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Lake Rukwa Basin IWRMD Plan: Final Report
Volume II (f): Rungwa Sub-basin Water Resources Management and Development Plan

by

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Atlanta, Georgia, USA

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Lake Rukwa Basin Integrated Water Resources Management and Development Plan

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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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Preamble

This report is one of six Final IWRMD Plan Report volumes developed under the project "Lake Rukwa Basin Integrated Water Resources Management and Development Plan (IWRMDP)." This project was carried out for the Ministry of Water, United Republic of Tanzania, under the Water Sector Development Program (WSDP).

A brief description of these reports is provided below.

Volume I: Lake Rukwa Basin IWRMD Plan Main Report – Volume I contains the synthesis of information generated from all project activities with emphasis on the main study findings, conclusions, and recommendations. It contains results from the basin-wide integrated assessments and recommended actions that cut across sub-basins.

Volume II: Sub-basin Water Resources Management and Development Plans – Volume II (a) to (f) of the report series presents the sub-basin specific water resources management and development plans for Katuma, Songwe, Momba, Luiche, Muze, and Rungwa. The sub-basin plans are the basis for development of the basin-wide IWRMD Plan.

Volume III: IWRMD Plan Implementation Strategy and Action Plan – Volume III presents the IWRMD Plan implementation strategy and action plan which includes two main components: (a) the implementation strategy which highlights the administrative and financial modalities of the IWRMD Plan implementation, and identifies the key players to be involved in implementation of the Plan and their corresponding roles; and (b) the Action Plan which outlines the requisite steps to be taken and preparatory activities necessary to kick-start the Plan implementation process. The report also presents the Monitoring and Evaluation Strategy for the IWRMD Plan implementation process and a Communication Plan for information dissemination to the public to facilitate sustained stakeholder engagement and feedback.

Volume IV: Capacity Building and Stakeholder Participation Plan – Volume IV presents the proposed capacity building and stakeholder participation mechanisms. The report identifies the different basin stakeholder groups, assesses their capacity needs, and proposes capacity building measures to enable them to effectively participate in basin water resources management activities, particularly IWRMD Plan implementation.

Volume V: Rukwa Decision Support System (Rukwa DSS v3.0) – Volume V describes the third version of the Lake Rukwa Basin Decision Support System (Rukwa DSS v3.0) developed to support integrated water resources planning and management. The Rukwa DSS v3.0 is a state of the science information and modeling tool including comprehensive databases; data management and analysis tools; and detailed models for hydrologic forecasting, river simulation, and scenario/policy assessment. The report is a systematic guide to the use of this modern information, modeling, and assessment system for integrated planning and management of the basin water resources.

Volume VI: Lake Rukwa Basin Monitoring Plan – This volume provides recommendations for comprehensive monitoring of the basin climate, surface water hydrology, groundwater hydrology, and water quality. The condition of the existing monitoring networks is critically reviewed and existing gaps identified. Guiding principles for the design of effective monitoring

networks are outlined and used as the basis for specific recommendations on network upgrade, expansion, efficient operation, and coordination. Important data management issues are discussed, and an integrated data and information management process is outlined.

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List of Acronyms and Abreviations

BMUs	Beach Management Units
CC	City Council
CITES	Convention on International Trade in Endangered Wild Flora
COSTECH	Commission for Science and Technology
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 Nationa
GBIF	Global Biodiversity Information Facility
GEF	Global Environmental Facility
GoB	Government of Belgium
GoT	Government of Tanzania
GR	Game Reserve
HEC	Human Elephant Conflict
HIMA	Hifadhi ya Mazingira
IMP	Integrated Management Plan
IUCN	The World Conservation Union
IWRDMP	Integrated Water Resources Development and Management Plan
LRBWB	Lake Rukwa Basin Water Board
MC	Municipal Council
MoLDF	Ministry of Livestock Development and Fisheries
MSY	Maximum Sustainable Yield
MW	Mega Watts
NEAP	National Environmental Action Plan
NEMC	National Environment Management Council
NGO	Non Governmental Organization
MNRT	Ministry of Natural Resources and Tourism
PID	Pelvic Inflammatory Disease
SADC	Southern African Development Cooperation
SMUWC	Sustainable Management of the Usangu Wetland and its Catchment
SRF	Systematic Reconnaissance Flight
TAFIRI	Tanzania Fisheries Research Institute
TAFORI	Tanzania Forestry Research Institute
TANAPA	Tanzania National Parks
TanBIF	Tanzania Biodiversity Information Facility
TAWIRI	Tanzania Wildlife Research Institute
TC	Town Council
TTB	Tanzania Tourism Board
TShs	Tanzanian Shillings
WB	The World Bank
WCS	Wildlife Conservation Society
WCST	Wildlife Conservation Society of Tanzania
WMA	Wildlife Management Area
WREM	Water Resources and Energy Management Incorporated

1. Introduction

The Government of the United Republic of Tanzania is implementing the Water Sector Development Programme (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 whose overall objectives are as follows:

