is dominated by forests and grasslands (in various states of degradation) and agriculture (see Figure 51).

The changes in land use over time in Malawi are an important driver in the degradation of the environment. Figure 52 shows the transition in land use between 1991 and 2008, reflecting the gradually increased emphasis on the agricultural sector and the reductions in the natural ecosystems. This is driven largely by increasing population pressure.
As is suggested by Figure 52, the forest resource in Malawi has been degraded heavily over the last three decades in particular, the entire country being affected. Data from the Food and Agriculture Organisation (FAO) indicate losses of forest area of approximately 3% per annum in the period between 1972 and 1992 and these have continued to date. In the last three decades, it has been estimated that more than 50% of the historical forest cover has been lost from Malawi as a whole.\textsuperscript{45}

\textsuperscript{45} More detailed information on forestry and deforestation is provided in Section 4.4.
8.3 Forests and Deforestation

Altitude in Malawi ranges from 50 meters above sea level (Lower Shire) to 3000 meters on Mulanje Mountain in the south and 2600 meters on the Nyika plateau in the north of the country. With slopes varying from steep escarpment to plains, there is a wide variety of vegetation formations in the country. The interaction of slope, soil, geology and climatic variables has resulted in at least 19 distinct vegetation communities. Population pressure has however modified biotic communities resulting in woodlands/trees interspaced with agriculture crops. Most of natural forests are miombo woodland type, with typically low annual growth rates estimated at 1 – 2 m³ per hectare per year. Most of the forests have low commercial value. In the past, Malawi was endowed with vast miombo woodlands, but this natural resource has been subject to considerable reduction in area mainly due human activities to the present state. Table 31 shows the present day forest resource extent.
Figure 53: Typical miombo forest in Malawi

![Figure 53: Typical miombo forest in Malawi](image)

Table 31: Forestry resources in Malawi

<table>
<thead>
<tr>
<th>Forest Category</th>
<th>Area (ha)</th>
<th>% of Total Forest Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Reserves</td>
<td>870,052</td>
<td>17</td>
</tr>
<tr>
<td>National Parks &amp; Game Reserves</td>
<td>981,479</td>
<td>19</td>
</tr>
<tr>
<td>Government Plantations</td>
<td>90,000</td>
<td>2</td>
</tr>
<tr>
<td>Private Plantation</td>
<td>20,000</td>
<td>0</td>
</tr>
<tr>
<td>Customary land</td>
<td>1,988,255</td>
<td>63</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>3,949,786</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Sam Kainja. Forestry Outlook Study for Malawi. December, 2000

Forest resources have been subjected to extensive deforestation. Between 1990 and 2010, it has been estimated that Malawi lost an average of 32,950 ha or 0.85% per year. In total, between 1990 and 2010, Malawi lost 16.9% of its forest cover, or around 660,000 ha. However, the rate of deforestation in the Shire River Basin is probably closer to 3%. Thyolo District is the least forested in all of Malawi at just 2%.

Natural forests represent the remainder of the miombo forests that once covered almost the whole country. Forest Reserves are managed by the

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Forestry Department and cover an estimated 0.87 million hectares, comprising 17% of forest cover in Malawi. There are 82 Forest Reserves scattered all over the country. Most of them are on hills and mountains protecting these fragile areas from environmental degradation through erosion but also protects important water catchment areas.

Wildlife forest reserves are managed by the Department of National Parks and Wildlife and comprise an estimated 0.98 million hectares which is 19% of total land area. There are five National Parks and four Game Reserves distributed throughout the country.

Those forest reserves and national parks within the Shire River Basin are shown in Figure 45.

Customary land forests are owned traditionally by the smallholders and cover 3.1 million ha, which is about 63% of forest area in Malawi, comprising of 22% of undisturbed forest and 4% of disturbed forest with 20% to 70% of cultivated land. The corresponding figures for the Shire River Basin only are not available.

Challenges to the forestry sector are essentially the same as for catchment amelioration and biodiversity protection, namely:

- Erratic rainfall and often high temperatures;
- Deforestation of catchments;
- Development of alternative livelihoods to reduce dependence on charcoal making;
- Soil erosion.

As discussed in more detail elsewhere, forest resources have been subjected to extensive deforestation as the deforested hillside in Figure 54.

**Figure 54: Deforested hillside**
Much of the forested areas have been depleted for the production and firewood and charcoal. and as already stated in Section 5.1, it is estimated that 89% of all of Malawi’s energy use is sourced from biomass, and mostly trees. Charcoal and firewood production are the highest threats to forests, after bush fires, and production mainly occurs in the forest reserves and customary woodlands. Kambewa et al (2007), estimate that a total of approximately 231,000 tonnes of charcoal is produced annually (this figure is undoubtedly much greater at the present time), and has categorised charcoal producers into three categories based on the volume of annual charcoal produced. The small-scale producers, who are the majority (less than 30 bags per month), produce about 100,000 tonnes per annum; the medium-scale producers (30-100 bags per month) produce approximately 60,000 tonnes per annum; and the large-scale producers (100 bags per month) produce about 80,000 tonnes per year.

A study of charcoal consumption, trade and production in Malawi has revealed that as many as 40,000 kilns operate each year with approximately 109 kilns used a day; 60% of this charcoal is produced in forest reserves or national parks and the rest comes from customary land (Kambewa et al. 2007). The same study also estimated that 15,000 ha of forest are cleared every year for charcoal production. While no specific figures are available for the Shire River Basin, on a pro rata area basis, forest clearing for charcoal in the basin would be about 4,000 ha annually.

This deforestation has had, and continues to have, significant adverse effects on agriculture, water management, and even hydropower production.

The anthropogenic threats to forests, in terms of risk, have been assessed by LTS48 and are shown in Figure 55.

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48 SRMBP consultancy on Strengthening the Information Base of Natural Habitats, Biodiversity and Environmental Services in the Shire Basin (SINHBES).
Figure 55: Risks to forests

Source: Provided by LTS (2015)
8.4 Soil Erosion

Apart from the destruction of forests for biomass fuel, it is reported\(^\text{49}\) that prime vegetation is being replaced with arable fields, mainly for the production of maize that has little groundcover even when fully grown. It is this practice, as well as that of deforestation, that exposes topsoil to splash action from precipitation and results in erosion.

**Figure 56: Major gully erosion - Chingale catchment**

![Image of gully erosion](source: Mott Macdonald)

In addition, because rainfall runs off more quickly where there is inadequate groundcover, flash flooding is increased in some areas and importantly, there is reduced infiltration to base flow and to the aquifers beneath the catchment. This results in reduced flows during the dry season and the chance that perennial streams will become ephemeral, and lowering of shallow aquifers possibly leading to the drying up of wells.

Figure 57 shows the estimated soil loss across the Shire River Basin.

In some areas, especially on and adjacent to areas of bare earth, like roads and villages, large erosion gullies form. These are of great concern, not only with regard to sedimentation of watercourses, but also as a result of their negative impacts on agricultural production, transport routes, hydropower production and other aspects of life in the basin.

\(^{49}\) Mott MacDonald (2015). Baseline assessments for selected catchments in the Shire River Basin. as part of SRBMP Component B.
Various estimates for annual soil losses for catchments in Malawi have been made that generally range from about 15 tonnes/ha/year and up. Estimates of around 50 tonnes/ha/year have been mentioned.

Mott MacDonald, under Component B of SRBMP, has derived estimates of soil loss for four pilot catchments in the Shire River Basin, based on the SWAT catchment model\textsuperscript{50}. These are shown in Table 32.

\textsuperscript{50} The Soil and Water Assessment Tool (SWAT) is a public domain model jointly developed by USDA Agricultural Research Service (USDA-ARS) and Texas A&M
### Table 32: Soil loss estimates for four catchments

<table>
<thead>
<tr>
<th>Area (ha)</th>
<th>Soil Loss (t/ha/year)</th>
<th>Soil Loss (t/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chingale</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subcatchment 1</td>
<td>5,180</td>
<td>9</td>
</tr>
<tr>
<td>Subcatchment 2</td>
<td>6,371</td>
<td>8</td>
</tr>
<tr>
<td>Subcatchment 3</td>
<td>6,710</td>
<td>6</td>
</tr>
<tr>
<td>Subcatchment 4</td>
<td>9,401</td>
<td>13</td>
</tr>
<tr>
<td>Subcatchment 5</td>
<td>13,596</td>
<td>27</td>
</tr>
<tr>
<td><strong>Whole catchment</strong></td>
<td>41,258</td>
<td>15</td>
</tr>
<tr>
<td><strong>Kapichira</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subcatchment 1</td>
<td>1,851</td>
<td>4</td>
</tr>
<tr>
<td>Subcatchment 2</td>
<td>12,948</td>
<td>7</td>
</tr>
<tr>
<td>Subcatchment 3</td>
<td>10,070</td>
<td>8</td>
</tr>
<tr>
<td>Subcatchment 4</td>
<td>8,288</td>
<td>2</td>
</tr>
<tr>
<td><strong>Whole catchment</strong></td>
<td>33,157</td>
<td></td>
</tr>
<tr>
<td><strong>Upper Lisungwe</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subcatchment 1</td>
<td>2,624</td>
<td>2</td>
</tr>
<tr>
<td>Subcatchment 2</td>
<td>5,389</td>
<td>5</td>
</tr>
<tr>
<td>Subcatchment 3</td>
<td>6,329</td>
<td>29</td>
</tr>
<tr>
<td>Subcatchment 4</td>
<td>11,613</td>
<td>21</td>
</tr>
<tr>
<td><strong>Whole catchment</strong></td>
<td>25,955</td>
<td></td>
</tr>
<tr>
<td><strong>Upper Wamkulumadzi</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subcatchment 1</td>
<td>8,447</td>
<td>5</td>
</tr>
<tr>
<td>Subcatchment 2</td>
<td>6,260</td>
<td>20</td>
</tr>
<tr>
<td>Subcatchment 3</td>
<td>2,603</td>
<td>19</td>
</tr>
<tr>
<td>Subcatchment 4</td>
<td>12,246</td>
<td>6</td>
</tr>
<tr>
<td><strong>Whole catchment</strong></td>
<td>29,556</td>
<td></td>
</tr>
</tbody>
</table>

Source: Computed from modelling data provided in Mott MacDonald (2015). Baseline assessments for selected catchments in the Shire River Basin as part of SRBMP Component B.

These figures indicate that soil losses are quite variable even within catchments, presumably depending on the vegetation and level of catchment degradation, ranging from 2 tonnes/ha/year to almost 30 tonnes/ha/year.

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AgriLife Research, part of The Texas A&M University System. SWAT is a small watershed to river basin-scale model to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. See: http://swat.tamu.edu
As for the economic impacts of soil erosion, in the report entitled *Economic Analysis of Sustainable Natural Resource Use in Malawi*, prepared for UNDP and UNEP in 2011, the following is stated:

“Estimates of soil loss based on a limited number of sample sites indicate an average loss of approximately 20t/ha/year. Studies that have translated this into yield losses suggest a 4% - 25% loss each year. A conservative estimate is that the annual on-site loss of agricultural productivity as a result of soil degradation cost MWK 7.5 billion (US$54 million) in 2007 which is 1.6% of GDP. In addition, soil erosion negatively affects hydroelectric power generation. Using data from ESCOM on the costs of minimising this impact, we estimate annual costs of some US$10 million in 2007 prices. We also identify small off-site impacts on drinking water treatment costs (approximately US$100,000 per annum for Blantyre Water Board alone) and impacts on the productivity of fisheries that we have not been able to quantify. Evidence from a computable general equilibrium model of growth-poverty linkages in Malawi indicates that lost agricultural productivity from soil degradation over the period 2004 to 2015 will leave more than 1.88 million people in poverty who would otherwise have escaped it.”

**Figure 58: An example of a heavily silted watercourse in the Chingale catchment**

Source: Mott Macdonald
8.5 Indicators – the Land

The following indicators are proposed for key characteristics related to the land.

Table 33: Indicators – land

<table>
<thead>
<tr>
<th>Key Area</th>
<th>Indicator</th>
<th>Estimated Value for 2015</th>
<th>Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land cover</td>
<td>Total forested area (% of basin area)</td>
<td>No data available</td>
<td>DF</td>
</tr>
<tr>
<td>Land use</td>
<td>Percentage of land becoming unavailable to agriculture annually due to erosion (ha/year)</td>
<td>No data available</td>
<td>DLHUD</td>
</tr>
<tr>
<td>Soil loss</td>
<td>Average soil loss (tonnes/ha/year)</td>
<td>No data available</td>
<td>DLHUD</td>
</tr>
</tbody>
</table>
9 Water Resources

9.1 The Shire River

The Upper Shire River starts at the outlet of Lake Malawi at Samama, a few kilometres upstream of Mangochi at an elevation of 474 masl. After passing the shallow Lake Malombe, just south of Mangochi, the river flows south through the Liwonde National Park and continues in a south-westerly direction towards Matope. In this upper reach the river flows through alluvium deposits over a distance of 140 km at an average river gradient of 0.12 m/km.

Figure 59: Lake Malombe (upper Shire)

The Middle Shire between Matope and Chikwawa is characterised by the steep topography on both sides of the river gorges. From Matope to Maganga, a few kilometres downstream of Kapichira Falls, the river passes the Basement Complex. In this reach of some 70 km all major falls (Nkula, Tedzani, Mpatamanga\(^{51}\) and Kapichira Falls) and many rapids are located therein. In this section with barrages diverting water to hydropower stations the river has an average gradient of 5.23 m/km.

\(^{51}\) Shown in Figure 55.
The Lower Shire is characterised by the flat floodplain wetland system with marshes of wildlife–biodiversity significance and major sugar estates as well as small-scale subsistence agriculture. The lower leach of the Shire passing through the Elephant Marsh extends to the Malawi border. The major tributary of the Shire is the Ruo River, which originates on the Mulanje massif and joins the Shire River at Chiromo. In the last section of the Shire River from Maganga, upstream of Chickwawa, to its confluence with the Zambezi River, the river flows again through alluvium formations at a gradient of about 0.26 m/km.
A map of the basin showing the stream network is shown in Figure 62.

Figure 62: Shire River Basin stream network

9.2 Tributaries

Most of the Shire River Basin is located in Malawi’s Southern Region except for some small areas of the Kirk range that are located in the Central Region. The main tributaries are the Rivirivi, Lisungwe, Wakulumadzi, and Mwanza on the right bank. The Lirangwe, Likabula, Mwamanzi, and some other rivers are small tributaries joining the Shire on the left bank, as well as the larger Ruo River.
Except for the Mwanza River all main tributaries are perennial, but with low to very low dry season flows. Most of the smaller streams are non-perennial except a few draining from the Thyolo hills and the escarpment. The Ruo River is the largest tributary of the Shire. Downstream of Chikwawa, the river enters the vast Elephant Marsh and joins the Shire just downstream of Chiromo.

The tributaries drain some areas of poor vegetation where rainfall is low and land degradation high. Rivers such as the Rivirivi, Lisungwi and Wamkulumadzi carry large amounts of sediments during the rainy season. Water abstraction from these rivers is relatively low, due to comparatively low economic activities in their catchments.

