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Lake Rukwa Basin IWRMD Plan: Final Report

Executive Summary

by

WREM International Inc.
Atlanta, Georgia, USA

May 2016

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Disclaimer

The views expressed in this report are those of WREM International Inc. and do not necessarily reflect the views of the Lake Rukwa Basin Water Board, or the views of the Ministry of Water of the United Republic of Tanzania.

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List of Acronyms and Abbreviations

BMUs	Beach Management Units
BRN	Big Results Now
CC	City Council
CITES	Convention on International Trade in Endangered Wild Flora
COWSO	Community Owned Water Supply Organization
DC	District Council
DSS	Decision Support System
EFA	Environmental Flow Assessment
EFRs	Environmental Flow Requirements
FAO	Food and Agriculture Organization of the United Nations
GDP	Growth Domestic Product
GoT	Government of Tanzania
Ha	Hectares
IUCN	World Conservation Union
IWRDMP	Integrated Water Resources Development and Management Plan
IWRM	Integrated Water Resources Management
LGA	Local Government Authority
LRBWB	Lake Rukwa Basin Water Board
MC	Municipal Council
MCM	Million Cubic Meters
MDA	Ministries, Departments and Agencies
MTEF	Medium Term Expenditure Framework
MW	Mega Watts
NEMC	National Environment Management Council
NGO	Non-Governmental Organization
NSGRP	National Strategy for Growth and Reduction of Poverty
PPP	Public-Private Partnership
SADC	Southern African Development Cooperation
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SMUWC	Sustainable Management of the Usangu Wetland and its Catchment
TANAPA	Tanzania National Parks
TDV 2025	Tanzania Development Vision 2025
TC	Town Council
TANAPA	Tanzania National Parks
TShs	Tanzanian Shillings
URT	United Republic of Tanzania
UWSA	Urban Water Supply and Sanitation Authority
WASH	Water, Sanitation and Hygiene
WB	The World Bank
WCST	Wildlife Conservation Society of Tanzania
WREM	Water Resources and Energy Management Incorporated
WRMD	Water Resources Management and Development
WSDP	Water Sector Development Program

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1. Background

The Government of the United Republic of Tanzania is implementing the Water Sector Development Program (WSDP; 2006-2025) to strengthen the existing water resources management framework, improve the delivery of sustainable water supply and sanitation services, and strengthen the capacities of sector institutions. The program includes four main components: *(i)* Water Resources Management and Development (WRMD); *(ii)* Community Water Supply and Sanitation (CWSS); *(iii)* Commercial Water Supply and Sewerage (CWS); and *(iv)* Sector Institutional Strengthening and Capacity Building.

The current project falls under the Water Resources Management and Development component. The overall objectives are summarized below:

(i) Develop a sound water resources management and development framework in all nine water basins for optimizing water resources utilization in a sustainable manner for the various competing uses.
(ii) Promote good governance of water resources through: empowering water users; encouraging participatory and transparent decision-making in the allocation, utilization, protection and conservation of water resources; devolving ownership to the user level and granting secure water use permits with responsibilities to the water users, community groups, local government and basin boards; and promoting economic instruments to encourage wise use of water.
(iii) Strengthen the capacity of basin boards to address trans-boundary water resources issues.

The overarching objective of the Lake Rukwa Basin IWRMD project is:

"To develop a basin-wide Integrated Water Resources Management and Development (IWRMD) Plan for the Lake Rukwa Basin by (i) assessing water resources and identifying current and future water demands of different sectors, (ii) formulating/evaluating alternatives that will meet those needs, (iii) recommending specific water resources development and management options for the short term (up to 2015), medium term (up to 2025), and long term (up to 2035), and (iv) building capacity of staff of the basin water board and office and other stakeholder agencies to ensure successful development and implementation of the Plan."

This report provides a summary of the Lake Rukwa Basin IWRMD Plan. It is intended for senior government officials, industry managers, and other stakeholders who may wish to have a brief overview of the Basin Plan without a full account of the voluminous and detailed information on which it is based. The executive summary describes the general approach adopted in the development of the Basin Plan, the methodologies employed, the main findings and conclusions reached, and the management interventions recommended over the planning horizon (2015–2035). A full account of the procedures, data, methods, and assessment findings supporting the recommended interventions can be found in the 16 report volumes comprising the Plan.

2. The Lake Rukwa Basin

2.1 Location and Demographics

The Lake Rukwa Basin is an internal drainage basin located in the south-western part of Tanzania. The basin lies within the Rift Valley with Lake Tanganyika on the northwest and Lake Malawi on the southwest. It covers an area of about 88,000 km^2 extending over parts of the districts of Mbozi, Chunya, Momba, Mbeya Rural, and Mbeya Urban in Mbeya region; Nkasi, Sumbawanga Rural, Kalambo, and Sumbawanga Urban in Rukwa region; and Mpanda Rural, Mpanda Urban, and Mlele in Katavi region. The major urban center is the City of Mbeya with a population of about 385,279 (2012 National Census). Other urban areas include the towns of Sumbawanga and Mpanda and townships such as Tunduma, Mbalizi, Mkwajuni, Namanyere, Laela, and Vwawa. **Figure 2.1** shows the geographical extent of the Lake Rukwa Basin.

Based on the 2012 National Population Census, Lake Rukwa basin population is estimated to be 2,531,692, up from about 1.8 million in 2002. About 80% of the population lives in rural areas and 20% in urban areas. Among the Lake Rukwa sub-basins, Songwe accounts for 33% of the total basin population (843,278 residents), while Rungwa is the most sparsely populated, with only 2% of the total basin population and 20% of the basin area. The Lake Rukwa basin has a fairly high population growth rate (basin average of 3.1%) with four of the sub-basins having a growth rate higher than the national average of 2.9%. The high population growth rate is a major challenge for the sustainable management of the basin natural resources.

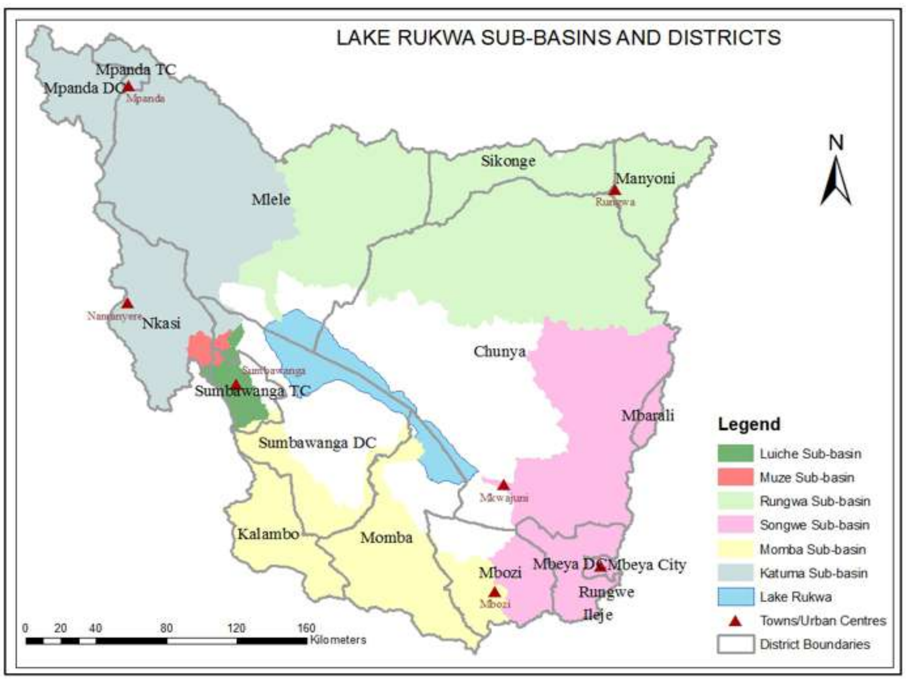

Figure 2.1: Lake Rukwa Basin.

2.2 Socioeconomic Importance

The Lake Rukwa basin supports a plethora of socioeconomic activities. It is a source of water for domestic water supply, irrigation, livestock, wildlife, mining, fishing, marine transportation, and ecological sustainability. Agriculture (including livestock keeping) is the largest and most important economic sector in the basin employing more than 80% of the population and contributing about 70% of the basin GDP. The major food crops include maize, potatoes, beans, and groundnuts. The basin two regions (Mbeya and Rukwa) are among the major maize producing regions in Tanzania. Several cash crops are also grown including cotton, coffee, paddy, tobacco, and horticultural crops.

The basin is home to the Katavi National Park, the third largest park in Tanzania, and several Game Reserves. The Park is the core of the western Tanzanian wildlife circuit and part of the Katavi-Rukwa-Lukwati ecosystem, an important local and national conservation area. The Katavi Park, together with the Rukwa and Lukwati Game Reserves and the surrounding hunting blocks, constitutes one of the biggest and richest wildlife areas in Tanzania. The basin is endowed with significant mineral deposits—gold, coal, mica, iron ore, limestone, salt, and several gemstones. However, exploitation of most of the mineral deposits is still carried out on a small scale, is unregulated, and is endangering the environment through pollution and contamination of water sources. Though the basin is well endowed with significant natural resources, it is still largely under-developed compared to other regions of Tanzania. Detailed discussion of the Lake Rukwa Basin socioeconomic conditions is presented in **Interim Report I, Volume II:** *Lake Rukwa Basin Socioeconomic Profile*.