(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, utilizationprotection and conservation of water resources; devolving ownership to the user level; 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 volume constitutes the Water Resources Management and Development (WRMD) Plan for the Rungwa Sub-basin, one of the six sub-basins of the Lake Rukwa Basin. The Sub-basin WRMD Plans are the basis and important inputs to the Lake Rukwa Basin Integrated Water Resources Management and Development (IWRMD) Plan. The Sub-basin Plans highlight the major water resources management and development issues and challenges specific to each sub-basin and identify water allocation priorities between competing users within the different sub-basins. In developing the Sub-basin Plans, a number of detailed assessments were carried out. These included (a) water availability assessments under historical and future climate conditions; (b) current sectoral water use assessments and future water demand projections; (c) water balance assessments under historical and future climate conditions; and (d) identification of specific priority intervention measures to address the sub-basin water needs in the short-, medium-, and long-term. To ensure reliability and relevance of the assessment findings, significant time and effort was dedicated towards collection, review, and quality control of the required information and data used in carrying out different technical assessments. All major sub-basin stakeholders were visited and accorded the opportunity to provide input, express their opinions, and raise any

concerns regarding the Plan development process. Likewise, all basin regional secretariats and districts were visited, and discussions were held with relevant officials to solicit their input into the Plan development process. Specifically, discussions were held with heads of departments in all basin districts on thematic issues to leverage local experience, seek guidance as key stakeholders, and access relevant district-specific and up-to-date data and information. Detailed data/information gathering questionnaires were circulated to all district heads of departments soliciting sector-specific water use related data and information at ward and village levels. The questionnaire response was 100%, indicating that the districts embraced the Plan development process and importance with great enthusiasm. All relevant documents were reviewed and critically assessed including the 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. In addition, detailed questionnaires were also administered to several households (about 50 households per ward) in 40 wards spread 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 significant useful data/information that formed the basis for all the assessments carried out and findings presented in the IWRMD Plan reports.

It was not possible to carry out comprehensive sub-basin water balance assessments for the Rungwa due to the lack of data. Large parts of the sub-basin watersheds are not monitored, largely because they lie within protected areas. It is therefore difficult to estimate with certainty what the sub-basin water availability is under historical and future climate conditions. If water use conflicts are used to represent water scarcity, then Rungwa is a water stressed sub-basin. Water use conflicts during the dry season are comparable to or worse than those in other water stressed sub-basins in Lake Rukwa Basin (e.g., Katuma). Human-wildlife conflicts are common in the Rungwa Game Reserve and surrounding villages. Water shortages during the dry season force wild animals to leave the park confines in search of water in nearby villages. The situation is exacerbated by the influx of pastoralists who encroach on the Game Reserve in search of water and pasture for livestock. The two way movement of wildlife into neighboring villages and pastoralists encroachment on the Game Reserve creates very volatile human-wildlife conflicts resulting in fatalities and deaths. These conflicts are signs of a water stressed sub-basin. However, without data, it is not possible to quantify the temporal and spatial magnitude of the observed water scarcities. The situation is likely to be exacerbated by climate change. Climate change is projected to impact the sub-basin hydrology, vegetation, and water resources through increased temperature and evapotranspiration. These changes are likely to reduce surface water flows, soil moisture, groundwater recharge, and lake levels.

The detailed sub-basin assessment findings, conclusions, and potential intervention measures were extensively reviewed and discussed by sub-basin stakeholders at different fora. Several technical assessment reports containing these findings and conclusions (Interim Reports I and II) were widely circulated to all major stakeholders for review and comments. The reports were also presented at several stakeholder consultation meetings and workshops facilitated by the LRBWB and the project team. Stakeholder comments were extensive and provided guidance to address priority stakeholder interests and concerns. These comments are reflected in the strategic objectives and priority interventions discussed in this report. The interventions were grouped into five strategic program areas to be implemented over the planning period (2016 to 2035):

(1) Water Security Enhancement Program;
(2) Water Resources Monitoring and Assessment Program;

(3) Water Permit Compliance Monitoring Program;
(4) Environment Flow Assessment and Monitoring Program; and
(5) Integrated Watershed Management and Environmental Conservation.

The total estimated budget required for implementation of the Rungwa Sub-basin WRMD Plan from 2016 to 2035 is about 10.53 Billion TShs. The Plan is expected to be reviewed every five years to benefit from updated water resources assessments and additional water resources data collection. The review will also ensure that the Plan is continuously re-aligned to address other emerging sub-basin challenges and to leverage new development opportunities as they arise.

The report is organized into six chapters. Chapter 1 introduced the IWRMD planning process and its general findings for the Muze sub-basin. Chapter 2 provides a general overview of the sub-basin including its location, topography, climate, water availability, and socioeconomic conditions. Chapter 3 discusses the current sectoral water use levels and water demand projections. Chapter 4 presents the sub-basin water balance assessments and highlights the strategies for addressing current and anticipated water deficits. Chapter 5 discusses the sub-basin Plan strategic goals, objectives and priority intervention measures. Lastly, Chapter 6 presents the Strategic Action Plan and estimated budget.

2. Overview of the Rungwa Sub-basin

2.1 Location

The Rungwa Sub-basin occupies the northern part of the Lake Rukwa Basin extending over parts of Chunya, Mlele, Sikonge, and Manyoni Districts (**Figure 2.1**). It covers an area of about 21,640 km^2, and it is the largest sub-basin draining approximately 25% of the Lake Rukwa Basin area. With a population of about 50,289 (2012 National Census), Rungwa is the most sparsely populated sub-basin in the Lake Rukwa Basin and has less than 2% of the total basin population. The sub-basin has an average population growth rate of 1.6% which is below the Tanzania national average of 2.9%. The sub-basin population is projected to increase to about 75,679 by 2035 (see **Figure 2.2**).