### 9.3 Hydrological Units

The Shire River Basin comprises two Water Resources Areas (WRAs), and eighteen Water Resources Units (WRUs), as defined by the Ministry of Agriculture, Irrigation and Water Development. The WRAs included in the basin are WRA 1 and WRA 14. The WRUs have been amalgamated into six sub-basins. The sub-basins (listed in Table 2) and WRAs are shown in Figure 2. About 4,580 km² of the Shire hydrological basin downstream of Chiromo and about 1,266 km² of the Ruo Basin upstream of Chiromo are located in Mozambique.

### 9.4 Lakes and Wetlands

Lake Malawi forms the headwater of the Shire River. The outflow from Lake Malawi is determined by the lake level, the sand bar threshold at the outlet and to some extent by the operation of the Kamuzu Barrage at Liwonde, which is supposed to maintain a minimum flow to downstream areas of 170 m³/s.

Within the Shire Basin there is one major lake, Lake Malombe, which is a shallow lake just downstream of Mangochi. The surface area of this lake varies with the outflow from Lake Malawi. The maximum surface area of the lake is 450 km². During the period 1915 to 1935 there was no outflow from Lake Malawi and Lake Malombe dried up.

Wetlands, locally known as *dambos* in Malawi, are defined as any permanently or seasonally wetlands in valleys, depressions or floodplains with open herbaceous vegetation – mainly grasses and sedges – and an absence of trees. A major wetland area in the Shire Basin is the Elephant Marsh near Chiromo, at the confluence of the Shire and Ruo rivers. The marsh varies in size from 400 to 1200 km², depending on the flow of the Shire and Ruo Rivers. In some places, floating mats of vegetation (Figure 63) are so thick that boat travel is almost impossible. Other wetlands include the Lake Malombe wetlands, the Ndinde Marsh and many smaller wetlands along the river system.
9.5 Monitoring

9.5.1 Meteorology

The Department of Climate Change and Meteorological Services (DCCM) operates a total of 23 meteorological stations in Malawi. These stations monitor evaporation and other climatic data, such as sunshine or radiation, humidity, temperature and wind speed. The stations operated in and around the Shire Basin are listed in Table 34 and their locations are shown in Figure 64.

Table 34: Meteorological stations in and around the Shire Basin

<table>
<thead>
<tr>
<th>Site</th>
<th>WMO_ID</th>
<th>Name</th>
<th>Start</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>M304</td>
<td>15353056</td>
<td>Bvumbwe</td>
<td>1946</td>
<td>-15.92</td>
<td>35.07</td>
<td>1146</td>
</tr>
<tr>
<td>M297</td>
<td>15353036</td>
<td>Chichiri Met</td>
<td>1967</td>
<td>-15.78</td>
<td>35.05</td>
<td>1132</td>
</tr>
<tr>
<td>M245</td>
<td>15344002</td>
<td>Chileka Airport</td>
<td>1941</td>
<td>-15.67</td>
<td>34.97</td>
<td>767</td>
</tr>
<tr>
<td>M296</td>
<td>15353035</td>
<td>Makoka</td>
<td>1965</td>
<td>-15.53</td>
<td>35.18</td>
<td>1029</td>
</tr>
<tr>
<td>M230</td>
<td>14351000</td>
<td>Mangochi Met</td>
<td>1921</td>
<td>-14.47</td>
<td>35.25</td>
<td>482</td>
</tr>
<tr>
<td>M379</td>
<td>16352009</td>
<td>Mimoso</td>
<td>1958</td>
<td>-16.07</td>
<td>35.62</td>
<td>652</td>
</tr>
<tr>
<td>M222</td>
<td>14342006</td>
<td>Monkey Bay</td>
<td>1935</td>
<td>-14.07</td>
<td>34.9</td>
<td>482</td>
</tr>
<tr>
<td>M249</td>
<td>15344009</td>
<td>Mwanza Boma</td>
<td>1935</td>
<td>-15.62</td>
<td>34.52</td>
<td>655</td>
</tr>
<tr>
<td>M318</td>
<td>16342010</td>
<td>Ngabu Met</td>
<td>1973</td>
<td>-16.5</td>
<td>34.95</td>
<td>102</td>
</tr>
<tr>
<td>M353</td>
<td>16351036</td>
<td>Thyolo Met</td>
<td>1963</td>
<td>-16.13</td>
<td>35.13</td>
<td>820</td>
</tr>
</tbody>
</table>
There has been a serious decline in the number of rainfall stations from the 1980s when the number of stations went down from some 800 in the country. The MAIWD (and its predecessors) used to operate rain gauges and evaporation pans but all stations are now owned, maintained, and operated by the Department of Climate Change and Meteorological Services. Some evaporation stations are being automated by adding sensors to existing stations or automatic loggers. Reportedly, few evaporation stations are currently properly operated.
Additional meteorological stations and automatic weather stations were installed as part of a project with the (former) Ministry of Agriculture\(^{52}\). There are also other institutions that operate their own meteorological stations.

There was a serious decline in the number of rainfall stations in the 1980s when the number of stations went down from some 800 in the country. The SRBMP has engaged the consulting firm, Atkins, to assist to upgrade the meteorological monitoring network, so hopefully this situation will improve in the near future.

9.5.2 Streamflow

This surface water monitoring network was quite extensive in the past but since the 1980s many stations have been closed due to limited budget. For the same reason also the remaining stations went into a serious state of decline. Rating curves for most stations were no longer updated when current metering (gauging) was discontinued.

Regarding the present status of the monitoring network, following field assessments made by Aurecon in 2011 and 2013, the overall situation for Malawi is shown in Table 35. Few of the stations are in the good quality category, with a significant number falling into the poor quality category (see Figure 65 as an example), mainly due to a lack of resources. Note that since that assessment, other stations have been damaged or destroyed during the floods of January 2015 in the Lower Shire (an example is given in Figure 66).

**Figure 65: Poorly maintained gauging station (Thuchila River at Chonde)**

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\(^{52}\) Now the Ministry of Agriculture. Irrigation and Water Development

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**NIRAS**
Table 35: Present status of hydrometric stations in Malawi

<table>
<thead>
<tr>
<th>Issue</th>
<th>Poor</th>
<th>Average</th>
<th>Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>River cross section</td>
<td>Unstable</td>
<td>Stable</td>
<td>Stable</td>
</tr>
<tr>
<td>Gauge plates</td>
<td>All missing</td>
<td>At least low flow gauges intact (station good for low flow measurement)</td>
<td>All gauges in good condition (station good for low and high flow measurement)</td>
</tr>
<tr>
<td>Hydraulic control</td>
<td>Unstable, or for weirs: badly damaged</td>
<td>Stable, or for weirs: generally serving its purpose</td>
<td>Stable, or for weirs: in good condition</td>
</tr>
<tr>
<td>Benchmarks</td>
<td>All destroyed</td>
<td>At least one intact</td>
<td>At least one intact on a solid object such as a bridge or bedrock or at least two intact with higher risk of movement</td>
</tr>
<tr>
<td>Vegetation</td>
<td>Overgrown so that gauges cannot be read properly</td>
<td>Cleared and neat</td>
<td>Cleared and neat</td>
</tr>
<tr>
<td>Siltiation</td>
<td>Silt prevents gauges from being read</td>
<td>Clean</td>
<td>Clean</td>
</tr>
<tr>
<td>High flow gauging (if necessary)</td>
<td>No suitable site for high flow gauging in vicinity</td>
<td>Suitable bridge nearby, or traverse or cableway in need of repair nearby</td>
<td>Suitable bridge nearby or traverse or cableway in good condition nearby</td>
</tr>
<tr>
<td>Access</td>
<td>Very challenging: road and/or path in extremely bad condition which limits visits to the station</td>
<td>Reasonable under the circumstances</td>
<td>Good road and path to station</td>
</tr>
<tr>
<td>Last gauging to check rating curve</td>
<td>Last gauging done more than 5 years ago</td>
<td>Last gauged within last 5 years</td>
<td>At least one gauging done in the last year</td>
</tr>
<tr>
<td>Gauge reader</td>
<td>Stopped work or vacant post</td>
<td>Reading gauges twice per day</td>
<td>Reading gauges twice per day</td>
</tr>
</tbody>
</table>

Source: Assessment of the status of the hydrometric monitoring network in Malawi by Aurecon (2011 and 2013)
Of all stations in the three regions that were visited, 45% were in a bad condition (that is, either not producing data at all or producing data of unacceptable quality). 25% were in an average condition (producing data of uncertain quality but which may be acceptable), and only 30% were in good condition (producing data of acceptable quality). For the Southern Region the situation was more or less comparable (see Table 36).

Table 36: Status of hydrometric stations in the Shire Basin

<table>
<thead>
<tr>
<th>District</th>
<th>District Open</th>
<th>Visited</th>
<th>Not visited</th>
<th>Total Open</th>
<th>Closed</th>
<th>Open &amp; Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poor</td>
<td>Average</td>
<td>Good</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blantyre</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>11</td>
<td>13</td>
<td>24</td>
</tr>
<tr>
<td>Ngabu</td>
<td>7</td>
<td>2</td>
<td></td>
<td>9</td>
<td>18</td>
<td>27</td>
</tr>
<tr>
<td>Thyolo</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>10</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>Zomba (Blantyre)</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>9</td>
<td>14</td>
<td>23</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>22</strong></td>
<td><strong>3</strong></td>
<td><strong>12</strong></td>
<td><strong>5</strong></td>
<td><strong>41</strong></td>
<td><strong>59</strong></td>
</tr>
</tbody>
</table>

Source: Assessment of the status of the hydrometric monitoring network in Malawi by Aurecon (2011 and 2013)
The hydrometric stations in the Shire River Basin are shown in Figure 67.

**Figure 67: Hydrometric stations in the Shire River Basin**

Major problems affecting the quality of the hydrometric stations as reported by Aurecon (2011) are:

- Vandalism (theft of angle irons, staff gauge plates etc.);
- Flood damage to staff gauge plates;
- Lack of general maintenance (for example, silting of the gauge plates so that they unreadable or overgrowth of vegetation);
- Access problems due to lack of maintenance of access paths and roads;
- Insufficient current meterings (gaugings) to update rating curves;
- Long periods since high flows were gauged resulting in low confidence in high flow portions of the rating curves for stations; and
- Compensation issues to gauge readers, which has resulted in gaps in readings and low quality of readings.

### 9.6 Meteorology

#### 9.6.1 Rainfall

Figure 68 shows the average monthly rainfall over the Shire River Basin. Estimated average monthly rainfall for the defined sub-basins is given in Table 37.

**Table 37: Average monthly rainfall in the sub-basins**

<table>
<thead>
<tr>
<th>SUB-BASIN</th>
<th>AREA (km²)</th>
<th>J (mm)</th>
<th>F (mm)</th>
<th>M (mm)</th>
<th>A (mm)</th>
<th>J (mm)</th>
<th>J (mm)</th>
<th>A (mm)</th>
<th>S (mm)</th>
<th>E (mm)</th>
<th>N (mm)</th>
<th>D (mm)</th>
<th>YEAR (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivi Rivi</td>
<td>4798</td>
<td>229</td>
<td>178</td>
<td>141</td>
<td>46</td>
<td>9</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>18</td>
<td>64</td>
<td>176</td>
</tr>
<tr>
<td>Lisungwe</td>
<td>4124</td>
<td>236</td>
<td>188</td>
<td>152</td>
<td>51</td>
<td>15</td>
<td>9</td>
<td>11</td>
<td>6</td>
<td>6</td>
<td>24</td>
<td>77</td>
<td>182</td>
</tr>
<tr>
<td>Wamkulumadzi</td>
<td>3375</td>
<td>216</td>
<td>173</td>
<td>139</td>
<td>50</td>
<td>17</td>
<td>14</td>
<td>16</td>
<td>9</td>
<td>8</td>
<td>25</td>
<td>77</td>
<td>170</td>
</tr>
<tr>
<td>Mwanza</td>
<td>5147</td>
<td>197</td>
<td>152</td>
<td>127</td>
<td>49</td>
<td>20</td>
<td>19</td>
<td>20</td>
<td>10</td>
<td>9</td>
<td>23</td>
<td>69</td>
<td>170</td>
</tr>
<tr>
<td>Thangadzi</td>
<td>1467</td>
<td>195</td>
<td>149</td>
<td>123</td>
<td>45</td>
<td>19</td>
<td>19</td>
<td>18</td>
<td>9</td>
<td>8</td>
<td>24</td>
<td>68</td>
<td>175</td>
</tr>
<tr>
<td>Ruo</td>
<td>3519</td>
<td>278</td>
<td>225</td>
<td>212</td>
<td>94</td>
<td>36</td>
<td>31</td>
<td>35</td>
<td>20</td>
<td>17</td>
<td>41</td>
<td>104</td>
<td>237</td>
</tr>
<tr>
<td>Shire Basin</td>
<td>22430</td>
<td>226</td>
<td>179</td>
<td>149</td>
<td>56</td>
<td>19</td>
<td>15</td>
<td>17</td>
<td>9</td>
<td>8</td>
<td>25</td>
<td>76</td>
<td>184</td>
</tr>
</tbody>
</table>

Source: Calculated by NIRAS from data downloaded from WorldClim.org

There are significant differences in rainfall among the sub-basins. The Ruo sub-basin experiences highest rainfall in all months, triggered by the Mulanje massif.

Annual rainfall in the Shire Basin for hydrological years during the period October 1960 to September 2009 is shown in Figure 70. The average annual rainfall in the basin is estimated at 965 mm/year, with a coefficient of variation of 16%. The minimum annual rainfall of 583 mm/year occurred in 1991-92. In addition, the years 1993-94 and 1994-95 were also very dry. No data is available as the year is not yet complete, but it would appear that 2015-16 will be also much below average in rainfall.
Figure 68: Mean annual rainfall over the Shire Basin
9.6.2 Evapotranspiration

Average monthly evapotranspiration estimates (ETo) for the Shire sub-basins are presented in Table 38. The seasonal variations shown in Figure 71 indicate quite similar patterns.
Table 38: Average monthly ET₀ values for the sub-basins

<table>
<thead>
<tr>
<th>SUB-BASIN</th>
<th>AREA km²</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
<th>YEAR mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivi Rivi</td>
<td>4798</td>
<td>129</td>
<td>115</td>
<td>123</td>
<td>115</td>
<td>109</td>
<td>95</td>
<td>102</td>
<td>128</td>
<td>155</td>
<td>185</td>
<td>166</td>
<td>138 1559</td>
</tr>
<tr>
<td>Lisungwe</td>
<td>4124</td>
<td>129</td>
<td>116</td>
<td>124</td>
<td>117</td>
<td>110</td>
<td>96</td>
<td>103</td>
<td>129</td>
<td>158</td>
<td>187</td>
<td>168</td>
<td>139 1576</td>
</tr>
<tr>
<td>Wamkulumadzi</td>
<td>3375</td>
<td>132</td>
<td>119</td>
<td>128</td>
<td>120</td>
<td>113</td>
<td>99</td>
<td>106</td>
<td>132</td>
<td>162</td>
<td>193</td>
<td>175</td>
<td>144 1624</td>
</tr>
<tr>
<td>Mwanza</td>
<td>5147</td>
<td>137</td>
<td>124</td>
<td>135</td>
<td>124</td>
<td>117</td>
<td>103</td>
<td>109</td>
<td>136</td>
<td>168</td>
<td>200</td>
<td>184</td>
<td>151 1687</td>
</tr>
<tr>
<td>Thangadzi</td>
<td>1467</td>
<td>138</td>
<td>125</td>
<td>137</td>
<td>126</td>
<td>119</td>
<td>104</td>
<td>111</td>
<td>137</td>
<td>170</td>
<td>203</td>
<td>187</td>
<td>153 1710</td>
</tr>
<tr>
<td>Ruo</td>
<td>3519</td>
<td>127</td>
<td>113</td>
<td>120</td>
<td>114</td>
<td>108</td>
<td>94</td>
<td>101</td>
<td>127</td>
<td>154</td>
<td>183</td>
<td>163</td>
<td>135 1540</td>
</tr>
<tr>
<td>Shire Basin</td>
<td>22430</td>
<td>132</td>
<td>118</td>
<td>127</td>
<td>119</td>
<td>112</td>
<td>98</td>
<td>105</td>
<td>131</td>
<td>160</td>
<td>191</td>
<td>173</td>
<td>143 1608</td>
</tr>
</tbody>
</table>

Source: Calculated by NIRAS from data downloaded from WorldClim.org

Figure 71: Seasonal variation of ET₀

Source: Calculated by NIRAS from data downloaded from WorldClim.org

9.7 Runoff

9.7.1 Shire River

The discharge of the Shire River at three stations is shown in Figure 72. This discharge consists of the outflow from Lake Malawi and the inflow from the various tributaries in the Shire Basin.
Based on the available discharge data from gauging stations on the tributaries of the Shire River the month with lowest runoff is October with an average runoff of less than 2 mm/month (based on an area weighted average of 17 stations), which is equivalent to some 14 m$^3$/s for WRA 1.