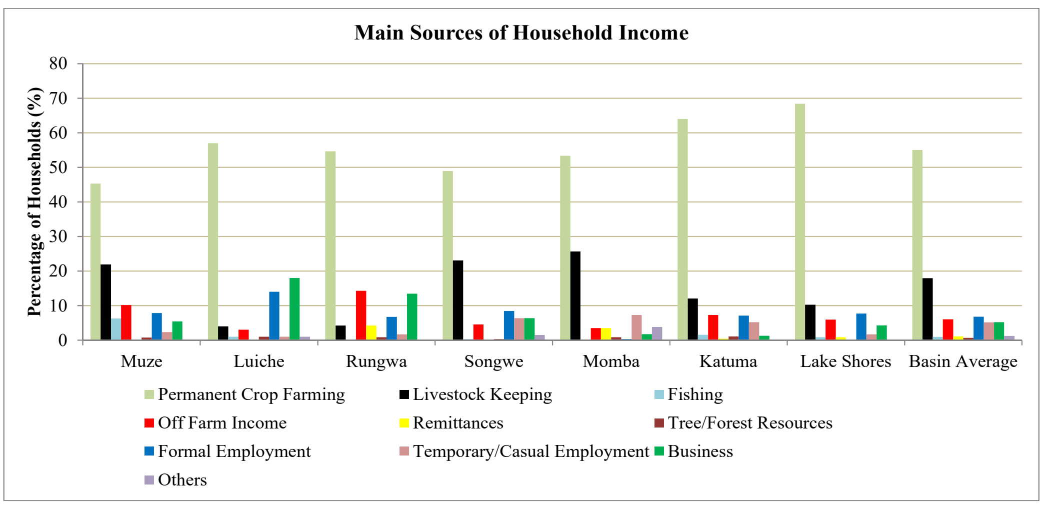

Figure 2.2: Agriculture – Main Source of Household Income in Lake Rukwa Basin. (*Source:* Lake Rukwa Basin Household Survey, WREM International, 2013)

2.3 Climate

The basin climate is greatly influenced by its diverse physiographic features and highly variable topography. It is a tropical wet climate with mean annual rainfall ranging from about 650 mm in the lowlands to as high as 2,500 mm in the highlands. The basin experiences only one rainy season with most rainfall occurring during November to April. The months of June to September receive virtually no rain. The average wet season rainfall over the entire basin is 133.8 mm/month, but it can be as low as 90 mm/month in dry years or as high as 192.5 mm/month in wet years. Average rainfall amounts vary by sub-basin, with Rungwa receiving the least (121.8 mm/month) and Momba the most (148.7 mm/month). The historical record does not show evidence of any statistically significant long term trend (increasing or decreasing) of the annual or wet season rainfall. Rainfall deficits and excesses affect all sub-basins at the same time and have the potential to magnify the basin-wide impacts of droughts and floods. The Rungwa sub-basin is most prone to severe droughts *and* severe floods. The basin climate exhibits marked variations at seasonal, annual, and inter-annual time scales. Climate cycles (i.e., years with rainfall higher or lower than normal) occur with an average frequency of 5 to 6 years. Temperatures vary according to altitude but generally range from about 12 ^{o}C in the highlands to about 30 ^{o}C in the lowlands, with the southern part of the basin being warmest. Seasonally, temperatures are highest during September to December, cool during June and July, and warm in the rest of the year.

2.4 Water Resources Availability

2.4.1 Surface Water Resources

The basin hydrology is characterized by an extensive network of seasonal and perennial rivers that feed and drain several small lakes and large expanses of swamps and wetland systems before all discharging into Lake Rukwa. Lake Rukwa is the main hydrological feature of the basin. The lake, which is an inland drainage lake with no outlet, is quite shallow with a mean depth of about 4 meters and a large surface area of 5,600 km^2. The basin is sub-divided into five major sub-basins (see **Figure 2.1**) including Katuma, Songwe, Momba, Rungwa, Luiche, and Muze. All other basin areas around the lake and outside these five sub-basins have been designated as Lake Shore areas. All basin rivers exhibit strong seasonality, with high flow in the rain season and little or no flow in the rest of the year. The rivers register peak flows during the period March to May and very low flows during the period July to November with the driest months being September and October.

Future climate assessments show that average future rainfall is not expected to change significantly from the historical regime, except that rainfall extremes are expected to intensify in magnitude and frequency of occurrence. Temperatures, however, are expected to rise significantly above historical levels. Lake Rukwa Basin temperatures are projected to rise by an average of 1 to 5 ^{o}C over current levels by the end of the century. Climate warming portends adverse hydrologic consequences, as it is expected to increase evapotranspiration, reduce watershed runoff, reduce groundwater recharge, increase irrigation (and other water) demands, and decrease lake levels. Detailed climate change assessments undertaken as part of the Plan development indicate that all major basin rivers are expected to experience significant flow decreases due to the reinforcing impacts of climate change and rising water demands. Specifically, Lake Rukwa is most vulnerable to climate variability and change because of its shallow depth and large surface area. Being the ultimate recipient of surface water flows from all basin areas, Lake Rukwa is particularly sensitive to changes in inflows from upstream watersheds. Under a “business as usual” management scenario (i.e., current practices), climate and water demand change (for 2035 targets) is projected to reduce the lake Net Basin Supply by up to 25%. Under such circumstances, Lake Rukwa would reduce in size and likely separate into two smaller lakes.

2.4.2 Groundwater Resources

The groundwater potential is unevenly distributed in the basin. The water table generally mirrors the basin topography and is influenced by major drainage lines. Depths to groundwater tend to become deeper toward Lake Rukwa which acts as an inland drainage 'sink' with no external drainage or outlets. Four aquifer types exist: intergranular, intergranular and fractured, fractured, and faults. 57% of the existing basin boreholes have yields between 0.5 and 2.0 l/s, while 22% have low yields < 0.5 l/s. The low yield boreholes are mostly located in the northeast around Rungwa, and toward the northwest near Namanyere. Yields greater than 2.0 l/s occur in the Lake Rukwa Rift Valley (LRRV) and along the higher lying recharge area of the Ufipa Plateau. Higher yielding boreholes also occur in the southeast along the Mbeya Range. No groundwater level monitoring stations exist in the basin. A comprehensive basin-wide groundwater monitoring network is urgently needed to characterize the existing aquifers and assess their groundwater potential. Tentative estimates (based on the basin general hydrogeology) indicate that up to 580 billion m^3 of groundwater may be in aquifer storage, with more than half in LRRV aquifers. The total volume of groundwater that is potentially exploitable to support various water uses is estimated to be 4.1 billion m^3/year. However, this is only a *tentative* estimate and needs to be verified or revised based on reliable field data.

2.4.3 Water Quality

Generally, the basin surface and groundwater have relatively poor physical and bacteriological quality, and good chemical quality. Poor physical quality is most pronounced in surface water. There is strong seasonality in water quality, with poor quality associated with the rainy season. Both surface and groundwater in several basin areas is contaminated with bacteria of fecal origin. The problem is most serious in surface waters, where about 75% of tested water samples had coliform counts above national standards. Only 10% of groundwater sources exhibited this problem. Lake Rukwa generally has poor physical and bacteriological quality. It is an alkaline lake with a sodium-bicarbonate water type. The pH of the lake ranges from 8.8 to 9.8, alkalinity is about 900 mg $CaCO_3$/L, and electrical conductivity ranges from 2200 to 2800 µS/cm. The main water quality issues in the basin include high silt loads from widespread catchment degradation; poor rural sanitation leading to physical and bacteriological contamination of surface and ground water resources; poor urban sanitation leading to heavy pollution of streams draining urban areas; high iron from rusting pipes and natural rock formations; high fluoride occurring naturally in groundwater sources; high levels of mineralization and hardness in groundwater; and heavy metal pollution from mining activities. Heavy metal pollution from gold mining poses the greatest threat to water quality. Artisanal mining activities increasingly mobilize heavy metals from goldfields and transport them to surface water bodies. Heavy metals are present and likely accumulating in Lake Rukwa.

Detailed discussion of the water resources status (availability and quality) in the Lake Rukwa Basin is presented in **Interim Report I, Volume II:** *Water Resources Availability Assessments*.

2.5 Current Water Use and Demand

This section summarizes the findings of the basin sectoral water use assessments. A more detailed account of these assessments is presented in **Interim Report I, Volume III:** *Current Water Demand and Use Assessment*.

2.5.1 General Outlook

The current mean annual water use in the Lake Rukwa Basin is estimated to be about 785 MCM compared to a total demand of about 1,480 MCM. Irrigation is the most significant water use sector accounting for about 94% of the total basin consumptive water use. Domestic, livestock, and industrial sectors account for only about 4%, 1.5%, and 0.5% respectively. These percentages do not account for other important non-consumptive water users like the environment and hydropower. Most water use (about 64%) takes place in Katuma sub-basin to support its extensive paddy irrigation activities. The least consumptive water use (about 0.1%) occurs in the Rungwa sub-basin, which is sparsely populated and has no significant irrigation activities. Significant water use also occurs in Momba and Songwe sub-basins, respectively accounting for about 19% and 14% of total basin water use.

2.5.2 Irrigation Water Use

Currently, less than 50% of the basin potential irrigable land is under irrigation. This implies that significant potential still exists for future irrigation expansion and increased water consumption by the sector. One of the major sector challenges, however, is that most irrigation activities are practiced on traditional irrigation schemes representing about 78% of all basin schemes. Traditional schemes are characterized by inadequate and poorly constructed water supply infrastructure and poor on-farm water use practices, resulting in low irrigation water use efficiency (about 15%). Improvements in irrigation infrastructure and on-farm water use practices in traditional irrigation schemes could improve water use efficiency up to 30% (RBMSIIP, 2001). Therefore, investment in improving traditional irrigation schemes has great potential for water savings and represents an effective demand-side management strategy. Such water savings could support future irrigation expansion without significant basin-wide increase in total irrigation water use.