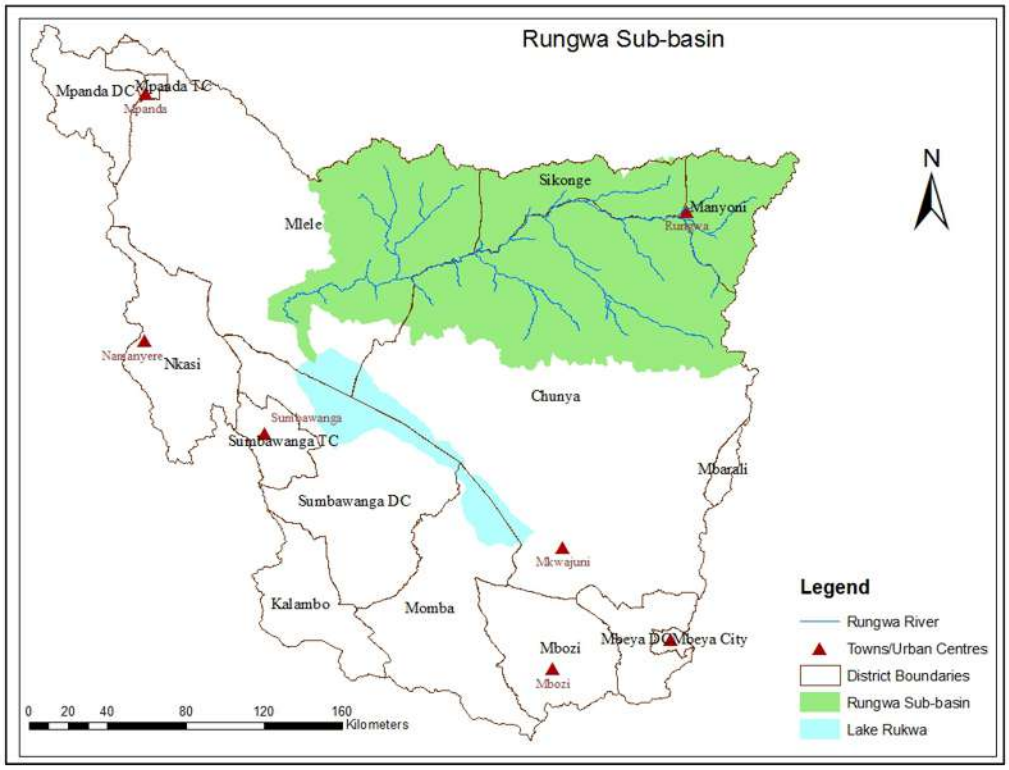

Figure 2.1: Location of the Rungwa Sub-basin.

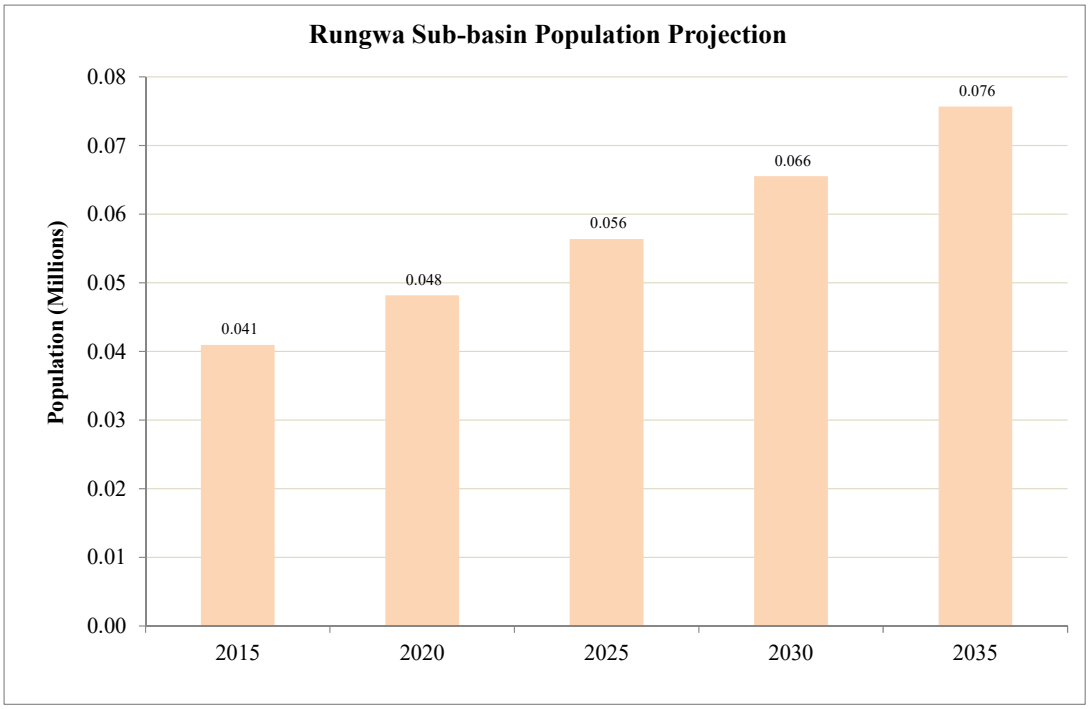

Figure 2.2: Rungwa Sub-basin Population Projection.

2.2 Socioeconomic Conditions

Detailed socioeconomic surveys and assessments were conducted to establish baseline conditions and dependence on the basin's water resources by riparian communities. Detailed findings are presented in ***Volume II: Lake Rukwa Basin Socioeconomic Profile***. Findings for the Rungwa Sub-basin are summarized next.

2.2.1 Socioeconomic Importance

Agriculture is the dominant activity employing more than 95% of the sub-basin population. Vast parts of the Rungwa fall within protected areas (game reserves, forest reserves, and game controlled areas), are mostly uninhabited, and are covered by vast miombo woodlands. Cultivation takes place in a few isolated, densely populated, and scattered settlements. Tobacco is a popular commercial crop grown in isolated complexes. Other crops grown mostly for subsistence include maize, beans, cassava, groundnuts, and sunflower. Bee keeping is popular activity with honey and bee-wax being an important source of household income. Livestock keeping is also practiced in the settled areas on a small scale.

2.2.2 Occupation and Source of Household Income

According to a detailed household survey conducted under this project (WREM International, 2013), the majority (60.4%) of household heads are engaged in agriculture (crop farming and livestock keeping) as their primary occupation (**Figure 2.3**). Other significant occupations include formal and self-employment (retail shops, street vending, brick and craft making, charcoal burning, and transportation). The major source of household income is the sale of

agricultural produce (food and cash crops). About 54.7% of the households depend on agricultural produce sales as their main income (see **Figure 2.4**).