Subtracting a discharge in the order of 10 m$^3$/s from the Chickwawa and Chiromo hydrographs at their annual lows would give an approximate estimate of the Liwonde discharges at the end of the dry season. From Figure 72 it appears that from 1995 onwards there is an unexplained gap between the Liwonde discharges and the Chickwawa and Chiromo discharges of some 200 to 300 m$^3$/s. NORPLAN (2013) adjusted the Liwonde rating curve after the 2003 peak. However, this correction resulted in an even larger unexplained gap with the Chickwawa and Chiromo hydrographs.

In view of the large consequences of incorrectly estimated outflows from the Liwonde barrage on earlier studies and future studies it is strongly recommended to review the rating curves and discharges of all hydrometric stations on the Shire River. According to Atkins (2011) there have been several major studies of the accuracy of the flow data from the Liwonde station 1B1 and it was concluded that the records are of good quality. However, if that is the correct conclusion then the records of both Chichwawa and Chiromo, which more or less seem consistent between one another, started to show a large gap with the Liwonde flows when these were drastically reduced at the Kamuzu Barrage. In that case not even the order of magnitude of the flows at Chickwawa and Chiromo would be correct.

### 9.7.2 Tributaries

For water resources planning in the Shire Basin long-term discharge records are needed, covering a period of 30 years or more. The only tributary in the basin having a long discharge record is the Rivirivi station at Balaka (Figure 73). Most other stations have rather short records.
9.7.3 Sub-basins

Rainfall-runoff modelling undertaken by NIRAS (reported in NIRAS 2015e) has produced estimates for the total runoff for each sub-basin. These are shown in Table 39 and Figure 74. The differences between the sub-basins are quite substantial, with lowest runoff in the Thangadzi and highest runoff in the Ruo sub-basin.

The variation coefficient of the annual runoff is 47% which seems very high but of the same order as the variation coefficient of the Rivirivi River at Balaka (see Figure 73).

Table 39: Average monthly runoff in the Shire sub-basins

<table>
<thead>
<tr>
<th>SUB-BASIN</th>
<th>Area</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivirivi</td>
<td>4798</td>
<td>24</td>
<td>37</td>
<td>41</td>
<td>16</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>140</td>
</tr>
<tr>
<td>Lisungwe</td>
<td>4124</td>
<td>25</td>
<td>41</td>
<td>49</td>
<td>19</td>
<td>9</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>154</td>
</tr>
<tr>
<td>Wamkulumadzi</td>
<td>3375</td>
<td>31</td>
<td>39</td>
<td>43</td>
<td>17</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>10</td>
<td>158</td>
</tr>
<tr>
<td>Mwanza</td>
<td>5147</td>
<td>25</td>
<td>28</td>
<td>32</td>
<td>13</td>
<td>5</td>
<td>3</td>
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<td>1</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>122</td>
</tr>
<tr>
<td>Thangadzi</td>
<td>1467</td>
<td>18</td>
<td>22</td>
<td>27</td>
<td>10</td>
<td>4</td>
<td>2</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>87</td>
</tr>
<tr>
<td>Ruo</td>
<td>3519</td>
<td>49</td>
<td>70</td>
<td>93</td>
<td>50</td>
<td>25</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td>327</td>
</tr>
<tr>
<td>Shire Basin</td>
<td>22430</td>
<td>29</td>
<td>40</td>
<td>48</td>
<td>21</td>
<td>9</td>
<td>5</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>167</td>
</tr>
</tbody>
</table>

Source: NIRAS rainfall-runoff modelling
Figure 74: Average monthly runoff in the sub-basins (mm)

Source: Computed from results of NIRAS rainfall-runoff modelling

9.8 Floods and Droughts

9.8.1 General

The Malawian economy is strongly depended on agriculture. According to World Bank sources agriculture accounts for one-third of the GDP, and almost 90% of its foreign exchange earnings, and 85% of its employment according. Since the majority of the Malawian population depends on agriculture, the impacts of droughts and floods are very severe.

Not only are rural livelihoods affected due to the severe impacts on the agricultural sector, but non-farm and urban households are also vulnerable given the strong production and price linkages between agriculture and the rest of the economy.

Over the past two decades, drought and flood events have increased in frequency, intensity and magnitude with negative consequences for sustainable livelihoods of rural communities RMSI (2009). Table 40 summarises the most severe floods and droughts that occurred during the last decades.\(^{53}\)

Table 40: Floods and droughts during the last decades and people affected

<table>
<thead>
<tr>
<th>Year</th>
<th>Total people affected</th>
<th>Year</th>
<th>Total people affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>268,000</td>
<td>1987</td>
<td>1,429,267</td>
</tr>
<tr>
<td>1997</td>
<td>400,000</td>
<td>1990</td>
<td>2,800,000</td>
</tr>
<tr>
<td>2001</td>
<td>500,000</td>
<td>1992</td>
<td>7,000,000</td>
</tr>
<tr>
<td>2002</td>
<td>246,340</td>
<td>2002</td>
<td>2,829,435</td>
</tr>
<tr>
<td>2003</td>
<td>81,604</td>
<td>2005</td>
<td>5,100,000</td>
</tr>
<tr>
<td>2007</td>
<td>180,246</td>
<td>2007</td>
<td>520,000</td>
</tr>
<tr>
<td>2015</td>
<td>106,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Report issued on 15 Jan 2015 by the Office of the Resident Coordinator

Out of the thirteen major disasters, six were caused by droughts and seven by floods. All caused significant hardship and loss of life and property in Malawi. It is not clear how accurate the data about total affected people are. Reportedly some of the data is likely to have been exaggerated, especially the older data.

9.8.2 Floods

The Shire Valley is regularly prone to floods that adversely affect local populations by causing loss of lives and destroying property including settlements, roads, rail and other national infrastructure. In terms of affected population and households, Nsanje and Chikwawa are the districts most affected.

On average 26,000 people and 6,000 households were likely to be affected by flood due to inundation each year. Average annual loss for households was found to be USD 6.5 million. Out of this, traditional type was USD 2.1 million. On average, about 8% of area and 12% of production is lost due to floods for maize crop. For tobacco, these figures are 6% and 9% respectively.

The floods in the floodplains of Lower Shire are generally caused by flash floods resulting from high intensity rainstorms (cloudbursts) in the various catchment areas of tributaries. These floods can be very destructive along their paths towards the flood plains of the Shire River where areas are flooded for longer durations. In some cases these flood events are aggravated by backwater of the Shire River.

54 Surveys conducted by the Department of Surveys using satellite imagery captured at the time of the floods of January 2015 indicated that this figure may be a significant overestimate.
9.8.3 Return period January 2015 flood

The flood that occurred in the lower Shire Basin in January 2015 was one of the most destructive floods in recent history affecting 15 districts. The graphic shown in Figure 75 is based on a satellite image taken on 13 January 2015. The image only shows areas with standing water at the time that the satellite image was taken, so many areas that were hit by the flash floods travelling downstream along the tributaries and causing much damage are not captured in the satellite image. Also parts of the Elephant Marsh where wetland vegetation is dominant (coloured blue in Figure 75) do not show up in the image.

Figure 75: Flooding in January 2015

Note: Red colour indicates standing water
Source: Department of Surveys

A detailed direct analysis of the recurrence period of the January 2015 has been hampered by the limited data on flooded areas in the past. Therefore, use was made of the rainfall records leading to the January flooding events. It appears that the peak rainfall occurred on January 12 with an observed maximum rainfall of almost 400 mm on 12 January in Chichiri. However, also the rainfall on the day before and the day after the maximum rainfall in
January appeared quite substantial and decisive for the maximum flooding extend on 13 January.

For Makoka, Chileka, Bvumbwe, Mimosa, Tyola and Ngabu, daily rainfall data were obtained for the 31-year period 1970-2000 and based on these data annual series were prepared for durations of 1 day up to 7 days. Using the Gumbel\textsuperscript{55} extreme value distribution subsequently the rainfall for these durations for different return periods ranging from 2 to 500 years were estimated. The results are given in Figure 76.

**Figure 76: Rainfall for different durations and return periods**

It can be seen that the differences among the stations is quite large, with highest rainfall at Mimosa. Comparing the observed rainfall data in January 2015 with the rainfall data at different return periods for different durations, it appears that four out of six stations had observed rainfall amounts that correspond with return periods between 200 to more than 500 years. Only two stations appeared to have return periods between 50 and 100 years (Chileka) and even as low as 5 to 10 years (Ngabu).

In summary, it is concluded that the rainfall resulting in the large January 2015 flood in the Lower Shire basin was exceptionally high. Based on the relatively short observation periods of 31 years it would be very speculative to estimate the return period more precisely than say 300 years plus or minus 200 years.

\textsuperscript{55} The analysis was repeated using the Log Pearson Type III distribution and the results were very similar.
Using more accurate terrain maps now available the flood modelling could be improved. Nevertheless the modelling for large return periods is questionable in view of uncertainties related to extreme value distributions based on limited observations.

### 9.8.4 Droughts

Two types of drought cells affect Malawi: the first originates in Namibia and covers Botswana, Zimbabwe, Southern Zambia and extends into southern Malawi and northwest Malawi; the second drought cell has its centre in Southern Malawi and Southern Zambia and extends outwards. Almost all droughts in Malawi have occurred during ENSO (El Niño Southern Oscillation) years (RMSI, 2009). Note that the below average rainfall over the 2015-16 growing season was as a result of an El Niño event^{56}.

Droughts have been observed to increase poverty by 1.3 percentage points, but this rises to almost 17 percentage points during a 1-in-25 year drought (roughly equal to an additional 2.1 million people falling below the poverty line). Models estimate that floods may cause an average GDP loss of almost 1% every year, while during periods of drought, economic losses are found to be much higher. Floods cause annual losses of about 12% of maize production in the south, where about one-third of Malawi's maize is grown.

### 9.8.5 Standardised Precipitation Index

Since rainfall varies significantly among different regions, the concept of drought may differ from place to place. For a more effective assessment of the drought phenomena, the World Meteorological Organization (WMO) recommends adopting the Standardized Precipitation Index (SPI) to monitor the severity of drought events.

In simple terms, the SPI is a normalized index representing the probability of occurrence of an observed rainfall amount when compared with the rainfall climatology at a certain geographical location over a long-term reference period. Negative SPI values represent rainfall deficit, whereas positive SPI values indicate rainfall surplus. Intensity of drought event can be classified according to the magnitude of negative SPI values such that the larger the negative SPI values are, the more serious the event would be.

Moreover, SPI enables rainfall conditions to be quantified over different time scales (for example, 3, 6, 12, or 24 month rainfall), facilitating the analyses of drought impact on various water resource needs. For example, SPI-3 measures rainfall conditions over a 3-month period, the anomalies of which impact mostly on soil water conditions and agricultural produce; while SPI-24 measures rainfall conditions over two years, as prolonged droughts can give rise to shortfalls in groundwater, stream flow and fresh water storage in reservoirs.

An advantage in using SPI is that only rainfall data are needed for its computation. SPI can also be compared across regions of different climatic zones. A classification of SPI values is given in Table 41.

With respect to the production rain fed crops, the rainfall in the wet season is obviously of most interest. For the different sub-basins SPI-6 values were computed for the wet season (November to April). The rainfall time series

^{56} See: http://www.wmo.int/pages/prog/wcp/wcasp/enso_update_latest.html
for each sub-basin are based on the WRU time series for the period 1960 – 2009. Results are shown in Figure 77.

**Table 41: Classification by SPI values**

<table>
<thead>
<tr>
<th>Classification</th>
<th>SPI Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme Drought</td>
<td>&lt; -2.0</td>
</tr>
<tr>
<td>Severe Drought</td>
<td>2.0 to -1.5</td>
</tr>
<tr>
<td>Moderate Drought</td>
<td>1.5 to -1.0</td>
</tr>
<tr>
<td>Minor Drought</td>
<td>1.0 to -0.5</td>
</tr>
<tr>
<td>Normal</td>
<td>0.5 to 0.5</td>
</tr>
<tr>
<td>Wet Conditions</td>
<td>&gt; 0.5</td>
</tr>
</tbody>
</table>

**Figure 77: SPI-6 values for the wet season in the different sub-basins for the period 1960-2009**

The number of severe and extreme droughts observed in the sub-basins during the 50-year period are summarised in Table 42.

**Table 42: Number of severe and extreme droughts experienced in the sub-basins during 1960 - 2009**

<table>
<thead>
<tr>
<th>Sub-basin</th>
<th>Severe floods</th>
<th>Extreme floods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivirivi</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Lusungwe</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Wamkulumadzi</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Mwanza</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Thangadzi</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Ruo</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
The Lusungwe and Wamkulumadzi sub-basins seem to have experienced the worst droughts. By far the worst drought occurred in 1992. For all sub-basins this was the worst drought experienced in the period of record, between 1960 and 2009.

### 9.8.6 Return period of severe droughts

Estimated return periods for severe droughts (SPI = -1.5) are given in Table 43. Also from this table Wamkulumadzi and Lusungwe appear to experience the most frequent severe droughts whereas Langadzi is affected least.