2.5.3 Domestic Water Use

The basin average water supply coverage is about 45% and 50% for rural and urban areas respectively. These figures are below the national averages and are also significantly lower than the 2015 national targets for *safe* water coverage for rural areas (65%) and small towns and rural growth centers (57%). Most of the existing rural and urban water supply infrastructure is old and requires major rehabilitation and expansion to cope with current and future water demands. The situation is exacerbated by poor maintenance of installed facilities resulting in frequent breakdown and abandonment. Urban water supply utilities are faced with the challenge of increasing water treatment costs due to pollution and high turbidity levels in raw water caused by various human activities in upstream catchment areas. The increased water treatment costs are transferred to water users as increased tariffs, a practice which discourages users from paying for the services. As a result, users either resort to the use of unsafe water sources or engage in illegal water connections. High water losses are also a major challenge for most urban water supply authorities in the basin. Thus increased investments in domestic water supply infrastructure are needed for the basin to achieve the national safe water coverage targets (i.e., 100% in all rural and urban areas by 2035).

2.5.4 Livestock Water Use

The main sources of water for livestock include rivers, streams, swamps/marshes, temporary ponds, charco dams, and irrigation canals. Lack of designated livestock watering areas results in pastoralists watering their herds in water sources also used by other users (e.g., irrigation canals), and causes conflicts. The situation is exacerbated by the uncontrolled influx of livestock from neighboring regions, increasing the pressure on Lake Rukwa Basin resources. Most areas have exceeded their livestock carrying capacity and are currently subjected to overgrazing, soil erosion, land compaction, destruction of wetlands and river banks, and intense land and water use competition and conflicts. There is urgent need for establishing land use plans for all basin villages, clearly designating and enforcing areas for livestock grazing and watering. Land use planning would (a) support the livestock sector through dedicated watering facilities and designated grazing areas and (b) minimize potential conflicts with other water users.

2.5.5 Wildlife Water Use

Wildlife needs water for daily consumption, environmental maintenance, and primary habitat. During the rainy season, water and pasture are widely available and evenly distributed in the parks and game reserves and so is wild life. During the dry season, however, most streams and rivers dry up and wildlife tend to concentrate close to the few available water sources such as swamps, springs, and excavated ponds. These sources are often inadequate to meet the water needs of the significant wildlife population, and human-wildlife conflicts usually escalate during the dry season. Such conflicts manifest in various forms. In some areas, upstream irrigators divert nearly all water in the rivers denying wildlife access to water downstream. This results in wildlife wandering into villages, surrounding parks, and game reserves causing human-wildlife conflicts, crop damage, and occasional loss of human life. Human-wildlife conflicts also occur by the encroachment of pastoralists from neighboring villages in protected areas in search of water and pasture for their livestock. Serious environmental and wildlife health risks are posed by water pollution due to increased unregulated small scale gold mining in areas around Katavi National Park. There is need for effective regulation of water use activities taking place upstream of protected wildlife areas to ensure availability of sufficient clean water for wildlife consumption and use throughout the year. Such regulation can be instituted through the water use permitting process upstream of parks and game reserves. Issuance and renewal of permits must ensure that adequate water supplies remain in the river for use by the downstream environment and wildlife. Furthermore, the LRBWB in close collaboration with wildlife officials should be vigilant in monitoring and preventing illegal water abstractions upstream of parks and game reserves.

2.5.6 Industrial Water Use

The Lake Rukwa basin has very limited industrial and manufacturing activities, the majority of which are concentrated in Mbeya City. Most of these industries are connected to the Mbeya Urban Water Supply and Sewerage Authority (Mbeya-UWSA) network which supplies them with raw water and also receives their effluent. Because of the small number of industries currently operating in the basin, their impact in terms of water use is small compared to irrigation. They also do no not generally pose serious pollution risks, except for a few localized problems caused by poorly managed effluent. Nevertheless, the LRBWB needs to periodically monitor all industries in the basin to ensure that they have valid water abstraction and waste discharge permits, and that the effluent discharged into neighboring water bodies complies with the provisions of their permits.

2.5.7 Mining Water Use

The basin water resources support mining activities as water supply sources for different mining processes and as effluent receivers from mineral processing activities. The current water used in the mining sector is very small compared to other uses like irrigation and domestic water use. However, small scale gold mining activities, especially in Chunya and Mpanda districts, pose a high risk to water pollution and environmental degradation. The main threat comes from unregulated use of chemicals (mercury and cyanide), especially in small scale artisanal gold mines, and poor handling and disposal of mine effluent. Unregulated mercury use in gold mining is of particular concern because of its potential health and general environmental hazards. The LRBWB, in collaboration with environmental agencies and local governments, should routinely monitor all mining activities to ensure that they are licensed and properly regulated to minimize pollution of neighboring water bodies. Routine monitoring of water quality should be carried out on water bodies in the vicinity of mining areas to monitor potential pollution from mine effluent.

2.5.8 Fisheries Water Use

Fishing is a very important socioeconomic activity and is mostly concentrated around Lake Rukwa and the major rivers flowing into it. Fisheries are an important source of food, household income, and livelihood for riparian communities. Fish play an important role in daily diets, being one of the cheapest sources of animal protein. The true economic importance of fish production would be underestimated if analyzed solely in monetary terms. Thus, any loss in fish production must also be viewed as directly resulting in a decline in per capita animal protein consumption. In the fishing areas around Lake Rukwa, fishing generates high economic returns to local fishermen. The occupation and related industries provide employment to many and keep young people from engaging in illegal activities. The artisanal fisheries support a large number of workers in related industries, including those who repair boats and fishing gear. In addition, many women are involved in the processing and selling of fish.

In view of basin high population growth rate, increase in fish yield should constitute an important part of the basin food security strategy. However, there has been an observed steady decline in fish production in Lake Rukwa in recent years. The decline is mostly attributed to over-fishing and use of illegal fishing gear. These practices are destructive especially because they trap mostly immature fish disrupting the fish breeding cycle. Some fish species (e.g., "*Poloki*", "*Kachinga*", and "*Ningu*") are reported to have become very rare in the lake (raising fears of extinction). The situation is exacerbated by poor monitoring of fishing activities, weak enforcement of fishing laws, and inadequate fisheries data. Establishment of Beach Management Units (BMU) at individual landing sites can motivate fishermen to organize and regulate themselves with minimum supervision from the district Fisheries Office. BMUs can also provide a more sustainable mechanism for collection of fish catch data, reporting of illegal fishing activities, monitoring use of illegal fishing gear, and controlling over-fishing. Quantifying the impact of changes in river flows/lake levels on fisheries production is not currently possible due to inadequate and unreliable concurrent hydrological and fishery catch data. Such data would enable water resources planners and managers to assess the impact of different upstream water uses, such as excessive upstream water abstraction for irrigation, on fisheries productivity in critical rivers, wetlands, and Lake Rukwa.

2.5.9 Environmental Water Requirements

Lake Rukwa Basin is home to many aquatic and terrestrial ecosystems of local, national, and global conservation significance. One of the main challenges is how to meet the increasing water demands of the different sectors to ensure socio-economic development and poverty eradication without compromising the proper functioning of the environment and sustainability of ecological biodiversity. The WRM Act (2009) prioritizes water allocation for environmental reserve over water for socioeconomic uses. It is, therefore, important that all water allocation decisions in the basin should give due recognition to environmental flow requirements as legitimate water use that must be provided to support vital ecosystem functions. It is also important that such decisions are informed by careful assessment of the impacts of proposed water resources developments on the environment and the associated potential trade-offs.

2.5.10 Hydropower Generation

Less than 5% of households in Lake Rukwa basin are connected to the national electricity grid. Some of the isolated urban areas close to the Zambia border (e.g., Sumbawanga MC) are connected to the Zambia electricity grid while others (e.g., Namanyere) are served by thermal generator power. More than 90% of the basin population depend on firewood and charcoal as their main source of energy for domestic cooking, heating, and lighting. Heavy dependency on fuel wood has contributed to environmental degradation by widespread cutting of trees in most parts of the basin. Several small-scale and mini hydropower sites have been identified: (i) Mtembwa River at Yala Falls (30 MW); (ii) Nzovwe River at Msia village (8 MW); (iii) Churu River at Nkwilo village (1.165 MW); (iv) Kilambwa River at Kalumbaleza (1 MW); and (v) Luiche River at Uzia village (0.1 MW). These schemes have already attracted potential investors who are currently assessing their commercial viability for development. Other sites with more limited hydropower potential also exist in different parts of the basin but have not yet attracted investor interest.

2.6 Synthesis of Prevailing Water Resources Problems

A number of water resources problems were identified, analyzed, and discussed in various stakeholder fora. The discussions also involved identification of specific socio-economic pressures causing the observed problems, and associated water related impacts. Information generated from this "*pressure-impact*" analysis enabled stakeholders to understand how and to what extent different socio-economic activities affect the basin water resources and environment in general. Several of the water related problems identified together with their potential causes and associated impacts are summarized in the matrix below.