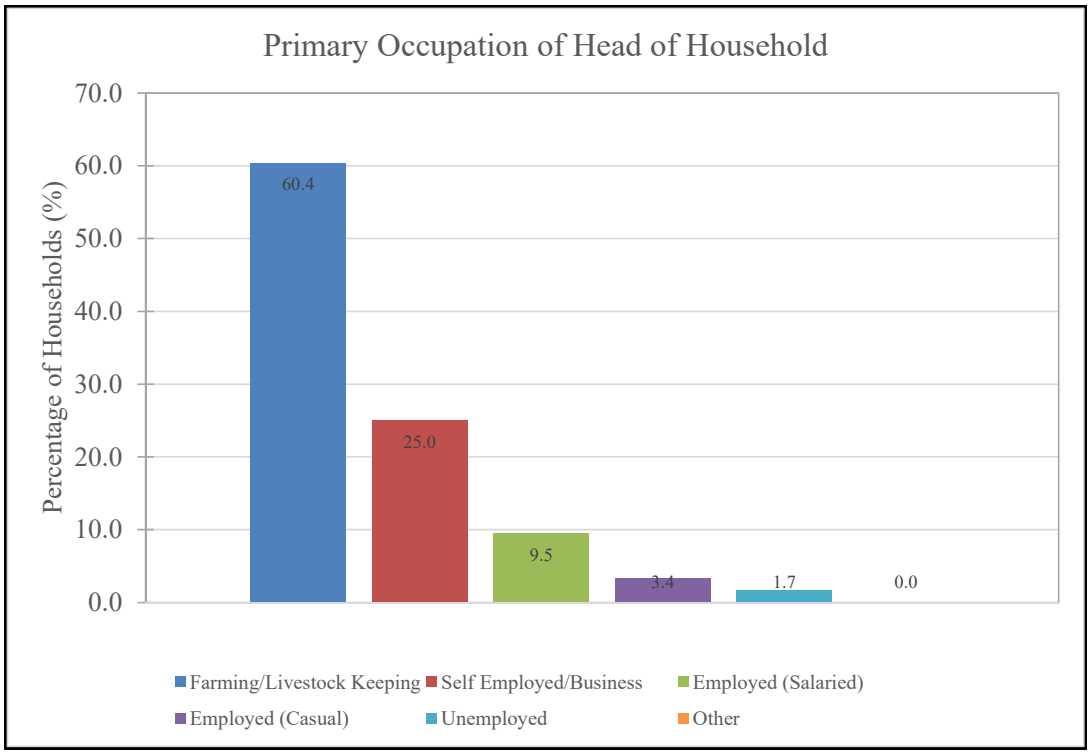

Figure 2.3: Primary Occupations of Heads of Households.

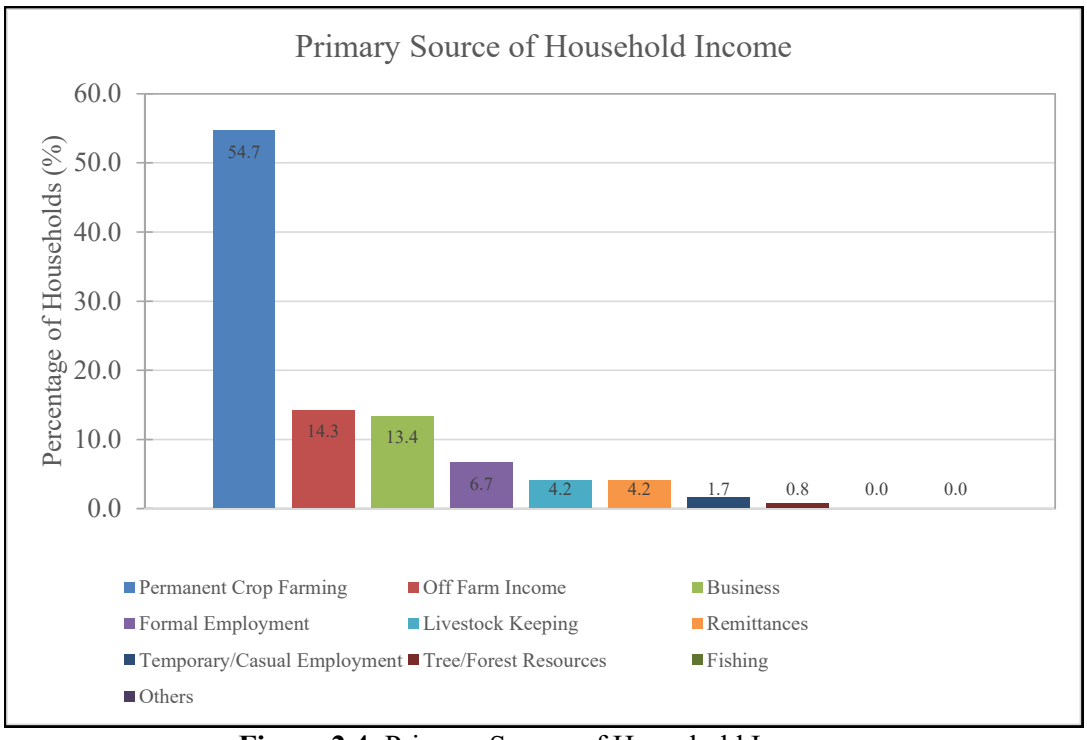

Figure 2.4: Primary Source of Household Income.

2.2.3 Access to Social Services

Domestic Water Supply: Domestic water supply coverage is very low in all sub-basin districts. Average access to clean drinking water is about 43%, which is lower than the 2015 national targets.