<table>
<thead>
<tr>
<th>Sub-basin</th>
<th>Return period severe drought (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivirivi</td>
<td>18</td>
</tr>
<tr>
<td>Lusungwe</td>
<td>13</td>
</tr>
<tr>
<td>Wamkulumadzi</td>
<td>9</td>
</tr>
<tr>
<td>Mwanza</td>
<td>24</td>
</tr>
<tr>
<td>Thangadzi</td>
<td>51</td>
</tr>
<tr>
<td>Ruo</td>
<td>15</td>
</tr>
</tbody>
</table>

### 9.9 Groundwater

#### 9.9.1 Geology of the basin

Malawi is generally classified into seven geologic systems that include the Precambrian basement complex, igneous intrusions of the Basement Complex, Permo-Triassic Karoo Sedimentary, Jurassic Karoo Volcanics, Mesozoic Chilwa Alkaline Province, Cretaceous-Pleistocene Sedimentary rocks and Quaternary Alluvium. The lower part of the Shire River Basin is mainly within the Quaternary Alluvium, while the upper part is within the basement complex.

The Shire River Basin is part of the East African rift system. The rift consists of eastern and western branches that dissect the entire eastern part of Africa. The Malawi rift, which is a southern extension of the western branch of the Rift System, extends 900 km from the Rungwe volcanism in Tanzania to the Urme graben in Mozambique. In Malawi, it is a single linear zone of extensive "en echelon" down-faulting, occupied by Lake Malawi, Lake Malombe and the Shire River.

Figure 78 illustrates a schematic cross-section of the lower Shire basin showing the effects of the faults within the basin.
9.9.2 Hydrogeological characteristics

Malawi has three major aquifer systems. namely:

- The extensive but low yielding weathered Precambrian Basement Complex (WB) aquifer of the plateau area (1-2 l/s);
- The high yielding alluvial aquifer of the lake shore plains and the Lower Shire Valley and the Lake Chilwa - Mphalombe Plain (QA) (>15 l/s);
- The medium yielding aquifer of the fracture zone in the rift valley escarpment (FB) (5-7 l/s).

The Shire River Basin is dominated by three aquifer types: weathered basement (WB), quaternary alluvium (QA) and fractured basement (FB). The extent of the three aquifer types are shown on Figure 79.

The Pre Cambrian Basement Complex Aquifer or the Weathered Basement (WB) is a direct result of the prolonged in situ weathering of the crystalline basement rocks, which has produced a layer of unconsolidated saprolite material; and it is this that forms an important source for rural domestic water requirements. The weathered zone is best developed over the plateau areas where it is commonly 15-30 m thick, and locally even thicker. Towards the crests of the escarpment the thickness of the weathered rock aquifer tends to be reduced in these areas. It also thins towards bedrock outcrops. The saprolite thickness tends to be greatest along fracture zones. Groundwater is commonly first struck near the base of the clays and usually rises (sometimes by several metres) before rest water level is found.

The fresh bedrock underlying the weathered zone is rarely a significant aquifer, except where extensively fractured, as the available storage is negligible in the rock matrix and likely to be low in the fractures. Although there are many old boreholes that have been drilled to considerable depths into fresh bedrock on the plateau areas (often reaching 50-70 m), these rely largely on storage in the overlying weathered zone.

The quaternary alluvium (QA) aquifer is highly variable in character in both vertical sequence and lateral extent. It occurs in several basins, which apart from Lake Chilwa, are all located along the Upper Shire Valley and Lower Shire Valley. The Quaternary alluvial deposits can be important areas for groundwater storage and generally form a good resource for water supply.
Figure 79: Aquifer types in Shire River Basin

Legend
- Cities and towns
- Rivers
- Waterbodies

Boundaries
- International
- Regional
- WRU

Aquifer Types
- FR
- CA
- WB

10 0 10 20 30 40 50 km

Mozambique
9.9.3 Hydrogeological data

The groundwater monitoring network in the Shire River Basin is shown in Figure 80. Unfortunately monitoring has taken place sporadically and so records are patchy at best.

Figure 80: Groundwater monitoring network

For many years in Malawi groundwater data was stored on Cardex cards, which recorded borehole records of drilling and pumping tests. Groundwater data has been available in two separate systems, namely WISH and HYDSTRA. Windows Information System for Hydrogeologists (WISH) was a
A groundwater data management module of the HYDSTRA system has been developed and a licence is available for the Groundwater Section to store and manage groundwater data. However, there appear to have been issues with the development of the software and the migration of the historic datasets to the HYDSTRA system.

The main challenges with respect to data are:

- Obtaining data on a regular basis. Ensuring that the data is in the right format and the location and time is correctly noted;
- Understanding the information gathered and how to best correlate and store that data;
- Understanding how the data should be used and made available for the relevant organisations.

At present, Malawi has a total of 35 groundwater monitoring wells (including twelve in the Shire River Basin), out of which only 30 are functional (examples shown in Figure 81 and Figure 82). Automatic recorders have been installed at many sites in this monitoring network. Regular visits are supposed to be made to the sites every three months to download data and check on the condition of the borehole and attend to any maintenance issues.

There are at present about 30,000 boreholes and 8,000 protected production wells in Malawi. The MAIWD is in the final stages of developing a map showing the distribution of boreholes in the country.
9.9.4 Borehole yields

Borehole yields, defined as the volume of water that can be abstracted from a borehole, in the Shire catchment (WRA 1 and 14) vary from nil or negligible to as high as 43 l/s or 1.35 million m³/year (see Error! Reference source not found. and Figure 82).

Data from 2086 boreholes from a master database of borehole logs developed by Atkins in 2011 – and provided by MAIWD – were used to generate a spatial distribution of borehole yields in the basin. Borehole yields are very dependent on aquifer type. The highest yielding aquifers are the Quaternary alluvium (QA) and weathered basement (WB) with average yields of 0.53 l/s and 0.73 l/s. The Karoo sedimentaries (KS) is a minor aquifer located in the western part of the area with lower average yields of 0.27 l/s and small maximum yields. Yields will vary considerably within the same aquifer depending on weathering, fracturing and the location of fault zones. A map of borehole yields shows that a few boreholes (13) with very high yields (5-43 l/s) are found in the fractured basement (FB). However, the majority of wells (83%) have yields below 1 l/s.

It appears that the mean yields for the three aquifers are very similar, which given the different hydrogeological properties, is unusual. It is thought that the recorded yields are largely a function of borehole equipment and the nature of the yield testing procedure. Due to this observation potential yields for each aquifer were estimated from experience and from single aquifer
tests. mainly in the alluvial aquifers in the Shire River Basin. The values are included in Error! Reference source not found.. Potential yields are assessed to be between 2 and 10 l/s in the quarternary alluvium but much lower in the other aquifers.

The total number of boreholes in each WRU indicates that groundwater exploitation is most prevalent in WRUs 1A (QA), 14B (WB) and 1H (QA). The database of boreholes used in the analysis is by no means a complete dataset of all abstraction wells, which means that this is not a representation of present groundwater abstraction. Total yield for the catchment for the wells as a whole is approximately 40 million m$^3$/year, which is significantly lower than total estimated rural demands of around 50 million m$^3$/year.

Table 44: Borehole yields summary data (l/s)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Total Abstraction</th>
<th>Mean (l/s)</th>
<th>Minimum (l/s)</th>
<th>Maximum (l/s)</th>
<th>No. of boreholes</th>
<th>Potential yield*</th>
</tr>
</thead>
<tbody>
<tr>
<td>FB</td>
<td>193</td>
<td>0.48</td>
<td>0.01</td>
<td>25.00</td>
<td>401</td>
<td>1.5</td>
</tr>
<tr>
<td>KS</td>
<td>7</td>
<td>0.27</td>
<td>0.03</td>
<td>0.64</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>QA</td>
<td>501</td>
<td>0.53</td>
<td>0.01</td>
<td>33.83</td>
<td>940</td>
<td>2-10</td>
</tr>
<tr>
<td>WB</td>
<td>521</td>
<td>0.73</td>
<td>0.01</td>
<td>42.70</td>
<td>718</td>
<td>1</td>
</tr>
</tbody>
</table>

* From: Atkins. 2011

FB ~ Fractured Basement. KS ~ Karoo Sedimentaries. QA ~ Quarternary Alluvium and WB ~ Weathered Basement
9.9.5 Groundwater abstraction

Groundwater resources within Shire River Basin are mostly used for domestic water supply and irrigation of farming areas in *dambo* areas (shallow wetland areas). Boreholes and shallow wells respectively fitted with Afridev and Malda hand pumps are used extensively for rural groundwater supply (Figure 83). Each borehole is designed to serve a total of 250 people at a per capita consumption of 36 litres per day within a walking distance of 500m radius, whereas a typical production well caters for 125 people.
However, urban centres such as Ngabu and Chikwawa also get their water supply from groundwater. It is envisaged that more rural areas and towns in Malawi will get their water supplies from groundwater resources in future because of the unsustainability of flows in rivers that are currently abstracted to sustain gravity fed rural piped water schemes and urban water supply and the resilience of groundwater to climate change.

Figure 83: Afridev hand pump fitted on a borehole

Groundwater use for irrigated agriculture is at present mostly confined to growing vegetables and maize in dambo areas during the dry season. In most cases, water is drawn from hand-dug wells and applied to crops using watering cans. But the advent of treadle pumps has seen the proliferation of these devices for irrigated agriculture in dambo areas. The Ngolowindo Irrigation Scheme in Salima District is the major scheme in Malawi that is supplied from groundwater.

Detailed studies on the assessment of groundwater potential for irrigated agriculture were done in 1980 by Huntsing Technical Services Limited of UK (Ministry of Agriculture and Natural Resources57, 1980), targeting Quaternary Alluvial aquifers of the lakeshore plain and the Lower Shire Valley. The study showed that alluvial aquifers in the Lower Shire Valley have great potential for irrigation. However, so far only Ngolowindo Irrigation Scheme uses groundwater on a large scale. Thus, groundwater potential has not been fully exploited for irrigated agriculture in the country.

A number of farmers use groundwater for livestock production. In addition, the government has also drilled several boreholes in national parks to supply water to wild animals, including those located in the Shire River Basin, namely: Liwonde National Park, Lengwe National Park and Majete

57 Now the Ministry of Agriculture, Irrigation and Water Development.
Game Reserve. All this confirms that groundwater in Malawi is suitable for domesticated and wild animals.

Groundwater use for industrial development is very limited in the Shire River Basin. From the assessments of groundwater availability and quality that have been done so far, the water is generally suitable for industrial production.

9.10 Challenges to Water Management

Climate change (covered in Chapter 10) will have an important effect on the water users and the water management practices. The District Water Officers are responsible for efficient water management in the Districts, including the balancing of water supply and demand, environmental protection, and the preparation of district development plans. One of the questions the water managers are faced with is what modifications might be necessary to adapt to climate change.

It should also be realised that all stages of major water resources development projects, from planning and design to construction, may take as long as 20 to 30 years. Hence, any climate change impact on the water resources might have consequences for the feasibility or viability of possible water resources developments, as well as on the design. Current engineering design practices should be modified since many are based on the magnitude of events that occur at specific return periods, based on the statistics of historic records but these may no longer be valid for future conditions.

Mainstreaming climate change risk management in the activities of various government departments seems imperative for the sustainability of its already implemented or planned infrastructural assets.

Of course, in the Shire River Basin water management is closely linked with land management and, as was discussed in Chapter 8, poor land management in the past and continuing at present due to population pressures have had considerable impact on the hydrology, hydrogeology and water quality of the basin and these will not be further elaborated here.

In addition, getting effective and sustainable monitoring networks in place in order to have timely and reliable data available for analysis and for supporting water resource management decisions will also be critical. The Atkins consultancy, as part of the SRBMP, will provide the hardware, software and training of government staff to achieve this, but a strong commitment from the agencies involved will be required if the monitoring effort is to be effectively maintained.
### 9.11 Indicators – Water Resources

The following indicators in table 45 are proposed for key characteristics related to water resources.

#### Table 45: Indicators – water resources

<table>
<thead>
<tr>
<th>Key Area</th>
<th>Indicator</th>
<th>Estimated Value for 2015</th>
<th>Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water resource monitoring</td>
<td>Number of operational stations in the meteorological network</td>
<td>Yet to be determined</td>
<td>DCCMS</td>
</tr>
<tr>
<td></td>
<td>Number of operational gauging (surface water monitoring) stations</td>
<td>Yet to be determined</td>
<td>DWR</td>
</tr>
<tr>
<td></td>
<td>Number of operational groundwater monitoring bores</td>
<td>Yet to be determined</td>
<td>DWR</td>
</tr>
<tr>
<td>Hydrology</td>
<td>Average yearly discharge from Kamuzu Barrage</td>
<td>Yet to be calculated</td>
<td>ESCOM</td>
</tr>
<tr>
<td></td>
<td>Average yearly streamflow of Shire River upstream of Ruo confluence</td>
<td>Yet to be calculated</td>
<td>DWR</td>
</tr>
<tr>
<td></td>
<td>Average yearly streamflow of Ruo River upstream of Shire confluence</td>
<td>Yet to be calculated</td>
<td>DWR</td>
</tr>
<tr>
<td></td>
<td>Average yearly streamflow of Shire River at Nsanje</td>
<td>Yet to be calculated</td>
<td>DWR</td>
</tr>
<tr>
<td>Flooding</td>
<td>Number of dwellings in flood-prone areas (return period &lt; 5 years)</td>
<td>Yet to be calculated</td>
<td>DWR</td>
</tr>
<tr>
<td></td>
<td>Yearly total lives lost due to flooding</td>
<td>Yet to be calculated</td>
<td>DODMA</td>
</tr>
<tr>
<td></td>
<td>Yearly economic flood damages</td>
<td>Yet to be calculated</td>
<td>DODMA</td>
</tr>
</tbody>
</table>
10 Climate Change

10.1 Climate Change Scenarios

In the thematic assessment of climate change prepared by NIRAS as part of Subcomponent A1, the impacts of climate change on the local hydrological conditions in the Shire basin are discussed in considerable detail and will not be repeated in this report.

Human induced climate change is caused by Green House Gas (GHG) emissions. In the IPCC Special Report on Emissions Scenarios (IPCC, 2000) four scenario families are described, (A1, A2, B1 and B2), which explore alternative development pathways, covering a wide range of demographic, economic and technological driving forces and resulting GHG emissions. The scenario “storylines”, which form the basis for many studies of projected climate change and water resources, consider a range of plausible changes in population and economic activity over the 21st century (see Figure 84).

Figure 84: Summary characteristics of the four SRES storylines

<table>
<thead>
<tr>
<th>Economic emphasis</th>
<th>Global Integration</th>
<th>Environmental emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A1</strong></td>
<td>World: market oriented&lt;br&gt;Economy: fastest per capita growth&lt;br&gt;Population: 2050 peak, then decline&lt;br&gt;Governance: strong regional interactions; income convergence&lt;br&gt;Technology: 3 scenario groups&lt;br&gt;* A1F: fossil intensive&lt;br&gt;* A1T: non-fossil energy sources&lt;br&gt;* A1B: balanced across all sources</td>
<td>World: convergent&lt;br&gt;Economy: service and information based; lower growth than A1&lt;br&gt;Population: same as A1&lt;br&gt;Governance: global solutions to economic, social and environmental sustainability&lt;br&gt;Technology: clean and resource-efficient</td>
</tr>
<tr>
<td><strong>A2</strong></td>
<td>World: differentiated&lt;br&gt;Economy: regionally oriented; lowest per capita growth&lt;br&gt;Population: continuously increasing&lt;br&gt;Governance: self-reliance with preservation of local identities&lt;br&gt;Technology: slowest and most fragmented development</td>
<td></td>
</tr>
</tbody>
</table>

NIRAS (2015). Thematic Assessment: Climate Change
The A1 storyline assumes a world of very rapid economic growth – a global population that peaks in mid-century and rapid introduction of new and more efficient technologies. A1 is divided into three groups that describe alternative directions of technological change: fossil intensive (A1FI); non-fossil energy resources (A1T); and a balance across all sources (A1B). B1 describes a convergent world, with the same global population as A1, but with more rapid changes in economic structures toward a service and information economy. B1 describes a world with intermediate population and economic growth, emphasising local solutions to economic, social, and environmental sustainability.