Problem	Underlying Causes	Impacts
Inadequate and/or poor quality data	• Inadequate and limited monitoring network with large unmonitored watersheds and groundwater aquifers. • Ad hoc and infrequent field data collection resulting in large data gaps. • Poor operation and maintenance of monitoring network resulting in frequent breakdown of field equipment.	✓ Poor water resources planning and management decisions. ✓ Inadequate water infrastructure designs. ✓ Inadequate water information dissemination to the public. ✓ Poor investment decisions on water related projects.
Non-compliance with water permit regulations and other provisions of the Act	• Weak enforcement capacity to crack down on illegal water abstractions and non-compliance with water permit conditions. • Inadequate awareness by water users of their rights and obligations under the Act. • Lenient penalty structure that cannot deter offenders from non-compliance with the Act. • Weak and poorly facilitated Water User Associations to monitor illegal water use. • Limited support from local community leaders in enforcement efforts either due to lack of awareness and/or motivation, and/or conflict of interest.	✓ Over abstraction of water by illegal users thus denying legal users rightful access to allocated water. ✓ Low revenue to the LRBWB since many illegal water users don't pay any water user fees. ✓ Distortion of catchment water balance since illegal abstractions are difficult to account for in the official water allocation plans. ✓ Water use conflicts between legal and illegal water users.
Water use conflicts	• Water scarcity in the basin, especially during dry periods. • Inefficient water use, especially in traditional paddy irrigation schemes resulting in farmers drawing more water than necessary. • Weak and poorly facilitated Water User Associations to monitor proper use of local water resources. • Weak enforcement capacity to crack down on illegal water abstractions and non-compliance with water permit conditions. • Lack of village Land Use Plans to guide orderly use of local land and water resources. • Uncontrolled movement of pastoralists into the basin in search of water and grazing resources.	✓ Reduced productivity and loss of revenue by downstream water users. ✓ Livestock and wildlife deaths and migration due to lack of water and grazing resources. ✓ Animosity between water users some of which may result in destruction of property and human deaths. ✓ Increased migration of people, especially pastoralists in search of water and pasture for their animals resulting in more conflicts and spread of diseases. ✓ Disruption of social order and socioeconomic activities due to insecurity.
Low safe water and sanitation coverage	• Inadequate investment in safe water supply and sanitation facilities. • Poor operation and maintenance of installed water supply and sanitation facilities resulting in low operational efficiencies and frequent facility break down.	✓ High prevalence of water related diseases resulting in high infant mortality rates, reduced productivity and unnecessary health expenses. ✓ Low productivity of women and girls who spend most of their time walking long distances to fetch water. ✓ High dropout rates of female students from school due to poor sanitation facilities.
Inadequate awareness of water resources related issues	• Lack of access to reliable water resources data and information. • Inadequate school curriculum that does not make adequate provisions for water resources and hygiene related studies. • Inadequate technical and financial capacity to sensitize local communities on water resources related issues.	✓ Lack of interest by local communities to participate in water resources related activities. ✓ Catchment degradation and pollution of water resources. ✓ Unsustainable and inefficient domestic, industrial, and irrigation water use.
Violation of minimum environmental flow requirements	• Lack of scientific data/information on required minimum environmental flow requirements for different river sections. • Lack of knowledge/awareness regarding legal requirements for minimum environmental flows. • Weak enforcement capacity to crack down on illegal	✓ Loss of biological diversity and ecological functions of water bodies. ✓ Loss of livelihoods and incomes for households dependent on river based socioeconomic activities for their survival. ✓ Increased suffering/death of wildlife in

Problem	Underlying Causes	Impacts
	water abstractions and non-compliance with water permit conditions. • Water scarcity especially during the dry season, making it difficult to enforce minimum environmental flow requirements due to competition for the little available water by different water users.	protected areas dependent on perennial rivers/streams for their survival.
Pollution of water sources/bodies	• Inadequate sanitation facilities in rural and urban areas. • Poor siting of sanitation facilities (e.g., location of shallow pit latrines near water sources). • Improper discharge of effluent from industries, abattoirs, and toilets into rivers. • Improper use of agro-chemicals. • Improper use of chemicals and uncontrolled disposal of effluent from small scale artisanal gold processing operations. • Watering of livestock in rivers. • Bathing, and washing of clothes, utensils, and chemical containers in rivers. • Lack of/and or poor solid waste disposal facilities. • Laxity in enforcement of environmental rules and regulations.	✓ Increased occurrence of water borne diseases due to consumption of poor quality water. ✓ Increased raw water treatment costs by utility companies and industries. ✓ Loss of aesthetic value. ✓ Ecological damage in rivers and wetlands. ✓ Increased water scarcity due to non-usability of heavily polluted water sources resulting in affected users looking for alternative water sources.
Inefficient water use	• Inadequate/poor irrigation infrastructure and on-farm water management practices especially in traditional paddy irrigation schemes. • Inadequate/old and poorly maintained urban water supply infrastructure resulting in high non-revenue water. • Low water tariffs resulting in wastage of water due to lack of incentives to conserve water. • Use of inefficient/water intensive industrial production technologies including limited use of recycled water.	✓ Water scarcity due to unnecessary excessive withdrawal of water resulting in water use conflicts. ✓ Low revenue from water use since a lot of water ends up being wasted. ✓ Disincentive for adoption of water conservation practices since any gains are wasted by inefficient water users.
Water Scarcity	• Lack of and/or inadequate water storage infrastructure to store water during rainy season to augment low flows during the dry season. • Excessive water withdrawals by upstream water users resulting in shortages for the downstream users. • Illegal water abstractions that are not factored in the official water allocation decisions resulting in excessive water use and scarcity. • Changes in streamflow patterns due to climate warming and increased evapotranspiration. • Changes in land use patterns resulting in increased flash floods and reduced dry season low flows. • Increased water demand due to increased population, climate change, and general socioeconomic development. • Inadequate water supply sources.	✓ Increased water use conflicts. ✓ Reduced productivity and loss of revenue due to water constraints. ✓ Increased water borne diseases and decreased quality of life. ✓ Increased water supply interruptions in urban areas. ✓ Increased environmental degradation due to loss of biological diversity and ecological functions. ✓ Increased migration of people, especially pastoralists in search of water and pasture for their animals resulting in conflicts and spread of diseases. ✓ Increased livestock and wildlife deaths.
Heavy sediment transport in rivers	• Cutting down of trees for expansion of agricultural activities and human settlements due to population pressure. • Charcoal burning and timber logging as alternative sources of household income. • Poor cultivation practices especially on steep slopes. • Uncontrolled bush burning. • Overstocking of grazing lands resulting in destruction of ground cover. • Cultivation of river banks and wetland areas resulting in destruction of buffer zones along rivers and lake shores.	✓ Deterioration in physical water quality in rivers/lakes making it unusable for some purposes. ✓ Drying up of streams and rivers due to reduction in base flow. ✓ Destruction of ecological biodiversity due to loss of habitat. ✓ Increased expenditure on raw water treatment by UWSAs due to poor raw water quality. ✓ Increased siltation of natural and man-made water storage reservoirs.
Inadequate capacity for water resources assessments	• Inadequate and/or lack of appropriate water resources assessment tools and decision support systems. • Limited technical and experienced staff with the required skills to carry out high level assessments. • Inadequate reliable water resources data on which to base the technical water resources assessments. • Difficulty to attract and retain high level technical staff due to low salaries compared to the private sector. • Inadequate funding to facilitate and motivate staff to undertake high level water resources assessments.	✓ Limited dissemination of technical information to the public. ✓ Heavy reliance and expenditure on consultants for high level technical expertise. ✓ Limited influence on water related planning and investment decisions in other sectors.
Inadequate water storage/supply infrastructure	• Inadequate funds for water supply infrastructure development. • Poor operation and maintenance of water infrastructure. • Inadequate technical capacity for design, construction supervision, and operation and maintenance of water	✓ Water scarcity. ✓ Water supply interruptions. ✓ Loss of production and revenue due to water constraints. ✓ Water use conflicts.

Problem	Underlying Causes	Impacts
	supply infrastructure. • Unfavorable topography and difficult terrain for construction of certain infrastructure (e.g., dams). • Old and dilapidated infrastructure characterized by frequent breakdown.	✓ Low access to safe water coverage.
Flooding	• Catchment destruction especially cutting down of trees and cultivation of hill slopes. • Climate change is likely to exacerbate severe floods.	✓ Loss of soil fertility and increased sediment loads in rivers due to soil erosion. ✓ Destruction of infrastructure, crops, farmland, and displacement of downstream communities. ✓ Waterborne diseases.
Drainage of wetlands	• Conversion of wetlands into agricultural land due to shortage of arable land. • Unsustainable harvesting of wetland products. • Disposal of excessive toxic wastes into wetlands • Brick making. • Lack of awareness on importance of wetlands.	✓ Loss of wetland ecosystem (biodiversity, water supply, etc.). ✓ Loss of wetland functions (flood control, erosion control, water filtration, water storage, etc.).
River bank cultivation	• Shortage of agricultural land due to population pressure. • Weak enforcement of river bank protection regulations and guidelines.	✓ Soil loss. ✓ Increased sediment loads in rivers. ✓ River bank failures and interference with natural river morphology.
Soil erosion	• Deforestation and vegetation removal. • Inappropriate land use practices. • Cultivation on steep slopes. • Inappropriately designed drainage systems.	✓ Soil/fertility loss. ✓ Increased sediment loads in rivers. ✓ Low crop yields. ✓ Loss of agricultural land.
Over-abstraction of groundwater	• Inadequate surface water sources in terms of quantity and quality. • High investment and treatment costs for surface water supply schemes. • Degradation of groundwater recharge areas.	✓ Depletion of groundwater reserves. ✓ Land subsidence due to rapidly receding water table. ✓ Drying up of rivers and streams due to reduced base flows.

3. IWRMD Plan Development Process

3.1 Planning Process

The Lake Rukwa Basin IWRMD Plan was developed through a four-step process as follows:

Step I focused on individual sub-basins and involved detailed assessments of (a) current and projected water use levels and (b) current and future water supplies. The former were carried out independently of the latter and aimed to determine *aspirational* water use targets in individual sub-basins and sectors assuming unlimited water supplies. Likewise, the latter aimed to determine the sub-basin water supply capacity under pristine conditions—conditions without anthropogenic influences.