Sanitation: The majority (more than 95%) of households rely on traditional pit latrines for their household sanitation. This has implications for water pollution due to poor latrine location and construction. Most pit latrines flood during heavy rains and contaminate neighboring water bodies. The problem is most pronounced in crowded, poorly-planned settlements in urban and peri-urban areas.

Energy Source: Fuel wood in the form of firewood and charcoal is the most important source of energy for more than 95% of the sub-basin population. Wood is mostly used for domestic cooking and lighting and in diverse subsistence economic activities such as brick making, pottery and tobacco curing. Over-reliance on fuel wood is responsible for the wide spread deforestation observed in many sub-basin areas. This has serious environmental consequences including soil erosion, drying up of water sources, and heavy sediment transport and deposition in surface water bodies.

2.3 Water Availability

Detailed water resources availability assessments were conducted for the whole basin and the findings are contained in ***Interim Report I, Volume II: Water Availability Assessments***. Findings for Rungwa sub-basin are summarized next. For more details, the reader is referred to the above report volume.

2.3.1 Climate

The sub-basin experiences one long rainy season (October to April). The dry season extends from around May to October (**Figure 2.5**). Annual rainfall ranges from 900 mm to 1000 mm.

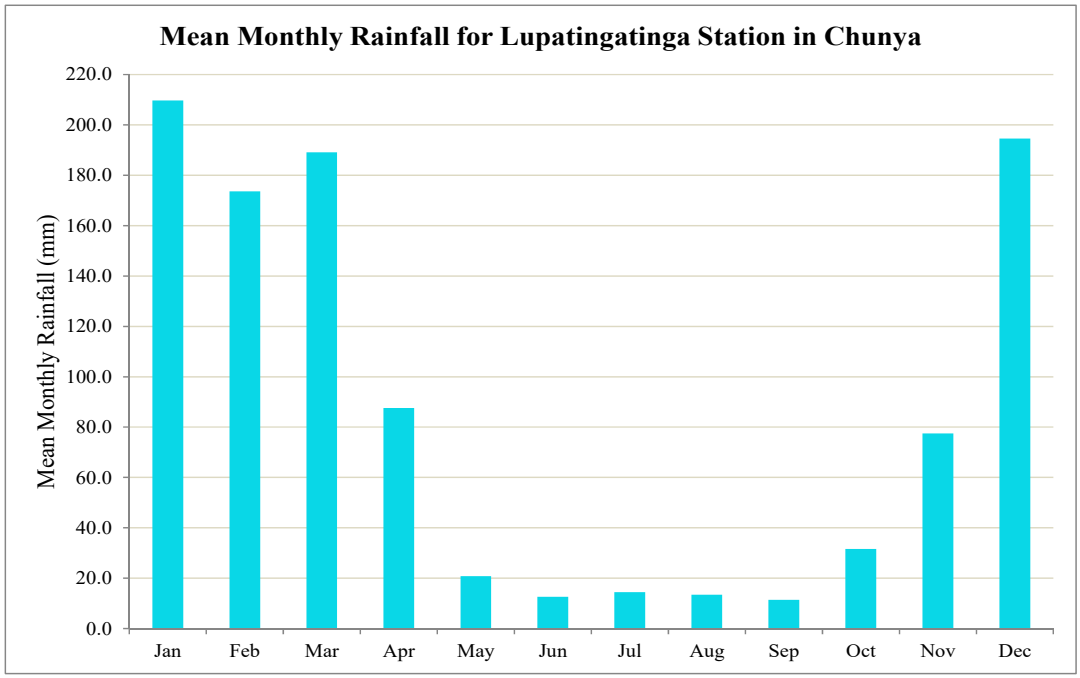

Figure 2.5: Mean Monthly Rainfall for Sumbawanga Maji Depot Station, Sumbawanga Town.

2.3.2 Surface Water Resources

The sub-basin is drained by the Rungwa River and a few other smaller rivers, the most notable ones being Musa, Mkombizi, Piti, and Mwipa. The Rungwa River originates from the Rungwa Swamp on the eastern plateau and flows northwards traversing vast expanses of permanent swamps. The Rungwa River receives inflows from several smaller tributaries before it finally discharges into the Itumba swamp on the northern shores of Lake Rukwa. The main Rungwa tributaries include Rivers Musa and Mkombizi, draining the eastern and northern parts of the sub-basin respectively, and Rivers Piti and Mwipa, draining the southern part of the sub-basin. The Rungwa River exhibits strong seasonality with high flows in the rainy season and low flows the rest of the year.

The Lake Rukwa Basin Water Board operates and maintains a water resources data collection network consisting of (i) two hydrometric stations (Musa River at Musisi (**3DA2**) and Rungwa River at Itigi Road Bridge (**3D4**)) and (ii) three climatic stations shown in **Figure 2.6.** No water quality monitoring stations exist presently. The two hydrometric stations have significant data gaps due to inconsistencies in the monitoring program. No rating curves have been established for the two stations. **Figure 2.6** depicts the uneven spatial distribution of monitoring stations and shows that most of the sub-basin is ungaged, especially in the protected areas (game reserves and forest reserves). In general, the existing data cannot provide any reliable estimate of the river flow generated in the Rungwa sub-basi, nor how much of it actually enters Lake Rukwa. The complete absence of data makes it very difficult to carry out reliable hydrologic and water resources assessments.