A2 describes a very heterogeneous world with high population growth, slow economic development and slow technological change. B2 describes a world in which the emphasis is on local solutions to achieving economic social, and environmental sustainability. It is a heterogeneous world with less rapid and more diverse technological change but a strong emphasis on community initiative and social innovation to find local, rather than global solutions. No likelihood has been attached to any of the SRES scenarios.

Among the scenarios that assume a world economy dominated by global trade and alliances (A1 and B1), global population is expected to increase from today’s 6.6 billion and peak at 8.7 billion in 2050, while in the scenarios with less globalisation and co-operation (A2 and B2), global population is expected to increase until 2100, reaching 10.4 billion (B2) and 15 billion (A2) by the end of the century.

The above emissions projections are widely used in the assessments of future climate change and their underlying assumptions with respect to socio-economic, demographic and technological change serve as inputs to many recent climate change vulnerability and impact assessments.

For this climate change studies conducted by NIRAS, results were downloaded from Climate Wizard for three scenarios: A2, A1B, and B1 – representing high, moderate and low carbon emissions respectively. This is considered to give the breadth of probable future outcomes needed for a robust scenario analysis during the Shire River Basin planning process.

## 10.2 Impact on Water Resources

### 10.2.1 Approach

Apart from the predicted future changes in temperature the major changes that are relevant to the hydrological conditions are the changes in rainfall and potential evapotranspiration. Once these changes are estimated the changes in runoff can be estimated through rainfall-runoff modelling.

To estimate changed conditions in the Shire River basin three areas are distinguished for which GCM outputs were downloaded and analysed:

- Catchment area draining to Lake Malawi;
- Lake Malawi surface;
- Shire Basin downstream of Lake Malawi.
10.2.2 Rainfall and potential evapotranspiration

For potential evapotranspiration and rainfall, the projections are shown in Figure 85, for the three respective areas.

Figure 85: Changes in $E_{\text{pot}}$ and rainfall for different areas and scenarios (base case = 100%)
The most pronounced changes in potential evapotranspiration are observed for the A1B and A2 emission scenarios in the area draining to Lake Malawi and the Lake area proper. The scenario differences in the downstream Shire River Basin are much less.

The predicted changes in rainfall are highest for the A2 scenario in the area draining to Lake Malawi and the lake area proper. For the Shire River Basin this picture is completely different. The predicted changes in this area are much less, with hardly any changes in the A1B and A2 scenarios and highest change in the B1 scenario.

10.2.3 Runoff

For the Shire River Basin downstream of Lake Malawi, the SMAP rainfall-runoff model was used to generate monthly runoff time series for each WRU for the 50-year period 1960-2009. The time series of areal rainfall and potential evapotranspiration prepared by Atkins (2011) were used. The model was calibrated for all WRUs. Using the change fields for rainfall and potential evapotranspiration predicted by the GCMs the runoff time series were estimated similarly to the runoff time series for the area draining to Lake Malawi. The results are shown in Figure 86.

The predicted changes in runoff differ substantially comparing the area draining to Lake Malawi and the Shire River Basin downstream (Figure 86). For the first area a moderate increase is predicted for the A1B and B1 scenarios. A maximum increase of some 10% is predicted for the A2 scenario at the end of the century. For the Shire basin a maximum increase of 10% is predicted for the B1 scenario whereas a maximum decrease of about 10% is predicted for the A1B and A2 scenarios.

The yield of Lake Malawi (sometimes called “free water”) constitutes the inflow to the Shire River at Mangochi (as regulated at present by Kamuzu Barrage). It shows a substantial increase of more than 10% at the end of the century (ignoring increases in water use due to upstream development). The highest increase is predicted for the A2 scenario (about 15% around 2050 and as much as 35% around 2090).
10.2.4 Lake Malawi levels

In Table 46 the projected water balance of Lake Malawi is shown for the three emission scenarios. Under all three scenarios the model predicts an increase in lake levels. Under scenario A2, the average lake water levels would increase by some 0.7 m at the end of the century in the equilibrium situation.

Note that this analysis says nothing about the variability of the lake levels, although it is probable that variability will increase under a climate change regime.

The increases in lake levels are projected to result in a major contribution to long-term average flows in the Shire River itself, as explained in the previous section.

Table 46: Lake Malawi water balance for different scenarios (mm)

<table>
<thead>
<tr>
<th>Water balance component</th>
<th>Base case</th>
<th>2046-2065</th>
<th>2081-2100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A1B</td>
<td>A2</td>
</tr>
<tr>
<td>Inflow</td>
<td>992</td>
<td>907</td>
<td>944</td>
</tr>
<tr>
<td>Rainfall</td>
<td>1252</td>
<td>1347</td>
<td>1380</td>
</tr>
<tr>
<td>Evaporation</td>
<td>1656</td>
<td>1731</td>
<td>1725</td>
</tr>
<tr>
<td>Outflow</td>
<td>506</td>
<td>523</td>
<td>599</td>
</tr>
<tr>
<td>Change in storage</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equilibrium situation ($\Delta S = 0$)

10.2.5 Rainfall intensities

A worldwide review of global rainfall data, carried out by the University of Adelaide, found that the intensity of the most extreme rainfall events is increasing as temperatures rise\(^{60}\). The study was based on data collected at more than 8000 weather stations around the world. It was concluded that a 7% increase in extreme rainfall intensity occurred for every degree increase in atmospheric temperature over the past century.

The predicted temperature increases for minimum and maximum temperatures for Malawi are given in Table 47.

Table 47: Predicted temperature increase in Malawi under different scenarios

<table>
<thead>
<tr>
<th>Variable</th>
<th>Scenario</th>
<th>Temperature increase (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2046-2065</td>
</tr>
<tr>
<td>$T_{\text{min}}$</td>
<td>A1B</td>
<td>2.482</td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>2.380</td>
</tr>
<tr>
<td></td>
<td>B1</td>
<td>1.860</td>
</tr>
<tr>
<td>$T_{\text{max}}$</td>
<td>A1B</td>
<td>2.212</td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>2.136</td>
</tr>
<tr>
<td></td>
<td>B1</td>
<td>1.767</td>
</tr>
</tbody>
</table>

Assuming an increase in average temperature by the end of the 21st century in the order of 2.5 to 4.5°C, the increases in rainfall intensities would be very substantial. The research found the strongest increases in rainfall intensity in tropical countries.

\(^{60}\) Source: www.globalccsinstitute.com
10.2.6 Impacts on floods and droughts

Due to climate change it is predicted that both floods and droughts will increase in frequency and severity. The increase in floods is mainly caused by more water vapour held by a warmer atmosphere which leads to heavier rains. Intense precipitation over the United States has reportedly increased 20% over the last century.

The Ministry for the Environment in New Zealand published a manual entitled “Tools for Estimating the Effects of Climate Change on Flood Flow”. In this manual the percentage increase in extreme rainfall intensities for different durations and return periods are given per 1°C increase in temperature for different durations (10 minutes to 72 hours) and return periods (2 to 100 years).

A review of predictions by different Global Climate Models (GCMs) and different carbon dioxide emission scenarios (low, medium and high) revealed that the average maximum rainfall intensities are predicted to increase by some 10 to 12% around the mid century and 12 to 23% towards the end of the century. As a consequence, certain design floods the occurred in the past at certain return periods are expected to occur in future more frequent.

With respect to droughts it is predicted that the dry seasons will become more severe due to less rainfall and that length of the dry season will increase by 13 to 16% around the mid of the century and by 15 to 23% at the end of the century.

10.2.7 Impacts on erosion and sedimentation

The increase in rainfall intensities has also consequences for erosion. It is predicted by the same GCMs and emission scenarios that erosivity will increase by some 14 to 17% around the mid century and 19 to 39% towards the end of the century. Unless land management practices in the future are improved significantly, soil erosion will increase.

Presently, there is much sediment transported in the Shire River and its tributaries. The consequences are quite evident at the intakes of the hydropower plants on the river where headponds are almost completely filled with sediments hampering the daily operation (as Figure 37 illustrates). In addition the abrasive sediments cause much wear and tear on the turbine runners and other moving parts.

The fact that some 80% of the flow in the Shire River is the almost sediment free outflow from Lake Malawi points to the rather extreme inflow of sediment from the different tributaries in the Shire Basin. Increased erosion losses in the catchments of these tributaries will bring this sediment transport and deposition to an even higher level.
10.3 Indicators – Climate Change

The following indicators are proposed for key characteristics related to climate change.

Table 48: Indicators – climate change

<table>
<thead>
<tr>
<th>Key Area</th>
<th>Indicator</th>
<th>Estimated Value for 2015</th>
<th>Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Yearly average maximum temperature</td>
<td>Yet to be calculated</td>
<td>DCCMS</td>
</tr>
<tr>
<td>Rainfall</td>
<td>Average rainfall (wet season)</td>
<td>Yet to be calculated</td>
<td>DCCMS</td>
</tr>
<tr>
<td></td>
<td>Average rainfall (dry season)</td>
<td>Yet to be calculated</td>
<td>DCCMS</td>
</tr>
</tbody>
</table>
11 Water Quality

11.1 Water Quality Monitoring

Malawi has had a water quality monitoring program in place at least since the 1980s, with a tendency towards lower monitoring frequencies in recent years, due to shortage of human and capital resources to conduct monitoring. The monitoring intervals are typically several months to several years, but are erratic in both time and space. MAIWD has identified around 25 existing sampling locations for routine ambient water quality monitoring. However, it appears that such monitoring has not been carried out for some time, presumably due to lack of resources. Based on historical data collated and “captured” by NIRAS, the graphic in Figure 87 shows the number of samples collected and analysed in the Shire River Basin (together with WRAs 2, 3, 10 and 11 – basically constituting the Southern Region) since 1980. Note that this may not be representative of the data collections efforts for Malawi as a whole.

Figure 87: Annual sample numbers for the Southern Region
The spatial “density” for sampling over the same period is shown (by WRU) in Figure 88. There appears to have been more sampling activity in the north of the basin.

**Figure 88: Annual sample numbers for the Southern Region**

Note: The sampling density is given in samples/100km²/year.

A number of sampling points in both ground and surface water have (in the past) been monitored for traditional water quality parameters, the full list of which is as follows:

- pH
- Electrical conductivity
- Total dissolved salts
- Carbonate
- Bicarbonate
- Chloride
- Sulphate
• Nitrate
• Fluoride
• Sodium
• Potassium
• Calcium
• Magnesium
• Iron
• Manganese
• Silica
• Turbidity
• Suspended sediment
• Hardness (CaCO₃)
• Alkalinity (CaCO₃)

It is noteworthy that these parameters are at least partly adequate for assessment of use for various use purposes (irrigation, livestock watering, raw drinking water, and so on) but inadequate for assessment of ambient water quality in environmental terms. Notably, the following parameters are not included in the routine monitoring program:

• Dissolved oxygen (important for living organisms)
• Organic matter (for example, BOD or COD) (indicator for potential for oxygen depletion)
• Ammonia (toxic to fish and important for eutrophication assessment)
• Total nitrogen and total phosphorus (important for eutrophication assessment)
• Heavy metals (potential indicator of industrial pollution, human health)
• Bacterial contamination (important for human health) ⁶¹

There are more parameters that could be relevant but in many cases they are difficult and/or expensive to measure, and therefore beyond the resources and capacity of Malawi as of present. The above-listed parameters are known to be possible to measure in Malawi (special surveys monitor them) so they could be made part of routine monitoring. Doing so would greatly enhance the value of monitoring data for water quality assessment purposes.

The results of routine ambient water sample analyses have, in the past, been entered into a computerised database written in Dbase III, which runs on a DOS computer. This was used by the Central Water Laboratory (CWL) since the middle of the 1980’s and still contains a substantial amount of data. The Dbase III allowed its users to enter the water quality records with fixed 18 chemical parameters, but did not allow change of definition of the parameter or add new parameter. The Dbase III based system is now outdated and cannot deal with new types of pollutants such as pesticides, heavy metals and radioactivity. Data in the Dbase III are not geo-referenced and do not have unique geographic identifiers and the description varies from sampling to sampling – that is, it is not possible to search and order the records according to geographic location. The historical database contained is not suitable as a management tool, although it has proven a valuable source of data that can be analysed by other software.

⁶¹ Some samples are analysed for coliform bacteria, and bacterial contamination is part of the new database format (see section on monitoring database).
From 2014 the Central Water Laboratory developed a database based on a system called CSPRO and tailored by its own staff. This system provides for storage of geo-referenced sampling locations, when recorded at the time of sampling (which is not all the time). The database format allows for inclusion of additional parameters (for example, dissolved oxygen, phosphate and coliform bacteria) but far from all samples are analysed for these parameters. However, the database is a “flat file” system (as opposed to a relational database) and so is inefficient in terms of data entry and error correction. It also has no capacity for any meaningful analysis of the data.

To assist in overcoming this short-coming, NIRAS is presently developing a new relational database and analysis tool to compile the available information from the CWL and a variety of other sources. Details are given in a report prepared by NIRAS.

With the assistance of CWL and by locating other sources, NIRAS has found (“captured”) almost 4,000 sample records taken at around 1,800 sites covering the period 1980 – 2015, from water quality monitoring samples taken in surface waters in the twelve districts that comprise the Shire River Basin (and including the part of the Lake Chilwa Basin in Malawi). These have been geo-referenced using a large database of Malawi place names – overcoming a major problem that prior to 2015 no spatial coordinates of the sampling sites were recorded.

This data has not been collected regularly at specific sites as would be the case with a proper water quality monitoring program and is not considered sufficient to undertake a comprehensive overview of the ambient water quality and trends associated therewith. However, in an attempt to provide at least a general overview of water quality, these data were analysed as described in the next section.

11.2 Current State of Water Quality

11.2.1 Overview

Prior to the NIRAS consultancy, lack of sufficient monitoring data for the surface and groundwater had severely hampered evidence-based and spatially distributed assessment of to what extent various human activities have had an impact on the water quality during the last decades. The human activities that have impact potentials on the water quality are, however, generally in an early stage of development and should therefore not be expected to threaten the water quality at basin scale yet – microbiological contamination may be an exception.

The surface water quality in the Shire River Basin reflects upstream flows and inputs of contaminants, in addition to the within-catchment flows and pollutant sources. The quality of Lake Malawi’s waters upstream has deteriorated over the last three decades, due to point-source discharges of sewage and also more diffuse run-off from the agricultural sector. Both of these contain significant quantities of nutrients, and the waters of the lake and also of the Shire River have become more eutrophic over time, reflecting this nutrient enrichment.