Step II continued to focus on the individual sub-basins, but its purpose was to integrate the independent water use and availability assessments of Step I and determine the extent to which supplies can meet demands. Specifically, Step II assessments aimed to determine existing or projected supply-demand deficits (if any), quantify water use tradeoffs across the sub-basin sectors, identify and assess promising water management options that may be able to reconcile supply and demand deficits, and develop stakeholder consensus on acceptable sectoral water use levels. These assessments are sectorally integrated *within* each sub-basin, but they are not concerned with possible adverse impacts to downstream sub-basins and Lake Rukwa. Because of this, the water use levels and associated management interventions identified in this step are tentative and subject to revision, pending the basin-wide assessments in Step III.

Step III focused on restoring the physical and socio-economic interactions *between* sub-basins and aimed to assess the *basin-wide* impacts of sub-basin water uses as well as the *basin-wide* benefits of the tentative sub-basin water management interventions. Stage III assessments are sectorally *and* regionally integrated and had three important goals: (a) provide a holistic understanding of water use impacts and benefits, (b) evaluate the combined effectiveness of alternative water management interventions, and (c) develop stakeholder consensus on the acceptable water use levels in each sub-basin and on the most effective water management interventions to be included in the basin plan.

The sub-basin water use levels agreed upon in Step III are not necessarily the same as the water use levels tentatively proposed in Step II. Thus, the purpose of **Step IV** is to revise the sub-basin sectoral water use levels and associated management interventions to be consistent with those of the basin-wide IWRMD plan agreed upon in Step III. These revisions form the basis of the final *sub-basin/sectoral plans*.

Stakeholder Consultations and Engagement – Significant time and effort was dedicated toward collection, review, and quality control of the required information and data used in carrying out the technical assessments. Major stakeholders in all basin districts were visited and their opinions and guidance sought on diverse issues pertaining to the IWRMD Plan development process. Particularly, discussions were held with heads of departments in all basin districts on thematic issues to leverage their local experience, seek their guidance as important stakeholders, and access relevant district-specific and up-to-date information and data. Detailed questionnaires were circulated to all district heads of departments soliciting for sector-specific water use data and information at ward and village levels. All relevant documents including latest Regional and

District Socioeconomic Profiles, District Development Plans; National Sample Census of Agriculture Reports, Livestock Sample Survey Census reports, and several other important sectoral planning documents were accessed and thoroughly reviewed. In addition, detailed questionnaires were administered in several households (about 50 households per ward) in 40 wards distributed across all basin districts. The data and information captured in the household questionnaires were vital in establishing baseline socio-economic conditions and the level of dependence on water resources by local communities. Overall, the detailed consultative and data/information gathering process generated a wealth of data and information used in various assessments and the development of the Basin Plan.

3.2 Methodologies—Data, Models, and Scenario Assessments

The development of the IWRMD Plan relied *critically* on quantitative data analysis and detailed models of the sub-basin and basinwide response to historical and future hydro-climatic conditions, water use levels, and management options. These tools and assessments are briefly described next.

Database development: First, all available hydro-climatic data and water use data (including rainfall, PET, streamflow, groundwater levels, borehole yields, water quality parameters, and water use permits, among others) existing in various organizations and forms were compiled, and their quality and completeness were carefully assessed. Data gaps were noted, and where possible, likely biases and errors were identified and corrected. The data were then entered into databases which formed the information component of the Lake Rukwa Decision Support System (Rukwa DSS). Separate databases and user interfaces were designed for surface water, groundwater, water quality, and water use data to reflect and support the specific monitoring procedures and requirements followed by the BWB staff in each data category. These databases currently house the existing historical data but can also facilitate the collection, archival, and management of future measurements. Specialized data analysis tools were also developed to facilitate the use of the data in model development. One such tool is the river gage rating tool (RGRT) which facilitates the development of rating curves from stage-discharge data, and subsequently uses them to convert river stage measurements to discharges. This tool has many unique features and has been provided with training to all Tanzanian BWBs. The RGRT was used extensively to update the rating curves at key river locations and to generate daily and monthly riverflow sequences that supported the development of hydrologic watershed models (described next). Inspection of the rating curves can also identify clear stage-discharge measurement priorities across the flow range and guide the BWB flow measurement schedule. The various features and functionalities of the Rufiji data bases and analysis tools are described in Volume V of the Final Report (*Rukwa DSS v3.0*).

In addition to data from basin organizations, data available from international sources were also compiled and used in various assessments. Notable among these data are the climate projections available through the Intergovernmental Panel for Climate Change (IPCC). Monthly climate projections for 2015 to 2099 were compiled for (i) temperature, rainfall, and potential evapotranspiration; (ii) two greenhouse concentration (GHC) scenarios, a mild GHC scenario (RCP4.5) and an intense GHC scenario (RCP8.5); and (iii) 23 global circulation models (GCMs). These voluminous data sets were subsequently properly downscaled (through state of the science methods) and used to create plausible future climate sequences for all Lake Rukwa Basin watersheds. These sequences were the basis of the detailed climate assessments reported in

Interim Report I, Volume II (*Water Resources Availability Assessments*), and Interim Report II, Volume II (*Sub-basin Water Balance Assessments*).

Hydrologic watershed model development: Second, rainfall-runoff models were developed for each major sub-basin and used to characterize the watershed runoff and soil moisture storage response to rainfall and potential evapotranspiration forcing, particularly under variable climatic conditions. The Rukwa sub-basin models are physically-based (of the Sacramento model type) and are designed to simulate the important hydrologic processes operating at the watershed scale including interception, infiltration/percolation, evapotranspiration, surface and subsurface runoff, soil moisture storage, and channel routing. The models include two subsurface soil moisture storage compartments and have a monthly temporal resolution. Model parameters are calibrated to concurrent sequences of rainfall, PET, and streamflow. Model calibration is assessed through several performance measures including error and correlation statistics between simulated and observed streamflows, and expected frequencies of outlier data values. The development of the watershed models is described in Interim Report II, Volume II (*Sub-basin Water Balance Assessments*). The model errors remaining after parameter calibration provide very useful guidance on needed improvements of the hydro-climatic monitoring network. Such information was extensively used in the development of the Lake Rukwa monitoring plan (Final Report, Volume VI, *Basin Monitoring Plan*).

Decadal simulation of historical watershed streamflows: Third, the calibrated rainfall-runoff models were used in connection with available historical rainfall and PET observations (from local and/or international sources) to simulate the sub-basin streamflow response over several decades outside the model calibration period. These long (multi-decadal) streamflow sequences represent the natural flow response of the respective watersheds (unimpaired flows) and were used to characterize the watershed water supply availability, including its inter-annual to decadal hydrologic variability and the frequency and severity of historical droughts and wet climatic periods. Natural streamflow series were also generated for ungaged watersheds (i.e., watersheds without or insufficient data to support formal hydrologic model calibration). This was achieved through proper regionalization of model parameters based on topographic and hydro-climatic watershed similarities. The quantitative understanding of droughts and floods is critical knowledge for assessing (i) the natural capacity of watersheds to meet specific water use targets during critical hydrologic periods and (ii) the relative effectiveness of alternative storage development options to mitigate any existing water supply–demand gaps. The simulated flow sequences are presented and discussed in Interim Report II, Volume II (*Sub-basin Water Balance Assessments*) and are also included in the *Rukwa DSS v3.0* (Final Report, Volume V) as part of the database used by the modeling tools.

Watershed and lake simulation and scenario assessments: Lastly, detailed water balance models for individual watersheds and the entire Lake Rukwa Basin were developed to quantify their response to (i) historical and future climate conditions, (ii) current or projected water use targets, and (iii) alternative management interventions, such as new storage reservoirs and improved irrigation schemes. In this regard, two notable modeling contributions were (a) the development of the Lake Rukwa model and (b) the development of tools to identify and assess promising storage development options that may exist practically anywhere in the basin watersheds. The Lake Rukwa model helped develop a new understanding of the unique way in which Lake Rukwa interacts with the surrounding wetlands and the underlying aquifer, and enabled the critical lake assessments reported in Interim Report II, Volume II (*Sub-basin Water Balance Assessments*).

The storage assessment tools combined (i) geospatial (GIS) methods for the identification of alternative reservoir sites based on basin topography (using available digital elevation models, DEMs), (ii) hydrologic regionalization methods to generate climatically consistent inflow series at the identified reservoir sites, and (iii) detailed reservoir simulation and assessment methods to assess the relative effectiveness of the identified reservoir sites for different hydrologic, demand, and management scenarios. These tools enabled the assessment of multiple reservoir development options (of different sizes) at nearly 3,800 river sites in the Lake Rukwa Basin, and identified the most promising development options recommended for each sub-basin [Final Report, Volume II (a) to (f): *Sub-basin Water Resources Management and Development Plans*].

3.3 Lake Rukwa Basin IWRMDP Plan Reports

A complete list of the documents associated with the Lake Rukwa IWRMD Plan is shown in **Table 3.1** below. The Lake Rukwa Basin IWRMD Plan comprises all volumes in Interim Report I, Interim Report II, and Final Report. The interim reports are essential components of the IWRMD Plan, providing detailed description of the science underpinning the plan recommendations.