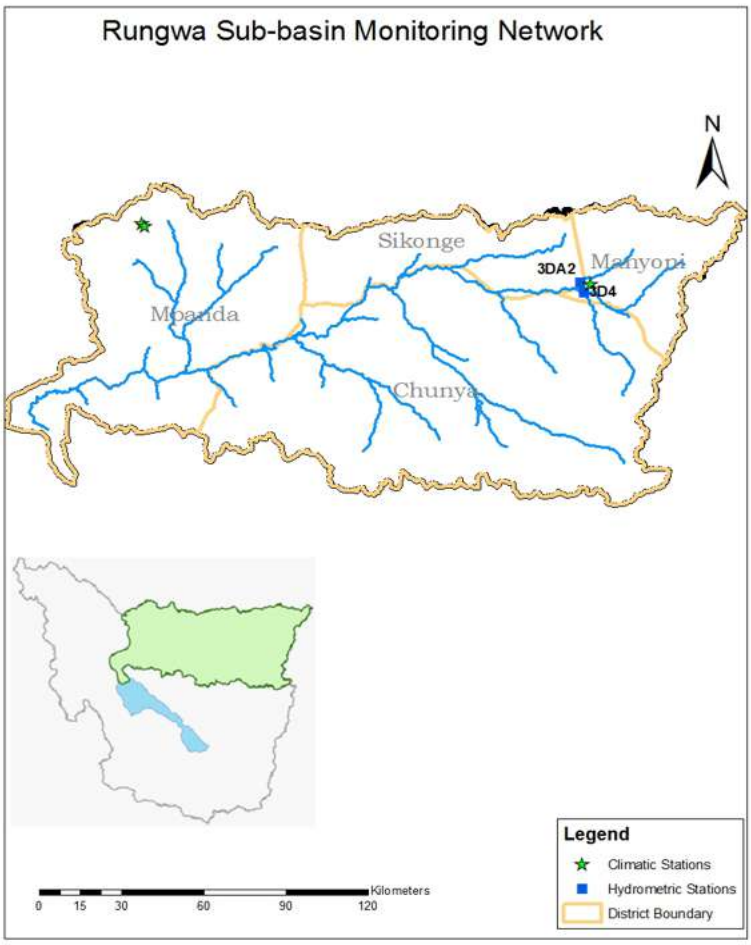

Figure 2.6: Muze Sub-basin Water Resources Monitoring Network.

2.3.3 Groundwater Resources

Groundwater is not presently monitored in the Rungwa Sub-basin, and hydrological data to assess the possible extent and potential of groundwater aquifers does not exist. Nevertheless, groundwater is used for domestic water supply in most rural areas. Thus, groundwater monitoring is needed urgently, and it is highly recommended in the sub-basin plan.

3. Sectoral Water Use and Demand Projections

3.1 Water Use and Demand Projections

The major water uses in the Rungwa Sub-basin are the domestic and livestock sectors which account for 70% and 25% of the total water consumption respectively. There are no significant irrigation activities or industries. The total water demand for the Rungwa sub-basin is projected to increase from 1.80 MCM in 2015 to 3.03 MCM by 2035. The projected increments in the individual sectors are as shown in **Figure 3.1** and **Table 3.1**. Only small increments are projected for the domestic water demand due to the very low human population growth rate. Detailed discussion of water demand projections for all Lake Rukwa sub-basins is contained in a separate report volume (***Interim Report 2, Volume I: Water Demand Projections***). Because the sub-basin is predominantly rural with very sparse settlements, groundwater is the most common source for domestic water supply. **Figure 3.2** shows the location of major water uses in the Rungwa sub-basin

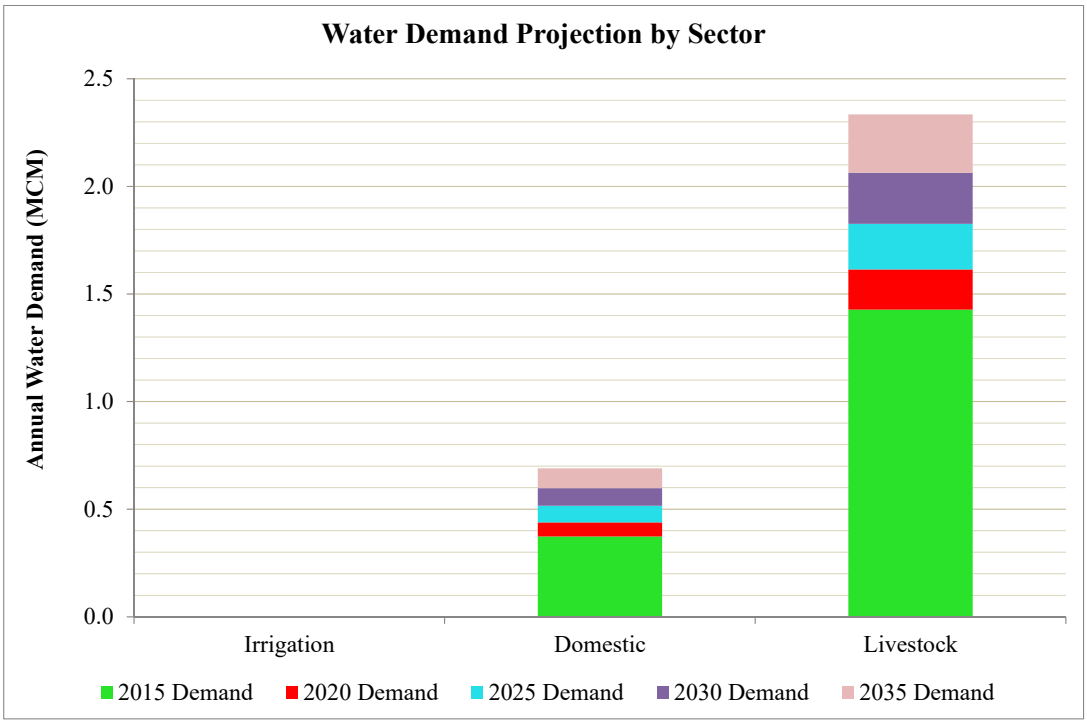

Figure3.1: Rungwa Sub-basin Water Demand Projections.

Table 3.1: Rungwa Sub-basin Water Demand Projections.