This has given rise to the proliferation of both native and alien invasive species, with the hippo grass *Vossia cuspidata* and the water hyacinth *Eichhornia crassipes* being of particular note. Floating mats of vegetation have created significant problems at all of the hydropower sites in the basin.

For groundwater, the water quality is more dependent on the geology of the area and in most cases affected less by human activities, except for microbiological contamination, which is prone to occur at village wells and bores.

Although more than 80% of the urban population have access to water supplied through pipelines from water treatment plants, more than 80% of the rural population do not, and instead have to rely on raw water for drinking such as boreholes, shallow dug wells, and intakes from rivers (gravity fed schemes). The quality of the untreated water is easily degraded by environmental changes. The number of victims of water-related diarrhoea increases every rainy season because the flooding rivers are contaminated, and the overflow from latrine pollutes groundwater in boreholes and wells. In urban areas, sewage treatment plants tend to be abandoned due to lack of financial sources. Hence, sewage water overflows into the nearest river or stream from the broken conduits and degrades the water. In addition, illegal disposal to rivers is widespread and unknown in extent and impact.

Heavy industrial factories or mining activities release toxic substances such as mercury, cadmium, lead, radioactive substances, and so on, into the aquatic environments and may cause significant health problems to people and ecosystem as many developed countries have experienced. The extent to which this is the case in Malawi is unknown due to lack of monitoring data to assess this issue.

### 11.2.2 Dedicated water quality monitoring surveys

Because of the lack of useful water quality monitoring data NIRAS has commissioned the Department of Water Resources’ Central Water Laboratory to undertake a surface water quality sampling campaign in an effort to establish a better picture of ambient surface water quality across the basin. Samples has been taken at 65 sites, on four separate occasions, from October 2015 to June 2016, covering both dry and wet seasons. One of the aspects that distinguish these surveys from existing monitoring programs is that the new surveys include more parameters that are relevant and necessary to properly assess ambient water quality. These surveys are meant to supplement the data collected from existing sources (see Section 11.1) and it is hoped and expected that they will contribute to a better overview of the ambient water quality in the basin than what is currently possible to establish based on the existing data.

### 11.2.3 Fitness for use

Because numerous parameters are tested for most samples, and because the suitability (or fitness) for different uses of water depends on different combinations in each case, using the data collected and geo-referenced as described above, a total of eight “indicators” of suitability were used in the overall assessment of ambient water quality for the Shire River Basin, computed by different methods as appropriate. These were supplemented by three of the “key” water quality parameters that also can be simple indicators of water quality: namely, salinity; suspended solids; and faecal
coliforms. These are listed in Table 49. More details on the methods used and the results are reported in NIRAS (2016).

Note that the “suitability for ecology” indicator was not computed for groundwater samples.

Table 49: Indicators of water quality

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Based on</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suitability for ecology</td>
<td>Water quality index protocol</td>
<td><a href="http://www.pathfinderscience.net/stream/cproto4.cfm">http://www.pathfinderscience.net/stream/cproto4.cfm</a></td>
</tr>
<tr>
<td>Suitability for irrigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suitability for aquaculture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suitability for industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suitability for recreation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suitability for domestic use63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salinity</td>
<td>Measured total dissolved solids (TDS)</td>
<td></td>
</tr>
<tr>
<td>Suspended solids</td>
<td>Measured suspended solids (SS)</td>
<td>Standard laboratory methods</td>
</tr>
<tr>
<td>Biological contamination</td>
<td>Measured faecal coliforms (FC)</td>
<td></td>
</tr>
</tbody>
</table>

For each sample, these indicators were divided into categories depending on the magnitude of the indicator for each sample, noting that not all required parameters were available for every sample. In this case, the sample was discarded for the purpose of computing the indicator. The indicators were then averaged by WRU for the periods of 1980-1995, 1996-2005 and 2006-2015. The results for the 2006-2015 data (as the best representation of the present status of water quality), plotted for each WRU are shown in Figure 89 and Figure 90 for surface water and Figure 91 and Figure 92 for groundwater.

---

63 Meaning all domestic uses except for drinking.
Figure 89: Surface water suitability for use by WRU (2006-2015)

- Suitability for irrigation
- Suitability for livestock
- Suitability for aquaculture
- Suitability for industry
- Suitability for recreation
- Suitability for domestic use
- Suitability for drinking
- Suitability for ecology

Legend:
- Excellent
- Good
- Tolerable
- Poor
- Very Poor
- n/a
Figure 90: Surface water key quality parameters by WRU (2006-2015)

Salinity

Suspended solids

Faecal coliforms

Legend:

- Excellent
- Good
- Tolerable
- Poor
- Very Poor
- n/a

Maps showing the distribution of salinity, suspended solids, and faecal coliforms across the basin.
Figure 91: Groundwater suitability for use by WRU (2006 – 2015)

Suitability for irrigation

Suitability for livestock

Suitability for aquaculture

Suitability for industry

Suitability for recreation

Suitability for domestic use

Suitability for drinking

Legend:
- Excellent
- Good
- Tolerable
- Poor
- Very Poor
- n/a
As can be seen, the quality of both surface and groundwater resources is generally tolerable or good for most uses except domestic use and drinking. This situation (poor suitability for domestic use and drinking) is mainly due to widespread faecal contamination in both surface and groundwater, although high salinity is a factor in some areas.

In some cases high sediment loads (that unfortunately have rarely been measured) meaning that water quality is often too poor to enable use for irrigation without additional pre-treatment, such as settlement, due to high risks of equipment damage. However, it should be noted that the majority of high sediment loads in Malawi’s watercourses occur during the wet season, when irrigation demands are lower and abstraction should be relatively limited. Sediment loads will fall during drier period and hence this assessment provides a very conservative assessment of the fitness of the water quality for irrigation.

It is stressed that these results are preliminary and a definitive assessment will not be possible until the surveys are completed in early 2016.

11.3 Sources of Pollution

11.3.1 Overview

To a large extent the pollution load assessment has taken its point of departure in what has been possible to achieve rather than what was necessary to achieve. For instance, the determination of pollution loads has been limited to the following parameters: BOD, total-nitrogen and total-phosphorus. Not necessarily because these are the only interesting pollutants, or the most serious in terms of environmental consequences, but...
because these are the only pollutants for which data and information are largely available. Having said that, the Shire River Basin is still dominated by agriculturally based economic activities indicating that organic matter and nutrients are likely to be the pollutants of major concern for the aquatic environment.

With few exceptions (for example, large agricultural estates), industries are largely confined to Blantyre, hence it is assessed that the issue of industrial pollution with various other pollutants is localised to this area and does not represent a serious issue at the basin scale, although local effects may be significant elsewhere.

### 11.3.2 Domestic wastewater

Estimates of pollution from domestic wastewater distinguish between urban and rural population. Urban wastewater is typically collected (and to some extent treated) and discharged at specific locations, whereas rural wastewater is typically discharged in a diffuse manner. Within the Shire River Basin, Blantyre is the only city to have a sewerage system in place. Based on the available information about the sewage system in Blantyre, as well as on various assumptions on production of human excreta and treatment and decay factors in rural conditions, the pollution loads (arrival into water bodies) from domestic wastewater are estimated as shown in Table 50.

#### Table 50: Estimated pollution loads reaching water bodies from domestic wastewater

<table>
<thead>
<tr>
<th>District</th>
<th>Total human pollution generated (t/yr)</th>
<th>Pollution from rural population</th>
<th>Resulting load to water body (t/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BODS</td>
<td>TN</td>
<td>TP</td>
</tr>
<tr>
<td>BALAKA</td>
<td>4,936.10</td>
<td>617.01</td>
<td>246.80</td>
</tr>
<tr>
<td>BLANTYRE CITY</td>
<td>10,440.12</td>
<td>1,305.02</td>
<td>522.01</td>
</tr>
<tr>
<td>BLANTYRE RURAL</td>
<td>5,231.84</td>
<td>653.98</td>
<td>261.59</td>
</tr>
<tr>
<td>CHIKHWAWA</td>
<td>6,716.64</td>
<td>839.58</td>
<td>335.83</td>
</tr>
<tr>
<td>CHIRADZULU</td>
<td>2,652.38</td>
<td>331.55</td>
<td>132.62</td>
</tr>
<tr>
<td>MACHINGA</td>
<td>2,450.99</td>
<td>306.37</td>
<td>122.55</td>
</tr>
<tr>
<td>MANGOCHI</td>
<td>3,242.76</td>
<td>405.35</td>
<td>162.14</td>
</tr>
<tr>
<td>MULANIE</td>
<td>7,127.31</td>
<td>890.91</td>
<td>356.37</td>
</tr>
<tr>
<td>MWANZA</td>
<td>1,446.10</td>
<td>180.76</td>
<td>72.31</td>
</tr>
<tr>
<td>NENO</td>
<td>1,669.69</td>
<td>208.71</td>
<td>83.48</td>
</tr>
<tr>
<td>NSANJE</td>
<td>3,653.01</td>
<td>456.63</td>
<td>182.65</td>
</tr>
<tr>
<td>NTHCHEU</td>
<td>3,988.21</td>
<td>498.53</td>
<td>199.41</td>
</tr>
<tr>
<td>PHALOMBE</td>
<td>484.18</td>
<td>60.52</td>
<td>24.21</td>
</tr>
<tr>
<td>THYOLO</td>
<td>9,108.84</td>
<td>1,138.60</td>
<td>455.44</td>
</tr>
<tr>
<td>ZOMBA RURAL</td>
<td>1,733.11</td>
<td>216.64</td>
<td>86.66</td>
</tr>
</tbody>
</table>

#### 11.3.3 Industrial pollution

No information has been obtained so far on industrial pollution in the Shire River Basin. Occasional measures appear to have been made in past times but these data are too few to draw any reasonable conclusions. Once such
information becomes available it will be included in the assessment. An approach that has been used in other basins and is based on the World Bank’s “Environmental, Health and Safety Guidelines” that typically estimates pollution loads based on production methodologies and raw materials used will be applied. Based on such guidelines, a table of specific pollution loads from different industrial sectors can be made.

11.3.4 Pollution from non-point sources

In addition to rural population there are a number of other sources considered to be non-point pollution sources:

- Runoff of nutrients from land;
- Additional runoff of pollutants from agricultural estates;
- Runoff of nutrients from livestock.

Traditionally, organic matter is not estimated for non-point sources typically because point sources are much more significant than non-point sources when considering organic pollution. Instead, only total nitrogen and total phosphorus are typically assessed.

Basic pollution loads from soils (before application of fertiliser or livestock pollution) has been estimated based on research done in Malawi. Based on unit loads from this research the following contribution from land into water bodies have been estimated as shown in Table 51.

Table 51: Estimated pollution from land to water bodies; before effects of fertilisers and livestock

<table>
<thead>
<tr>
<th>District</th>
<th>Cultivated Area [km²]</th>
<th>Non-Cultivated Area [km²]</th>
<th>Total Land Area [km²]</th>
<th>Cultivated Land Resulting load to water body</th>
<th>UnCultivated Land Resulting load to water body</th>
<th>Total Resulting load to water body</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t N/yr</td>
<td>t P/yr</td>
<td>t N/yr</td>
<td>t P/yr</td>
<td>t N/yr</td>
<td>t P/yr</td>
</tr>
<tr>
<td>BALAKA</td>
<td>276.5</td>
<td>2075.4</td>
<td>2351.8</td>
<td>77.4</td>
<td>13.8</td>
<td>290.6</td>
</tr>
<tr>
<td>BLANTYRE CITY</td>
<td>703.4</td>
<td>2333.4</td>
<td>3037.4</td>
<td>197.1</td>
<td>35.2</td>
<td>326.7</td>
</tr>
<tr>
<td>BLANTYRE RURAL</td>
<td>449.8</td>
<td>496.6</td>
<td>946.4</td>
<td>126.0</td>
<td>22.5</td>
<td>69.5</td>
</tr>
<tr>
<td>CHIKHWAWA</td>
<td>911.7</td>
<td>1674.7</td>
<td>2586.4</td>
<td>255.3</td>
<td>45.6</td>
<td>234.5</td>
</tr>
<tr>
<td>CHIRAZULI</td>
<td>842.1</td>
<td>746.6</td>
<td>1588.7</td>
<td>208.1</td>
<td>42.1</td>
<td>1048.1</td>
</tr>
<tr>
<td>MACHINGA</td>
<td>1178.7</td>
<td>2239.9</td>
<td>3378.6</td>
<td>501.1</td>
<td>89.5</td>
<td>313.6</td>
</tr>
<tr>
<td>MANGOCHI</td>
<td>1175.6</td>
<td>2022.2</td>
<td>3197.8</td>
<td>329.2</td>
<td>58.8</td>
<td>283.1</td>
</tr>
<tr>
<td>MULanje</td>
<td>249.5</td>
<td>160.7</td>
<td>410.2</td>
<td>69.9</td>
<td>12.5</td>
<td>22.5</td>
</tr>
<tr>
<td>Mwanza</td>
<td>103.3</td>
<td>147.4</td>
<td>250.7</td>
<td>28.9</td>
<td>5.2</td>
<td>20.6</td>
</tr>
<tr>
<td>Neno</td>
<td>869.5</td>
<td>686.3</td>
<td>1555.8</td>
<td>243.5</td>
<td>43.5</td>
<td>96.1</td>
</tr>
<tr>
<td>Nsanje</td>
<td>441.2</td>
<td>609.8</td>
<td>1051.0</td>
<td>123.5</td>
<td>22.1</td>
<td>85.4</td>
</tr>
<tr>
<td>Nyiru</td>
<td>87.9</td>
<td>445.1</td>
<td>532.9</td>
<td>22.4</td>
<td>4.0</td>
<td>62.3</td>
</tr>
<tr>
<td>Phalombe</td>
<td>162.2</td>
<td>966.2</td>
<td>1128.4</td>
<td>45.4</td>
<td>8.1</td>
<td>135.3</td>
</tr>
<tr>
<td>Thyolo</td>
<td>234.8</td>
<td>1851.3</td>
<td>2086.1</td>
<td>68.8</td>
<td>11.7</td>
<td>259.2</td>
</tr>
<tr>
<td>Zomba Rural</td>
<td>2090.8</td>
<td>1835.6</td>
<td>3926.4</td>
<td>586.4</td>
<td>104.5</td>
<td>257.0</td>
</tr>
</tbody>
</table>

Collection of information on fertiliser application is ongoing. Once this becomes available, estimates of runoff of fertilisers from land (particularly from agricultural estates) into water bodies will be included in the pollution load analysis.

Based on an assessment of nutrients in livestock excreta and reduction factors for land runoff, the following estimates for non-point pollution from livestock have been obtained for the Shire River Basin area as shown in Table 52.

Since the pollution loads estimates are work in progress and data still being collected, no conclusions can be drawn at this stage.
11.4 Challenges to Water Quality Management

The current level of awareness, knowledge and capacity on water quality management of the Shire River basin is quite low. Although the scarce data available suggest that basic water quality in the basin may still be reasonable for most uses, challenges will occur if development takes root as planned. Population growth, industrial development and more productive agriculture will all put more pressures on water quality.