Table 3.1: Lake Rukwa IWRMD Plan Reports

Phase	Deliverable	Report Volumes	Date Completed
Inception Phase	Inception Report	Final Inception Report	November 29, 2012
Interim Phase I	Interim Report I	**Volume I**: Lake Rukwa Basin Socio-economic Profile and Water Resources Management Framework. **Volume II**: Water Resources Availability Assessment. **Volume III**: Current Water Demand and Use Assessment. **Volume IV**: Rukwa DSS v1.0	June 6, 2014
Interim Phase II	Interim Report II	**Volume I**: Water Demand Projections (2015 – 2035). **Volume II**: Sub-basin Water Balance Assessments. **Volume III**: Sub-basin Environmental Flow and River Health Assessments. **Volume IV**: Pre-feasibility Studies for Mwamapuli and Kakese Irrigation Projects. **Volume V**: Rukwa DSS v2.0.	March 18, 2015
Final Phase	Final Report	**Volume I**: Lake Rukwa Basin IWRMD Plan Main Report. **Volume II**: Sub-basin Water Resources Management and Development Plans. **Volume III**: IWRMD Plan Implementation Strategy and Action Plan. **Volume IV**: Capacity Building and Stakeholder Participation Plan. **Volume V**: Rukwa DSS v3.0 **Volume VI**: Lake Rukwa Basin Monitoring Plan	April 30, 2016

4. Water Demand Projections

Basin water use, though currently low, is projected to grow significantly in the near future due to a growing population, expansion of irrigated agriculture, and general increase in the basin other socio-economic activities. Sectoral water demand projections (see **Figure 4.1**) indicate that the biggest increase in water demand over the planning horizon is expected to be in the irrigation sector (631.7 million m^3, accounting for 90% of total basin increase by 2035). Other sectors are expected to experience much smaller increases in water demand: Domestic water demand (56 million m^3, accounting for 8%); Livestock water demand (8 million m^3, accounting for 1%); and Industrial water demand (2 million m^3, accounting for less than 1% of total basin increase). The basin total consumptive water demand is projected to increase from 600.42 million m^3 in 2015 to about 1298.49 million m^3 in 2035, an increase of about 116%.

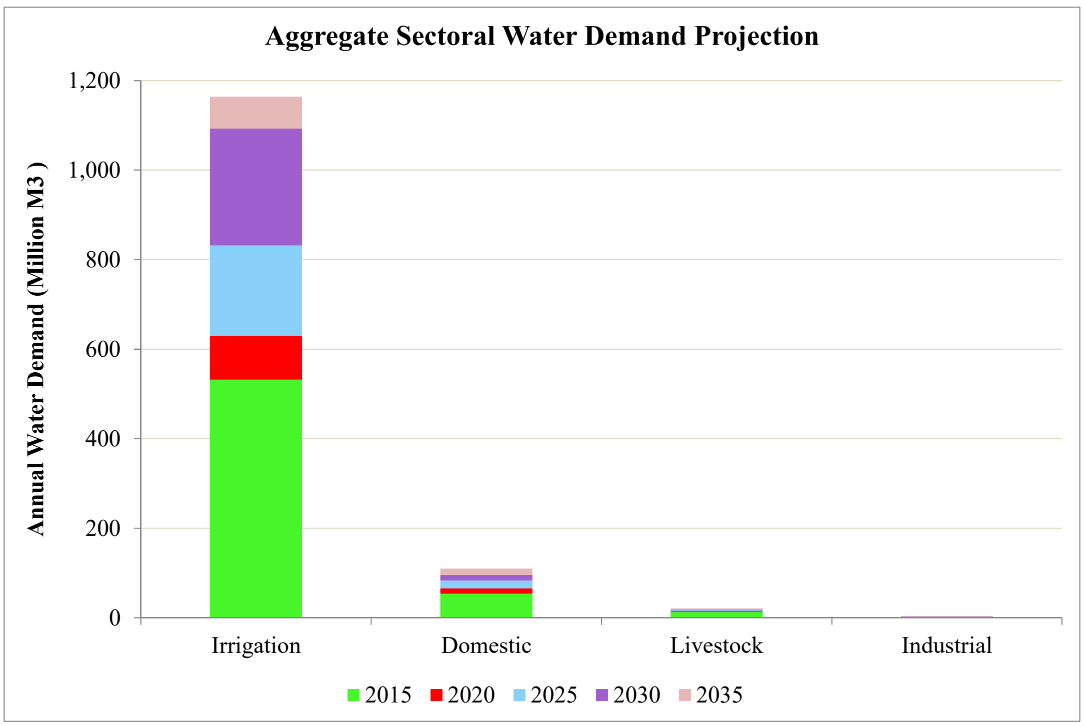

Figure 4.1: Sectoral Water Demand Projections.

Currently, less than 50% of the potential irrigable land is under irrigation. This implies that significant potential still exists for future irrigation expansion. The rising water demands are expected to exert more pressure on water resources and intensify conflicts among competing water uses. The situation is likely to be exacerbated by global climate change, the impacts of which are already being manifested in more severe and more frequent droughts and floods. The challenge of the basin management authorities is to curb inefficient water use and demand growth, balance supply and demand in the face of decreasing supplies, and maintain environmental integrity.

At sub-basin level, Katuma currently accounts for about 70% of the total basin water consumption. This is mostly attributed to the intensive irrigation water use for paddy production in the traditional irrigation schemes. Sub-basin aggregate water demand projections (see **Figure 4.2**) indicate that the largest water demand increase over the planning horizon is anticipated in Momba (267 million m^3, accounting for 38% of total basin increase). This increase is associated with ambitious plans for large scale irrigation expansion in this sub-basin. Other sub-basins with fairly large projected water demand increases include: Lake Shores (207 million m^3, accounting for 30% of total basin increase), Katuma (103 million m^3, accounting for 15% of total basin increase), and Songwe (67 million m^3, accounting for 10% of total basin increase). If these plans materialize, Katuma is projected to have the highest water demand of about 525.5 million m^3 accounting for 41% of the total basin water demand. The 2035 projected demand targets for other sub-basins are as follows: Momba (317 million m^3, 24% of total basin demand), Lake Shores (258.4 million m^3, 20% of total), and Songwe (127.4 million m^3, 10% of total).

Detailed discussions of the basin water demand projections are presented in **Interim Report II, Volume I:** *Water Demand Projections.*

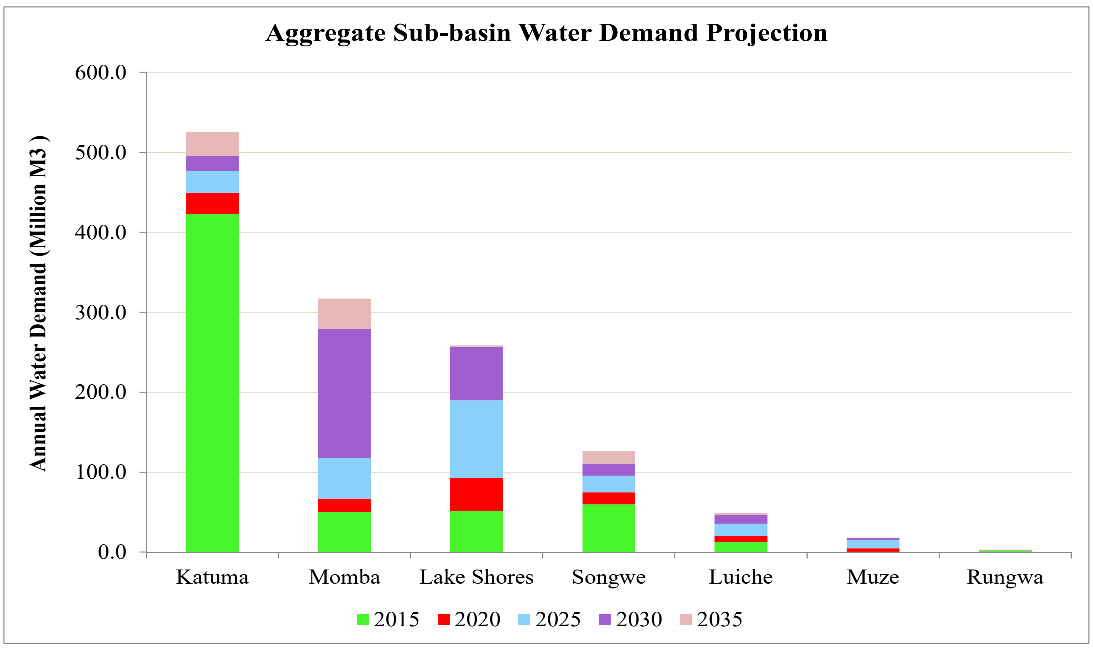

Figure 4.2: Total Water Demand Projections by Sub-basin.

5. Sub-basin Water Balance Assessments

The main findings and conclusions from the sub-basin water balance assessments (**Interim Report II, Volume II:** *Sub-basin Water Balance Assessments*) are as follows:

(1) Lake Rukwa Basin lacks adequate water resources data and information. Although most of the sub-basins are gaged, flow measurements are irregular and inconsistent creating large data gaps. Groundwater data is totally lacking. In addition, there are no systematic water use or withdrawal measurements in most sub-basins. Inadequate and unreliable data present a serious challenge for water resources planning and management processes. It is important that LRBWB put high priority on data collection and management in all basin watersheds to support more accurate and reliable water resources assessments.