Sector	Demand Projection (MCM)				
	2015	**2020**	**2025**	**2030**	**2035**
Irrigation	0.00	0.00	0.00	0.00	0.00
Domestic	0.37	0.44	0.52	0.60	0.69
Livestock	1.43	1.61	1.83	2.06	2.33
Sub-basin Total	**1.80**	**2.05**	**2.34**	**2.66**	**3.03**

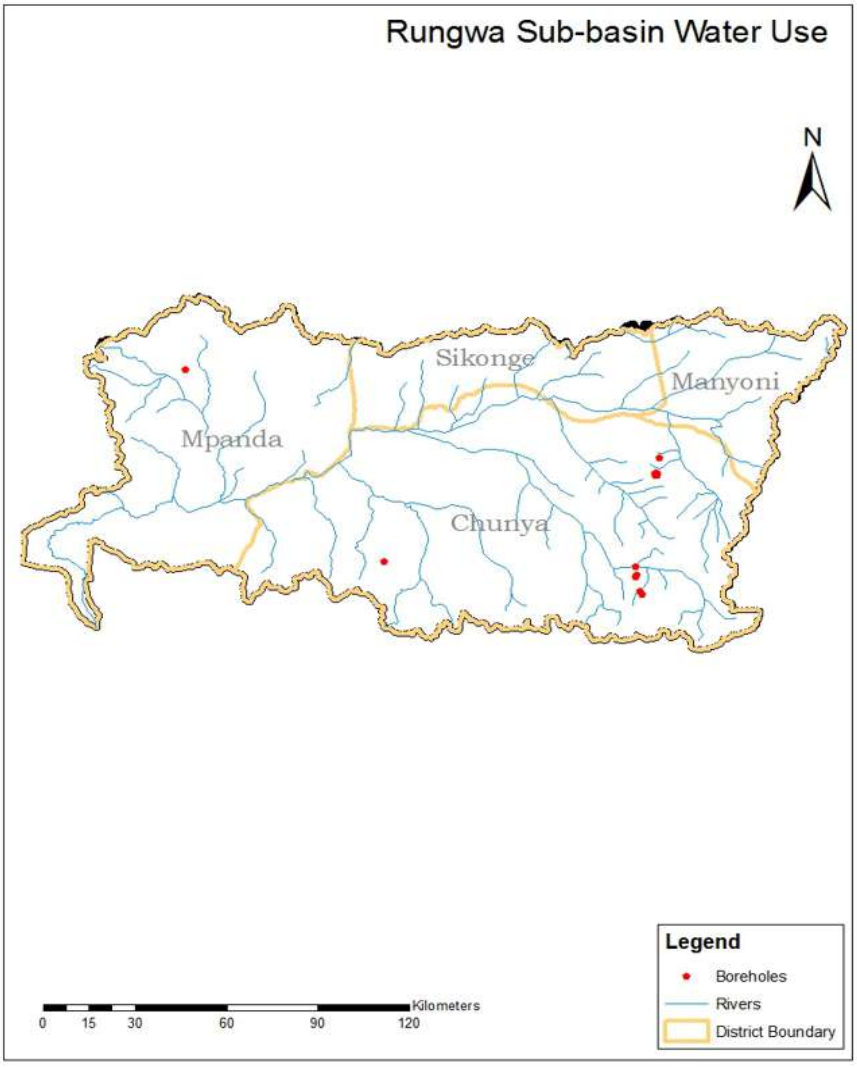

Figure 3.2: Location of Major Water Uses in the Rungwa Sub-basin.

3.1.1 Irrigation Water Use

Because most of the sub-basin falls in protected areas, there are neither ongoing nor planned irrigation activities for the foreseeable future. Therefore irrigation water use has been assumed to remain insignificant over the planning period (2016 to 2035).

3.1.2 Domestic Water Use

Domestic water supply coverage in the Rungwa sub-basin is generally low. The sub-basin domestic water demand is projected to increase from 0.37 MCM in 2015 to about 0.69 MCM by 2035, an increase of about 86% (see **Figure 3.3**).

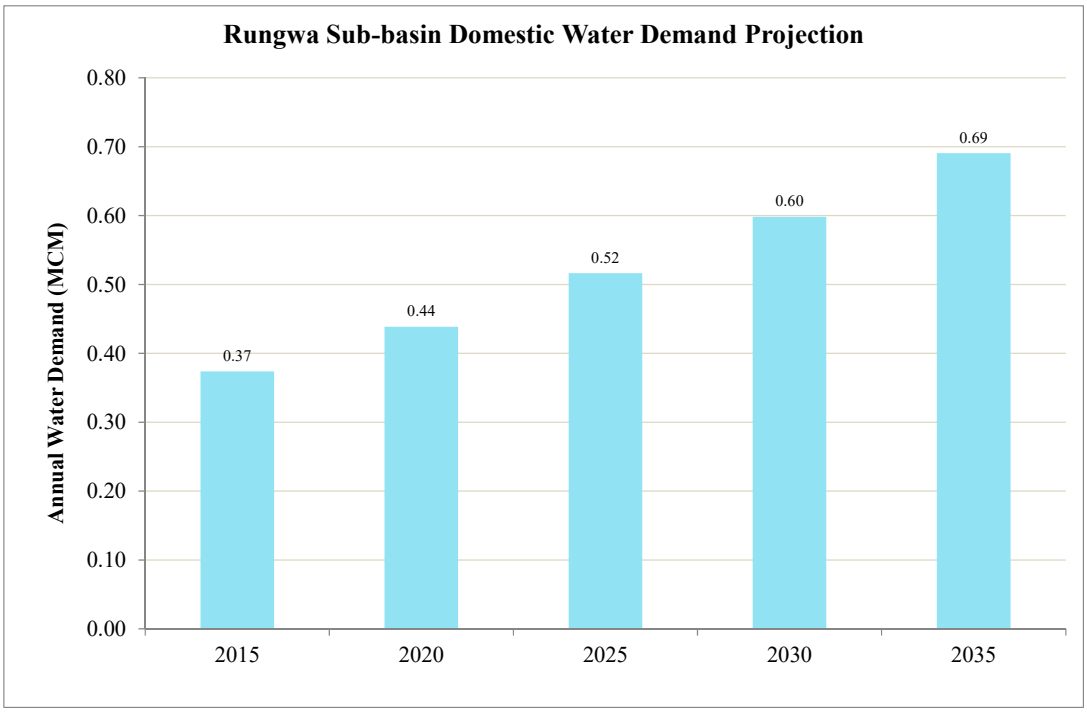

Figure 3.3: Rungwa Sub-basin Domestic Water Demand Projections.