The institutional landscape around water quality management is still in the making, with the National Water Resources Authority designated to play an important role, and potentially a Shire River Basin agency (SRBA) emerging as well. A third important player is the Environmental Affairs Department that sets environmental standards and regulates development activities with environmental impacts. One challenge for water quality management will be to establish a good and effective coordination between these different authorities.

Irrespective of the distribution of tasks and responsibilities between the different organisations, there are several other challenges such as:

- Building the necessary water quality management capacity in the relevant organisations. Currently, both human and institutional resources are very weak in this area.
- Striking a proper regulatory balance between protection of water quality and aquatic resources on the one hand – while allowing for use and development of the water and related resources on the other. In most cases industrial and agricultural development activities that bring economic growth may also impair water quality to some degree.
- Translating knowledge on desired water quality objectives and actual water quality conditions into required actions at the river basin planning level.
- Finding sustainable financing mechanisms for monitoring and enforcement of water quality and related regulations.
11.5 Indicators – Water Quality

The following indicators are proposed for key characteristics related to water quality.

Table 53: Indicators – water quality

<table>
<thead>
<tr>
<th>Key Area</th>
<th>Indicator</th>
<th>Estimated Value for 2015</th>
<th>Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient water quality</td>
<td>Average water quality index (out of 100)</td>
<td>80.5</td>
<td>EAD</td>
</tr>
<tr>
<td>Sediment</td>
<td>Yearly average sediment load in Shire River (measured at Nsanje)</td>
<td><em>Yet to be calculated</em></td>
<td>EAD</td>
</tr>
</tbody>
</table>
12 Biodiversity

12.1 Biodiversity Overview

Malawi has unique and diverse flora, fauna and ecosystems, which are attributed to its diverse climate, soils and topography. Currently, with over 800 species of fish, 90% of which are endemic, Malawi is one of the countries with the largest number and most diverse communities of freshwater fish in the world. Around 15% of the global total freshwater species are found in Lake Malawi alone. Ninety-five percent of these species are haplochromine cichlids, which are internationally recognised as an outstanding example of rapid speciation, with a potential to provide greater insights into the understanding of the evolutionary process. Because of their sedentary habits, most of the cichlids rarely migrate long distances from their locality. The resultant isolation of communities has created species endemic not only to the lake but to certain restricted areas within the lake itself. In turn, this aspect has led to adaptive speciation of fish species, which is more diverse than the finches of the Galapagos Islands.

The level of endemism in plants, invertebrates and mammals is not well known. However, it is estimated that approximately 47 species of the 172 species of molluscs, twelve species of reptiles and about seven species of amphibian, especially frogs, are endemic to Malawi.

Figure 93: Unique animal species per 10,000 km² in Malawi (1990s)

![Bar chart showing unique animal species per 10,000 km² in Malawi](http://www.vub.ac.be/klimostoolkit/sites/default/files/documents/malawi_biodiversity_country_profile.pdf)
There is lack of detailed knowledge of the distribution and status of endemic and/or rare plant species in Malawi. The 2002 IUCN Red Data List of Threatened Plants for Malawi lists 14 endangered, 89 vulnerable, and 25 critically endangered species. Approximately 114 plant species are known from only a few localities in Malawi but none of these are formally protected. Only eleven plant species have legal protection in Malawi.

It is clear from the above that Malawi’s biodiversity is unique and an important part of the global biodiversity. The responsibility to conserve and manage the biodiversity therefore does not rest in Malawi alone but also in the international community.

### Table 54: Number and status of species in Malawi

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher plants</td>
<td>3,765</td>
<td>13</td>
</tr>
<tr>
<td>Mammals</td>
<td>195</td>
<td>8</td>
</tr>
<tr>
<td>Breeding birds</td>
<td>219</td>
<td>11</td>
</tr>
<tr>
<td>Reptiles</td>
<td>108</td>
<td>0</td>
</tr>
<tr>
<td>Amphibians</td>
<td>46</td>
<td>0</td>
</tr>
<tr>
<td>Fish</td>
<td>163</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Adapted from data at… http://www.vub.ac.be/klimostoolkit/sites/default/files/documents/malawi_biodiversity_country_profile.pdf

### Figure 94: Possible new species of butterfly recently recorded from Mangochi Forest Reserve (*Balioschila* and *Cymothoe* sp)

Source: Bayliss (2015)

The Shire River Basin situation with regard to biodiversity is very similar to the country as a whole, with extensive wetlands, national parks and some forested areas.

One of the indicators for the Millennium Development Goals for Malawi is the proportion of area protected to maintain biodiversity to surface area. The ratio of surface area protected to maintain biological diversity has remained
constant since 1990 as shown in Figure 95, with no new land designated for habitat protection. The reality is though that due to encroachment into protected areas for agricultural and production of charcoal the area effectively protected for biodiversity conservation is declining.

Figure 95: Malawi - ratio of area protected to maintain biodiversity to surface area

![Image of Figure 95 showing ratio of area protected]

Source: UNEP (online database)

However, Malawi’s efforts to halt the current rate of biodiversity loss (both at national level and for the Shire River Basin) can be achieved if factors that contribute to habitat loss, population growth and poverty are also reduced. These factors are perceived here as major challenges to biodiversity conservation in Malawi.

12.2 Terrestrial Ecosystems

The high diversity of terrestrial habitats and ecosystems, ranging from dry miombo to Afromontane peaks coupled with diverse soils and climate support a wide range of plants and animals. A substantial amount of Malawi’s indigenous terrestrial species have been documented although many taxa remain poorly documented or are unknown and the total number of species is undoubtedly much higher than the currently recorded numbers. An example is shown in Figure 96.

Management of terrestrial biodiversity is under a number of sectoral policies and acts. These policies are grouped into three broad categories: those related to utilisation of biological resources (for example, forestry, fisheries and wildlife); those related to soil and water conservation; and those that influence biodiversity utilisation, for example land tenure and liberalisation of agricultural production linked to biodiversity and ecosystem management. Most of these policies were revised in line with the requirements of the National Environmental Policy that was adopted in 1996 to promote sustainable social and economic development through sound management of the environment in the country.
Terrestrial plants are under the management of the National Forestry Policy of 1996, the National Parks and Wildlife Policy of 2004, and the National Land Resources Management Policy and Strategy of 2000. These policies attempt to protect biodiversity and ecosystems through:

- Identifying and protecting rare and threatened species;
- Identifying and restoring degraded ecosystems; and
- Protecting indigenous species and habitats from alien invasive species.

The terrestrial ecosystems under the customary land tenure system, mostly under subsistence agriculture, are prone to extensive deforestation for various reasons – for example, fuelwood for domestic purposes and curing of tobacco, charcoal production for supplying urban areas and clearing for gardens/shifting cultivation. These activities have resulted in fragmentation of forests and misrepresentation of species in protected areas. The identified “ecoregions” of the basin are shown in Figure 97.
Figure 97: Ecoregions of the Shire River Basin

Source: LTS
12.3 Aquatic Ecosystems

Most rivers in the Shire River Basin, for part of their length, flow through farmland and urban areas but for a few rivers some parts of the river systems flow through the protected areas. No river has any form of protection and many rivers are ecologically degraded by invasive species, sedimentation, cultivation and deforestation. There are major marsh/swamp systems located in the Basin, the largest of which is the Elephant Marsh. Marshes are important habitats for a wide diversity of plants and animals, and in some cases are important habitats for waterfowl and large mammals. Much of the marshland has been lost due to cultivation and invasive species. The loss is very pronounced in the central region where over 60% of the marshes and *dambos* have been lost to winter cultivation. Apart from the loss of swamps and marshes due to anthropogenic activities, invasive species such as water hyacinth are major threats to aquatic biodiversity.

While aquatic life is diverse, the species richness is poorly known mainly due to inadequate research and ineffective information dissemination.

Atkins (2011) have carried out an assessment of the integrity of the aquatic habitats of the catchments of Malawi. The basis of this method is that the ecological integrity of a river is defined as its ability to support and maintain a balanced, integrated composition of physio-chemical and habitat characteristics, as well as biotic components, on both temporal and spatial scales that are comparable to the natural characteristics of similar ecosystems of the region.

The method was based on a qualitative assessment of a number of pre-weighted criteria that indicate the integrity of the instream and riparian habitats available for use by riverine biota. The assessment was undertaken
using professional judgment and experience of the people undertaking the assessment. It is thus a qualitative, rather than a rigorous quantitative, method but it is claimed to give a good measure of the relative condition of catchments across different areas. The assessment considered both in-stream and riparian criteria, and scores were allocated to each WRU against each criterion.

The assessment of the severity of impacts was based on six descriptive categories with ratings ranging from 0 (no impact), 1 to 5 (small impact), 6 to 10 (moderate impact), 11 to 15 (large impact), 16 to 20 (serious impact) and 21 to 25 (critical impact). The estimated impacts of all criteria calculated in this way were summed, expressed as a percentage and subtracted from 100 to arrive at a provisional assessment of habitat integrity for the instream and riparian components, respectively.

A composite score between 0 and 100 was calculated using weightings assigned to each criterion. Six categories were then defined depending on the composite scores as shown in Table 55.

**Table 55: Habitat integrity categories**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Composite Score Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Unmodified, natural.</td>
<td>90-100</td>
</tr>
<tr>
<td>B</td>
<td>Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.</td>
<td>80-89</td>
</tr>
<tr>
<td>C</td>
<td>Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.</td>
<td>60-79</td>
</tr>
<tr>
<td>D</td>
<td>Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.</td>
<td>40-59</td>
</tr>
<tr>
<td>E</td>
<td>The loss of natural habitat, biota and basic ecosystem functions is extensive.</td>
<td>20-39</td>
</tr>
<tr>
<td>F</td>
<td>Modifications have reached a critical level and the biotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.</td>
<td>0-19</td>
</tr>
</tbody>
</table>

Source: Atkins (2011)

The results of the assessment are shown in Figure 99.

It can be seen that for all WRUs in the Shire River Basin, it is assessed that the habitats are moderately or largely modified. This result is not unexpected, given the significant changes to land cover and land use that have occurred in the catchments.
Figure 99: Habitat integrity assessment for the Shire River Basin

Note: For definition of categories see Table 55.

Source: Atkins (2011)
12.4 Biodiversity Surveys

12.4.1 Need for biodiversity surveys

There is a paucity of up-to-date scientific information related to habitats and biodiversity in the Shire River Basin. While it is known that land use change is continuing to convert forests and protected areas into (mostly inappropriate) agricultural lands and bare hills due to charcoal production, the impacts of this on actual habitat and biodiversity within the basin are poorly documented. The SRBMP aims to change this with two significant consultancies.

12.4.2 LTS biodiversity surveys

The consultants LTS have been engaged to undertake a consultancy under SRBMP entitled: Strengthening the Information Base of Natural Habitats. Biodiversity and Environmental Services in the Shire Basin. A key objective of this work is to provide information on habitats and biodiversity to other sub-components of SRBMP, including the NIRAS planning process. The consultancy is expected to produce:

- Preliminary Maps and Satellite Imagery
- Rapid Surveys/Assessments and Reports
- Rapid Survey Information for State of the Basin Report

Furthermore, the results should:

- Inform management decision making;
- Increase awareness of the value of natural ecosystems and species within local communities;
- Improve collaboration among local communities and government agencies responsible for natural resources management to conserve and sustainably use natural habitats and species; and
- Enhance the information available to the public, including tourists visiting the Shire River Basin.

This work is ongoing but some preliminary results can be reported. The initial rapid surveys concentrated on flora and were analysed under four themes, namely:

- Overview of plant species diversity
- Vegetation classification
- Vegetation condition (intactness, level of disturbance or use)
- Natural regeneration potential
- Presence of globally-rare/restricted-range species

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64 As described in LTS presentation to the Technical Team at a meeting in November 2015.
Plant species diversity

During the surveys, 1,134 species were identified among the approximately 4,200 specimens collected (from about 60 to 160 species per site). These species belonged to 569 genera and 147 families. So far, 88 species were identified only to family or genus level; these could represent new species, but it is more likely that they could be identified as known species if flowers, fruits, or additional specimens were collected. Species of the family Fabaceae (legumes) are dominant, along with the Asteraceae, Rubiaceae, Poaceae, and Acanthaceae – this is considered typical for the Zambezian Regional Centre of Endemism. The rapid survey data collected give a reasonably complete sample of plant species diversity in the project area.

Vegetation classification

The classification of vegetation was determined by a process of ordination, whereby the similarity between samples in terms of the species they contain is expressed as the distance between them. This can be plotted in two dimensions on a graph. Then, groups or clusters of samples close to each other on the graph can be selected to enclose classes of samples that represent distinct vegetation types. Most vegetation maps have to show polygons of discrete types, and for practical reasons there are usually a rather limited number of classes (for example, 8 to 12). In the case of the Shire River Basin, eight classifications were identified as shown in Figure 100. A map showing the locations of the vegetation groups is shown in Figure 101.
Figure 100: Vegetation classification analysis

Source: LTS
Figure 101: Vegetation classification – locations of groups identified

Source: LTS
Presence of globally-rare / restricted-range species

Based on the results of the survey, the species were classified according to their degree of rarity as shown in Table 56.

Table 56: Presence of globally rare / restricted range species

<table>
<thead>
<tr>
<th>Global restricted range/rarity category</th>
<th>Number species identified in surveys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most restricted/rare</td>
<td>36</td>
</tr>
<tr>
<td>Somewhat restricted/rare</td>
<td>53</td>
</tr>
<tr>
<td>Intermediate</td>
<td>262</td>
</tr>
<tr>
<td>Common and widespread</td>
<td>741</td>
</tr>
<tr>
<td><strong>Total species</strong></td>
<td><strong>1092</strong></td>
</tr>
</tbody>
</table>

Source: LTS

An index score for globally restricted-range/rare plants (Global Rarity Index – GRI) can be calculated for each site. This index provides an estimate of the uniqueness of a site in the context of global species diversity. Non-tropical countries (for example, United Kingdom, Canada, Argentina) typically have global rarity index scores of 50 or less, with many common and widespread species. Tropical countries with high species-level biodiversity may have global rarity index scores of 450-500 (for example, Cameroon, Ecuador).

The Shire river Basin RBS surveys show a medium level of globally restricted range/rare species with GRI score of 205, with a range of:
- Low of 34 at Lisungwe disturbed woodland site;
- High of 445 at Malosa Mountain montane grassland (recently burned) site.

High-altitude sites tend to have higher GRI index scores – for example: 377 at Mangochi grassland; 281 at Mangochi Mountain ridge; and 258 at Malosa Forest Reserve. Chingale dry northern escarpment.

Even some higher-elevation miombo woodland sites harbour species of significant global uniqueness and have “warm” GRI scores – for example: 222 at Neno East Escarpment, intact miombo on steep slope; and 216 at Liwonde Forest Reserve miombo woodland on hills and rocky outcrops.

12.4.3 Elephant Marsh studies

In addition, the consultants MRAG have been engaged to undertake a consultancy under SRBMP entitled: Climate resilient livelihoods and sustainable natural resources management in the Elephant Marsh. This work includes activities related to identification of habitats and flora and fauna of significance.

The specific key objectives of the consultancy are to:
- Improve understanding of the functional ecology of the Marshes;
- Assess the feasibility of designating the marshes as a protected area and Ramsar site;
Identify strategies and development options to build resilience of local communities to environmental change.