(2) Most sub-basins are already experiencing water stress even under current water demand levels. Paddy production, especially in Katuma sub-basin, dwarfs all other water uses. The only exception is the Songwe sub-basin where paddy production is not as popular as in other basin areas. High water use in paddy growing sub-basins is mostly attributed to paddy production by traditional irrigation schemes characterized by poor irrigation infrastructure and inefficient irrigation practices suffering high water losses. Although at an annual level most sub-basins do not seem to experience deficits, all sub-basins are vulnerable to monthly water deficits. Without appropriate intervention measures, water deficits will grow with rising demands and will inevitably undermine the socio-economic value of all water related sectors. Structural measures like construction of water storage reservoirs could help eliminate some water deficits and restore environmental flow conditions. These should go hand-in-hand with demand management measures, especially through improvements in irrigation infrastructure and on-farm irrigation water use efficiency. Improvements in irrigation water use efficiency (through lining of irrigation canals and adoption of efficient irrigation water use practices and technologies) could reduce the current demand by half. Such interventions can most likely address the observed shortages. These measures coupled with more sustainable agronomic practices, such as diversifying from paddy growing to other, less water-intensive high value crops, could reverse the current trend of unsustainable demand growth.

(3) Lake Rukwa sub-basins experience water stress at different times of the year and for different reasons. Unlike the other sub-basins that experience most water stress during the wet season (paddy growing season), the Songwe sub-basin experiences water shortages during the dry season when supply is low. Thus, individual sub-basins have unique water issues that warrant unique solutions. Paddy growing sub-basins have to confront the challenge of inefficient irrigation as part of the strategy to address water deficits. For several of the sub-basins, structural measures like construction of water storage infrastructure could help reduce water deficits. Conjunctive use of surface and groundwater is another potential water supply augmentation measure. However, lack of data and information on the basin groundwater potential makes this option speculative and underscores the critical importance of groundwater monitoring.

(4) Although subsection 6(2) of the Water Resources Management Act (2009) prioritizes water allocation for domestic purposes first, water for environmental reserves second, and water for socioeconomic activities third, the current practice of water allocation and use

in the basin does not follow the legislative mandate. Instead, the common practice is to first allocate water for all non-environmental uses and leave the residual flow for the environment. It is uncommon for current water allocation decisions to explicitly take into consideration specific EFRs. This may be attributed to the complexity of assessing EFRs and to the lack of data for developing EFRs at critical river sections. It is therefore important that comprehensive basin-wide environmental flow assessments are carried out to establish EFRs for all critical river sections. Proactive management actions should also be taken to protect these EFRs from competing water uses.

(5) The Lake Rukwa basin is vulnerable to climate change. Climate change is expected to impact the basin hydrology and water resources primarily through increased evapotranspiration from watersheds, wetlands, and lakes. Higher evapotranspiration is likely to reduce surface water flows, soil moisture, groundwater recharge, and lake levels. In addition to supply side impacts, higher evapotranspiration is likely to increase agricultural water demand (due to increased crop evapotranspiration) and possibly demand for other water uses. The water balance assessment findings highlight notable decreases in future streamflow in all major rivers in the basin. Particularly, Lake Rukwa, being the ultimate recipient of flows from all basin areas, is most vulnerable to the reinforcing impacts of climate change and increasing water demands. It is very important that climate change impacts and risks be understood and considered *proactively* in water resources planning and management decisions. A comprehensive basin climate change adaptation strategy is urgently needed to ensure that climate change issues are given due attention in all basin planning processes.

Several recommendations are included in the Basin Plan to address the above issues. Some of the most critical recommendations are listed below:

(1) The assessments undertaken for the development of Lake Rukwa Basin Plan highlight the vulnerability of Lake Rukwa to the combined stresses of climate change and water consumption growth under current practices. The assessments demonstrate that the basin has reached a historic crossroads, in which consumptive use growth beyond the 2015 water use levels will take a heavy toll in the long term sustainability of Lake Rukwa and other environmentally sensitive areas. The environmental impacts notwithstanding, such consumptive use increases would undermine the interests of the individual sectors they promise to benefit. Basin stakeholders, government authorities, and private investors in the agricultural sector must realize that expansion of irrigated lands under current management practices in Katuma and other intensely cultivated areas will lead to more frequent and more severe irrigation shortages, exposing the sector to higher socio-economic risks and diminishing investment returns. This does not imply that the agricultural sector should abandon future expansion plans; only that such plans must be contingent on concurrent and equivalent irrigation efficiency improvements to ensure that total consumptive use does not exceed natural supplies. It is thus recommended that a moratorium be imposed on further expansion of irrigation activities as the LRBWB works together with farmers and other basin stakeholders to improve irrigation water use efficiency and reduce consumptive water use and demand in the long term. The LRBWB should consider lifting the moratorium after it has factual and verifiable evidence that the Plan interventions have been satisfactorily implemented and the targeted water use efficiency gains have actually been achieved.

(2) Improvements in irrigation water supply infrastructure should commence immediately in all traditional irrigation schemes to minimize water losses and improve irrigation water use

efficiency. This activity requires proper supervision and coordination from the LRBWB to ensure that the intended reductions in irrigation water use are achieved. The LRBWB should require, as a condition for irrigation permit renewal, that all existing permit holders commit to an agreed time-bound plan to line all their irrigation canals, install permanent water diversion control and quantity measuring structures and devices, construct lined return canals, and implement a self-monitoring water abstraction program with mandatory periodic submission of water abstraction data to the LRBWB. Permit holders should be required to demonstrate substantive and factual progress toward improving irrigation efficiency in their farms before their permits can be renewed. The LRBWB should work closely with farmers and other stakeholders to set realistic improvement targets (and milestones) to be met by all permit holders in the basin.

(3) Construction of water supply reservoirs, where feasible, should be undertaken to increase sub-basin water storage capacity and help mitigate water use deficits to within acceptable risk levels. Most promising development options are identified and recommended for each sub-basin in Final Report, Volume II (a) to (f): *Sub-basin Water Resources Management and Development Plans.* Detailed follow-up field studies are recommended to ascertain technical, economic, and environmental feasibility of the identified storage sites so that construction plans are finalized and implemented as soon as possible.

(4) Relevant authorities (e.g., MAFC, LGA, LRBWB, etc.) should begin sensitizing farmers regarding the challenges associated with intensive paddy production and work toward reducing the irrigated paddy acreage to sustainable levels. Realistic targets for irrigated paddy acreage reduction should be set and agreed upon with farmers to help monitor Plan implementation progress. Farmers should also be advised (by extension services) to experiment with and consider adopting other, less water-intensive rice varieties and/or diversify into production of more drought-resistant crops.

(5) Inter catchment/basin water transfers, where feasible, present opportunities for water scarce watersheds to augment their water resources. Such promising opportunities have been identified for the Songwe and the Momba sub-basins. However, more detailed assessments are recommended to ensure that the potential water transfers do not compromise the long-term water use and environmental sustainability of the source watersheds.

6. IWRMD Plan

6.1 Sub-basin IWRMD Plans

Sub-basin Water Resources Management and Development (WRMD) Plans highlight the major water resources management and development issues specific to each sub-basin and the corresponding priority intervention measures to address the sub-basin water needs in the short-, medium-, and long-term. They are the basis for the development of the Lake Rukwa Basin Integrated Water Resources Management and Development (IWRMD) Plan. The individual sub-basin plans are presented as **Volume II (a)** to **(f)**: *Sub-basin Water Resources Management and Development Plans* for Katuma, Songwe, Momba, Luiche, Muze, and Rungwa.

6.2 Strategic Objectives and Priority Actions

The matrix below presents the IWRMD Plan strategic objectives and priority actions, as detailed in the individual sub-basin water resources management and development plans.

Strategic Objective	Priority Actions
Strategic Objective 1: To achieve sustainable balance between water supply and demand in an environmentally friendly manner.	• Ensure availability of water resources of adequate quantity and quality to satisfy current and future basin water demands. • Achieve sustainable water demand growth over the planning horizon. • Incorporate climate change impacts in all basin water resources planning and management decisions.
Strategic Objective 2: To ensure availability of adequate and reliable water resources data for all watersheds and aquifers.	• Upgrade and expand the existing water resources monitoring network to cover all important watersheds and aquifers. • Review and upgrade existing data processing, storage, and assessment hardware and tools.
Strategic Objective 3: To identify and register all basin water uses and ensure full compliant with permitting requirements.	• Undertake comprehensive annual water use surveys to identify and register all basin water uses. • Establish water abstraction and use monitoring network to quantify basin water use. • To strengthen permit enforcement and compliance monitoring mechanisms.
Strategic Objective 4: To determine and ensure compliance with the environmental flow requirements for all critical basin river sections.	• Undertake detailed environmental flow assessments for all critical basin river sections and establish appropriate environmental flow requirements. • Monitor and ensure compliance with established environmental flow requirements.
Strategic Objective 5: To promote integrated watershed management and environmental conservation	• To protect vulnerable watersheds and reverse basin environmental degradation. • To control pollution from point and non-point sources.
Strategic Objective 6: To strengthen the capacity for water resources management at all basin levels.	• Establish all lower level WRM entities and committees as provided for under the WRM Act (2009) and empower them to effectively undertake their mandates. • Strengthen the technical and financial capacity of the LRBWB to ensure effective and timely implementation of planned activities. Empower all key basin stakeholders to ensure their active and sustained involvement in WRM activities.

The IWRMD Plan strategic objectives, goals, and priority actions are discussed in detail in the IWRMD Plan **Final Report**, **Volume I:** *Lake Rukwa Basin IWRMD Plan.*

6.3 Strategic Action Plan

The Lake Rukwa Basin Strategic Action Plan (SAP) is based on the specific objectives and priority actions presented in the previous section. The SAP shows the proposed sequencing and duration of implementation of each of the planned activities. It provides specific timelines for achieving desired targets during the implementation process and is thus a useful tool for monitoring implementation progress against budget expenditures. The detailed SAP is presented in **Final Report**, **Volume I:** *Lake Rukwa Basin IWRMD Plan.*

6.4 Budget Estimates

The total estimated budget required for implementation of the Lake Rukwa Basin IWRMD Plan over the period 2016 to 2035 is estimated at 176.68 Billion TShs. The budget estimates are derived using unit costs from several planning documents including the Lake Rukwa Basin Business Plan, WSDP—Programme Implementation Manual, District Development Plans, Five Year Development Program-1 and several other sources. **Table 6.1** shows the budget estimates by program area and implementation phase. Program 1 (Water Security Enhancement) has the highest budget allocation (55%) because of the high capital costs associated with construction of water storage and supply infrastructure. Phase 1 activities account for the highest percentage of the budget (30%) because of the initial investments in the water resources monitoring network and the several initial technical studies to be undertaken under most programs.

Table 6.1: Budget Estimates by Program

	Rukwa IWRMD Plan Summary Budget Estimate (TShs Billion)				
PROGRAM	**Phase 1 (2016-2020)**	**Phase 2 (2020-2025)**	**Phase 3 (2025-2030)**	**Phase 4 (2030-2035)**	**TOTAL**
PROGRAM 1: Water Security Enhancement Program	27.10	20.60	21.60	24.60	**93.90**
PROGRAM 2: Environmental Flow Assessment and Monitoring Program	4.14	1.60	1.60	4.14	**11.48**
PROGRAM 3: Water Resources Monitoring and Assessment Program	8.94	2.80	3.34	3.40	**18.48**
PROGRAM 4: Water Permit Enforcement and Compliance Monitoring Program	2.94	2.80	2.84	2.80	**11.38**
PROGRAM 5: Integrated Watershed Management and Environmental Conservation Program	5.30	5.30	5.30	5.30	**21.20**
PROGRAM 6: Human and Institutional Capacity Development Program	5.24	5.00	5.00	5.00	**20.24**
TOTAL	**53.66**	**38.10**	**39.68**	**45.24**	**176.68**

6.5 IWRMD Plan Implementation Strategy

The proposed IWRMD Plan implementation strategy is intended to ensure that the IWRMD Plan activities are integrated within the national strategic, medium-term, and short-term planning processes. To achieve the required synergy, first and foremost, it is expected that all sectors "buy into" the concept of integrated planning and recognize the IWRMD Plan as an important basin planning document for basin water resources management and development. Secondly, all water related sectors should use the IWRMD Plan as one of the main reference documents during their routine planning and budgeting processes. This will ensure that the IWRMD planned activities are incorporated into the FYDPs, MTEFs, and sectoral and LGA annual work plans and budgets to guarantee their funding and implementation. Support of the basin LGAs, private sector, and development partners is particularly crucial during the IWRMD Plan implementation process.

The above represent a paradigm shift in current administrative practices, and to ensure that such a shift occurs, a multi-pronged approach is recommended to popularize the IWRMD Plan among all stakeholder agencies and groups. First, the LRBWB (and the Ministry of Water) should invest in disseminating the IWRMD Plan and sensitizing all stakeholders at national and local levels.

Second, a high level directive should be communicated from the central government giving strong recognition to the IWRMD Plan as an important government planning document and instructing all concerned MDAs and LGAs to begin reference it in their planning and budgeting process. Such a directive could be issued by the Office of the President through the President's Office Planning Commission responsible for coordination of national development planning processes.

Third, the Ministry of Water should follow up with the Ministry of Finance to ensure that the annual budget call circulars include an explicit directive to the responsible MDAs and LGAs requiring that all sectoral and LGA budget submissions should show proof that their budgeting requests are consistent with relevant IWRMD Plan recommendations and actions.

Lastly, the LRBWB should ensure that preparation of all future basin business plans be based on the approved IWRMD Plan.

6.6 Plan Implementation Roles and Coordination

Implementation of the Lake Rukwa Basin IWRMD Plan requires involvement of several stakeholder agencies and organizations at national and local levels. Thus, there is need for effective coordination of different stakeholder inputs to avoid duplication of efforts. The specific roles to be played by individual stakeholder institutions and groups shall be in line with their formal mandates. Being the legally mandated steward of water resources management in Lake Rukwa basin, the LRBWB will play a central role in coordinating implementation of the IWRMD Plan activities in the basin. The Ministry of Water shall provide overall policy and technical guidance and also coordinate inputs by national level stakeholder agencies. Specifically, the Ministry will coordinate mobilization of financial resources from different funding agencies and development partners required to ensure successful implementation of the IWRMD Plan. LGAs, WUAs, NGOs, and CBOs will help in mobilization of local community participation in Plan implementation. Concerned line ministries and statutory agencies will also be involved in resources mobilization and provision of technical support and guidance in implementation of Plan activities within their mandates. Regular (quarterly/biannual) inter sectoral coordination meetings shall be convened by the LRBWB to review implementation progress and address any emerging issues. Detailed description of implementation roles and coordination mechanisms, including those related to plan monitoring and evaluation, is presented in **Volume III**: *IWRMD Plan Implementation Strategy and Action Plan.*

6.7 Action Plan

Following preparation of the IWRMD Plan, a number of preparatory activities will have to be implemented before actual Plan implementation can begin on the ground. The Action Plan presented in this section addresses the activities intended to initiate the Plan implementation process following its approval. The actual scheduling of activities in the Action Plan is therefore contingent on when the Plan will be approved. The preparatory phase activities include:

- IWRMD Plan launch and high-level awareness raising;
- IWRMD Plan dissemination and general stakeholder sensitization;
- Initiation of the process to integrate the IWRMD Plan into national planning and budgeting processes;
- Mobilization of the necessary financial resources for Plan implementation; and
- Mobilization and set-up of the necessary coordination and implementation structures.

The preparatory phase activities are estimated to last up to 18 months from the date of approval of the Plan and cost about 437 million Tshs. Details of the activities and their scheduling and cost estimates are presented in **Volume III**: *IWRMD Plan Implementation Strategy and Action Plan*.

6.8 Communication Plan

Being a multi-sectoral undertaking, it is important that the IWRMD Plan implementation process is as transparent as possible to ensure maximum stakeholder ownership and support. This will require effective and routine communication with and information dissemination to stakeholders regarding progress of activity implementation, accountability for resource utilization, and demonstration of expected outputs and outcomes. Because of the significant information to be generated by different implementation agencies, it is important that all activities be channelled through a central unit that will be responsible for properly synthesizing and packaging the information to be communicated to different stakeholder groups. The proposed Communication Plan includes, among others, the following information dissemination strategies:

(i) Conduct regional stakeholder workshops to officially launch the IWRMD Plan implementation process;
(ii) Conduct sensitization campaigns and focus group briefings/discussions for different stakeholder groups at the national level (Members of Parliament, Central Government Ministries/Departments/Agencies, Funding Agencies, Development Partners, NGOs, private sector, media, etc.) regarding the importance and content of the IWRMD Plan and their respective implementation roles;
(iii) Conduct sensitization campaigns and focus group briefings/discussions for different stakeholder groups at the basin level (LGAs, WUAs, NGOs, CBOs, private sector, media, etc.) regarding the importance and content of the IWRMD Plan and their respective implementation roles;
(iv) Upload the IWRMD Plan and regular implementation progress reports on the LRBWB and Ministry of Water Websites for public access, review, and feedback;
(v) Produce several copies of the IWRMD Plan and distribute to important stakeholders at all levels (national and local);

(vi) Produce a brochure (highlighting the Plan) in Swahili for dissemination to different stakeholder groups at the local level, especially basin Ward and Village leaders, Water User Groups, Irrigation Associations, and others;
(vii) Produce regular Radio and TV programs through which information is aired to the public regarding the IWRMD Plan implementation process and progress updates;
(viii) Hold regular press briefings to update the public on implementation progress and dissemination of important results and outcomes; and
(ix) Hold regular thematic workshops targeting different stakeholder groups to discuss important issues regarding the IWRMD Plan implementation process and findings.

Detailed description of the proposed Communication Plan including planned activities and budget estimates are presented in **Final Report**, **Volume III**: *IWRMD Plan Implementation Strategy and Action Plan*.

6.9 Monitoring and Evaluation Plan

Monitoring and evaluation is a very important component of the IWRMD Plan implementation process. Effective monitoring is required to provide early information on implementation progress toward achieving the intended objectives, outcomes, and impacts of the IWRMD Plan, and to take early and appropriate corrective actions, if necessary. Routine evaluation of IWRMD Plan implementation progress will be required to determine why and the extent to which intended and/or unintended implementation results were achieved, and what overall impact they have on different stakeholder groups. To this end, systematic monitoring shall be undertaken to (i) ascertain that activities are implemented as planned, (ii) verify that intended objectives and targets are achieved in a timely manner, (iii) enable the implementation teams to assess the effectiveness of their implementation strategies and approaches and make appropriate adjustments as necessary.

Detailed description of the proposed Monitoring and Evaluation Plan is presented in **Final Report**, **Volume III**: *IWRMD Plan Implementation Strategy and Action Plan*.

6.10 Review of the IWRMD Plan

The frequency of review and amendment of the IWRMD Plan is specified under Section 31 (4) of the Water Resources Management Act (2009). The Act stipulates that the IWRMD Plan shall be reviewed and amended as appropriate at least once in each successive five year period following Plan approval, but not earlier than three years. Five year Plan reviews and updates are an important part of the monitoring and evaluation process. The review enables the Plan to be regularly updated based on new data and information collected during the implementation process. The periodic review also enables the Plan to benefit from some of the lessons learned in the initial implementation phases, and also to address other emerging basin challenges and take advantage of new development opportunities over time.