Some important results of the study that will inform the State of the Basin Report and ultimately the Shire River Basin planning process include:

- Description of the historical flora and fauna based on literature/available data;
- A quantitative and spatial description of current flora and fauna (birds, mammals, reptiles, amphibians, fish (stocks), dragonflies, and butterflies);
- Determination of the current threat status of all species, and provide an evidence base to support registration of the Elephant Marshes as a Ramsar site;
- Describe the overall ecology and the functional role of each group. and;
- Description of the sensitivity of different biota to environmental changes highlighting groups/species particularly vulnerable to impacts of climate change.

**Figure 102: Fishing in the Elephant Marsh**

![Fishing in the Elephant Marsh](source: MRAG)

Important information that will be used for the development of an environmental flow regime under the Plan will also be generated.

Again, it appears that at the time of writing none of the consultancy’s activities related to biodiversity were at a stage where information could be shared with NIRAS for this report.

**12.4.4 Surveys in Lengwe National Park**

To provide an example of the threat to important species, the results from surveys at Lengwe National Park are described here (taken from Bayliss 2015). These surveys have been undertaken as part of the process for developing a management plan for the park.

According to the analysis of 2013/2014 survey data the Nyala *Tragelaphus angasi* is showing continual and worrying declines to less than 400 individuals in the park (Figure 103). Similarly, all other showed declines except Impala *Aepyceros melampus* which were similar to the previous few
years, and is in fact the animal with the highest population counts (3,105), followed by Buffalo *Syncerus caffer* (1,362). The Nyala *Tragelaphus angasi* is the flagship species of Lengwe NP with a recorded population of only 327 animals compared to 4,207 in the year 1991. This is a serious decline that needs to be investigated and reversed.

Populations of other mammals like Kudu *Tragelaphus strepsiceros*, Bush Pig *Potamochoerus porcus*, Warthog *Phacocorax aethiopicus*, Bushbuck *Tragelaphus scriptus* and Suni *Neotragus moschatus livingstonianus* have slightly increased in the past two years, whereas Common Duiker *Cephalophus grimma* and Sharpe’s Grysbok *Raphicerus sharpie* have remained constant.

**Figure 103:** Graph showing rate of decline of Nyala and gradual increase of Impala from 1990 to 2014 in Lengwe NP.

![Trends of the two species (Nyala & Impala)](source: Bayliss (2015))

**Figure 104:** Trend of population change in seven mammals from 2013 to 2015

![Trends of other mammals in Lengwe](source: Bayliss (2015))
12.5 Threats to Biodiversity

12.5.1 Habitat loss and fragmentation

The greatest threat to biodiversity in the Shire River Basin is the dramatic loss of habitats, fragmentation of species and habitats and isolation of remaining communities due to unsustainable land use practices. In Malawi agriculture, urbanisation, infrastructure development and human settlements are the major uses of land.

The small-scale farming in the Shire River Basin is characterised by continuous cultivation on the same piece of land, cultivation in wetlands and riverbanks, encroachment into protected areas and cultivation on mountain slopes. This practice has contributed to soil degradation and has subsequently resulted in low productivity. The estate sector is dominated by tobacco, tea, coffee and sugarcane production. Estates are required by law to set aside 10% of their land for forests. Despite this requirement, deforestation is widespread in forests within and outside the estates while enforcement of the 10% requirement is weak.

Developmental activities contribute to habitat loss through conversion of arable land, wetlands and forests for road construction, urbanisation and human settlements. In addition, damming of rivers for irrigation and water supply lead to changes in ecosystems downstream and also impede migration of aquatic organisms upstream and hence cut off species access to spawning areas.

12.5.2 Invasive alien species

Invasive alien species have either been intentionally or accidentally introduced into Malawi and threaten indigenous biodiversity through consuming and preying on them, competing with indigenous species. A major threat to biodiversity is from invasive plants. There are four main invasive aquatic species in Malawi (*Azolla filiculoides*, *water hyacinth*, *Salvinia molesta* and *Pistia stratiotes*), which mainly threaten biodiversity through alteration of the microclimate and displacing the indigenous aquatic flora and fauna. This is because these plants cover the whole surface of the water bodies leading to eutrophication, which leads to reduction of available oxygen/carbon dioxide balance to aquatic flora and fauna.

Atkins (2011) carried out an assessment of the risk of infestation by invasive non-native aquatic weeds for all catchments in Malawi. The idea behind this was to show the risk of infestation of new water resources infrastructure by species of invasive weeds and thus whether certain proposals might be better than others, or that proposals for new investments especially structures such as dams and reservoirs, may also need to be accompanied by management plans to deal with such potential infestations. The information on these four species was combined into a single risk matrix.

The four species considered were:

- **Azolla filiculoides** – a small, floating water fern that affects water bodies by covering the surface, especially in standing or slow moving waters. As this is the smallest and most fragile of the four species considered, it is considered to pose the lowest risk.
- **Salvinia molesta** – the large floating water fern and as its species names suggests it has a habit of completely covering and smothering water bodies, especially standing and slow flowing water. This is the species that is already causing problems to Blantyre Water Board where it infests the Mudi Dam and blocks intake pipes and other features of the distribution system.

- **Pistia stratiotes** – more commonly known as water lettuce (or water cabbage) this is a largish soft leaved floating water plant that infests standing and slow flowing waters. It has been recorded at a number of locations around Malawi and can cause problems to intake pipes. as well as result in smothering of waters and de-oxygenation as dying plants decompose.

- **Eichornia crassipes** – the water hyacinth is Malawi’s most problematic invasive weed. This species is a very large floating plant with a distinctive flower raceme at the top. It reproduces rapidly producing many hundreds of seeds. It is common in standing or slow-flowing water bodies and is notorious as one of the main problematic plants on the Shire River resulting in blockages at the Liwonde Barrage, the Walkers Ferry intake and at the hydropower schemes on the river.

Of these four species, *Eichornia crassipes* was ranked to be the worst offender and given a score of 4. *Salvinia molesta* and *Pistia stratiotes* were determined to be the next most serious, and were given a score of 3. The last species, *Azolla filiculoides*, was ranked as the least problematic and was given a score of 1.

In addition to the seriousness of infestation by each of the four species, the data collected also indicated a risk, ranging from High (Score 3), Medium (Score 2) and Low (Score 1), of the chances of an infestation occurring from these species in each WRU. This was based on the amount of each species already present in watercourses and water bodies in each area. A risk matrix was produced combining all of the above information for all four species into a single risk assessment for invasive aquatic weeds for each WRU.

The results for the Shire River Basin are shown in Table 57.

Terrestrial alien species – for example *Eucalyptus sp.*, *Prosopis sp.*, *Gmelina arborea*, *Lantana camara*, *Rubus fruticosus* – also affect biodiversity in similar manner. New invasive terrestrial species affecting ecosystems in Malawi include black wattle and *Jatropha curcas*, which is being introduced as a biofuel but has adverse impacts to ecosystem. Forest Research Institute of Malawi (FRIM) recently identified a new exotic pest *Leptocybe invasa* locally termed as blue gum chalcid that attacks a wide range of Eucalyptus species.
Table 57: Overall risk of infestation by invasive non-native aquatic weeds

<table>
<thead>
<tr>
<th>WRU</th>
<th>Assessed Risk</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Azolla filiculoides</td>
<td>Eichhornia crassipes</td>
</tr>
<tr>
<td>1A</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>1B</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>1C</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>1D</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>1E</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>1F</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>1G</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>1H</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>1I</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>1J</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>1K</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>1L</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>1M</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>1N</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>1O</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>1P</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>1Q</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>1R</td>
<td>3</td>
<td>12</td>
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<td>1S</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>1T</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>1A</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>1B</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>1C</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>1D</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: Adapted from Atkins (2011)

12.5.3 Population pressure

High population and density are considered the greatest causes of biodiversity degradation since more land is cleared for settlement and in search of fertile areas to increase food production. These activities have directly contributed to the reduction in forest cover from 45% in 1975 to 28% in the early 2000s. Of the 28% forest cover, 21% are forest reserves, national parks and wildlife reserves, and 7% are customary land forests. Deforestation has resulted in soil erosion, resulting in reduction in species composition and abundance, as well as increased sedimentation and siltation of many rivers and lakes.

The increased population has also brought about great demand for fish for domestic consumption leading to an increase in the number of fishers,

65 Overall Risk per WRU was calculated as maximum of the risk scores for the WRU.
localised fishing, and reduced fish catches. In recent years, fish landings have fallen dramatically due to overfishing and environmental degradation. There has been a decline in the stocks of *Oreochromis sp.* (chambo) in both Lakes Malawi and Malombe from 8,500 to 6,000 tonnes between 1984 and 2000, representing about 75% reduction in fish catches.\(^{66}\)

Lakeshore areas are also experiencing ecological and environmental degradation because of the very dense and increasing human population whose livelihood depends on the utilization of a limited and diminishing resource base. Anadromous fish species face more serious threats from unsustainable agricultural practices in catchment areas where there is a complete damming of rivers without provision of fish ladders to enable migration of the fish into the rivers to spawn. In addition, cultivation on riverbanks has been suggested to be responsible for the degradation and eventual loss of spawning habitats due to siltation, exacerbated by pesticide pollution. For instance, *Labeo mesops* (ntchila), which used to be the most abundant species, has almost disappeared because of loss of spawning habitats along the rivers and river mouths.

The high population and density has also resulted in increased demand for indigenous plant resources for food, medicine, fodder, fuelwood and construction material, and has led to these becoming locally rare. This coupled with unsustainable harvesting methods of plant resources, such as uprooting, tree felling and debarking have reduced their populations to non-sustainable levels.

Wildlife is equally threatened due to increased population since deforestation for cultivation and settlements destroys natural habitats for large animals. Increased population also has resulted in increased demand for game meat.

Land for human settlement cannot be determined with certainty. The southern region is heavily populated and this has forced the communities to encroach into protected areas and estates. For example in 2002, communities around Thyolo Forest Reserve encroached into the reserve for settlement and cultivation. To ease pressure on land, the government has embarked on a land reform program in which families from densely populated districts in the south (Thyolo and Mulanje) would be resettled in designated areas.

As long as the population growth rate remains high, pressure on land for settlements, agriculture and resource use will remain the biggest challenge to achieving sustainable biodiversity conservation.

### 12.5.4 Poverty

Malawi is a growing economy, but with still a greater part of the population living below the poverty line. The highest population densities and growth rates occur in the Shire River Basin. Poverty forces people to depend on (increasingly scarce) natural resources for energy (fuelwood and charcoal), food, construction material, medicine and fodder. Thus poverty forces people to trade-off long-term sustainable resources for short-term consumption of stocks since they depend entirely on the existing natural resources. This has a direct impact on biodiversity in terms of hunting of native fauna for food and animal products (such as ivory), as well as the destruction of habitat.

\(^{66}\) Note that corresponding figures for the Shire River Basin are not available.
### 12.6 Indicators – Biodiversity

The following indicators are proposed for key characteristics related to biodiversity.

**Table 58: Indicators – biodiversity**

<table>
<thead>
<tr>
<th>Key Area</th>
<th>Indicator</th>
<th>Estimated Value for 2015</th>
<th>Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protected areas</td>
<td>Ratio of area protected to maintain biodiversity to total basin land area</td>
<td>0.16 (all Malawi)</td>
<td>DNPW</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>index score for globally restricted-range/rare plants (GRI) for the basin</td>
<td>205</td>
<td>National Herbarium</td>
</tr>
<tr>
<td></td>
<td>index score (GRI) for animal species for the basin</td>
<td><em>Yet to be determined</em></td>
<td>DNPW</td>
</tr>
</tbody>
</table>
13 Conclusions

This State of the Basin Report contains information drawn from a wide range of sources, and draws upon additional work done by NIRAS (mainly through the seventeen sector and thematic assessments that have been carried out) and other SRBMP consultants undertaking parallel consultancies of relevance (for example, Mott MacDonald, LTS International and MRAG). Importantly, the Report contains indicators of various outputs and outcomes that are to be achieved through the implementation of the Shire River Basin Plan and the SRBMP more generally, as well as other indicators that can be tracked to inform policy decisions of a wide range of issues. The Report on Key Performance Indicators for the Shire River Basin Plan submitted by NIRAS in June 2015, discusses the use of indicators for this purpose and proposes a broad range of indicators to be used. It should be noted however, that at this point in time, not all data needed to calculate the proposed indicators is available, mainly due to the fact that most statistics are not gathered specifically for the basin, and others may not presently be collected at all. It would be expected that in future revisions of the report, these will become available.

In terms of the current status and trends in the Basin, as identified in this report, generally the picture is not good. This is not surprising given that Malawi is ranked within the poorest few countries in the world. Within Malawi, it could be argued that the Shire River Basin is worse off than the rest of the country. Paradoxically, with the highest share of usable water resources, and abundant land resources, the basin is the source of a high percentage of Malawi’s GDP, but at the same time has higher average levels of poverty than the nation as a whole. This is clearly due to the high population density in the basin, plus the fact that the majority of households are dependent on subsistence farming for their survival.

Deforestation and catchment degradation have occurred at a frightening rate of the past two decades or so, and continue unabated. The forests that once covered much of the basin have all but disappeared. This has been driven by the need for biomass, predominantly in the form of fuelwood and charcoal, for use as an energy source, in the absence of electricity, petroleum products and other sources. In Malawi as a whole it is estimated that 89% of all energy used comes from biomass, and although there are no specific figures for the Shire River Basin, it could be expected that percentage is even higher.

Catchment degradation has “flow on” effects to other sectors as well. Increased erosion leads to high sediment loads in rivers, causing siltation of hydropower plant headponds (reducing electricity production – and ironically, leading to greater dependence on biomass for energy and increasing the deforestation rate), reduction in waterway areas and natural habitats in important wetlands, such as the Elephant Marsh, reduction in fisheries and so on.

Inappropriate agricultural practices also contribute to catchment degradation and massive loss of soils further reduces agricultural production. This
problem cannot be solved by enforcement of existing or new legislation. Alternative livelihoods must be provided to rural household dependent on subsistence farming and/or charcoal production for their existence.

In the future, climate change is most likely to exacerbate the existing problems. According to the NIRAS assessment of climate change, while average rainfall is likely to increase over the basin, the intensity of rainfall will likely increase, while there will also be an increase in the incidence of dry periods. Increased rainfall intensities will tend to increase erosion and soil loss, while increasing dry spells and rising temperatures are most likely to impact agriculture and reduce crop yields.

Population, probably the biggest factor driving poverty in the basin, is growing at almost 3% per year. Unless brought under control, this will result in a huge population and outweigh attempts to reduce poverty by other means.

A key purpose of this report is to inform the development of the Shire River Basin Plan. To be effective, the Plan must directly address the issues contain herein and summarised above. NIRAS will ensure that the Plan will be both holistic and integrated, even though water management will be a central theme.

However, the full benefit of a State of the Basin Report is to allow the systematic review of the basin characteristics that need to be taken into account in water and land resources management, as well as in other areas of governance in Malawi. According, processes should be put in place to routinely update the indicators proposed and convey these results to key decision-makers to take into account when developing future policies and plans.
14 References


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