(1) Urban Water Supply

The Rungwa is a predominatly rural sub-basin with no notable urban centers. Urban domestic water supply is insignificant.

(2) Rural Water Supply

Boreholes are the main source of rural water supply for the sub-basin. Of the 59 existing rural water supply sources, 58 are boreholes. Water from rivers, streams, and rainwater harvesting from roof-tops is also commonly used to supplement the existing domestic water supply sources although its quality is very poor compared to borehole water. Groundwater is particularly suitable as a major water supply source for a sparsely populated sub-basin like Rungwa due to its wide spatial distribution, perennial availability, and reasonably good quality.

Implementation of the rural water and sanitation component of WSDP has helped improve rural water supply and sanitation coverage in most districts. WSDP has begun to focus on new projects in villages that do not currently have provisions for water supply or in villages that used to have water supply access facilities but have become inoperable and cannot be viably rehabilitated. This second round of rural water supply infrastructure expansion is expected to significantly improve the rural water supply coverage to within or above the national targets. The biggest challenge, however, is sustainability of the rehabilitated and new water supply infrastructure. Because the rural water supply schemes serve poor communities, they are usually poorly maintained and managed resulting in frequent breakdowns.

3.1.3 Livestock Water Use

Livestock keeping is one of the major socio-economic activities in the Rungwa sub-basin. Domestic animals constitute one of the most important non-land assets owned by the majority of people in rural areas. Livestock products such as milk, meat, eggs, and ghee are a good source of protein to farmers, while any surplus is sold to enhance household incomes. Local and regional demand for livestock products is high and there is very good potential for sustained growth of the livestock industry. The most commonly kept livestock include cattle, goats, and sheep, most of which are indigenous and free ranging. Other commonly kept livestock include pigs, donkeys, chicken, ducks, and pigeons. Total livestock population in the sub-basin is approximately 225,437. **Figure 3.4** shows the sub-basin population for the different livestock types. Cattle are the most commonly kept accounting for about 66% of the total livestock population. Chicken and goats are also popular and account for about 20% and 7.5% of the total sub-basin livestock population respectively. The main sources of water for livestock include rivers, streams, swamps/marshes, and temporary ponds during the rainy season. The annual livestock water consumption for the Rungwa sub-basin is projected to increase from about 0.0723 MCM in 2015 to about 0.118 MCM in 2035 (see **Figure 3.5**). This increase is relatively very small compared to the projected increase in irrigation water demand.

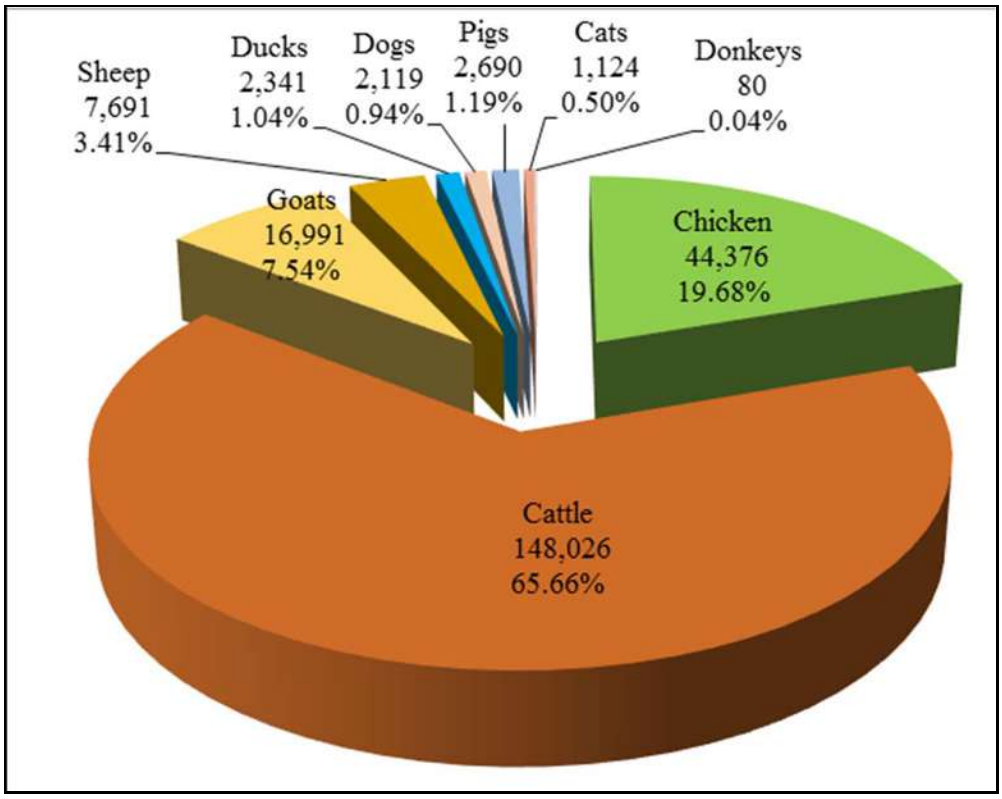

Figure 3.4: Rungwa Sub-basin Livestock Population.

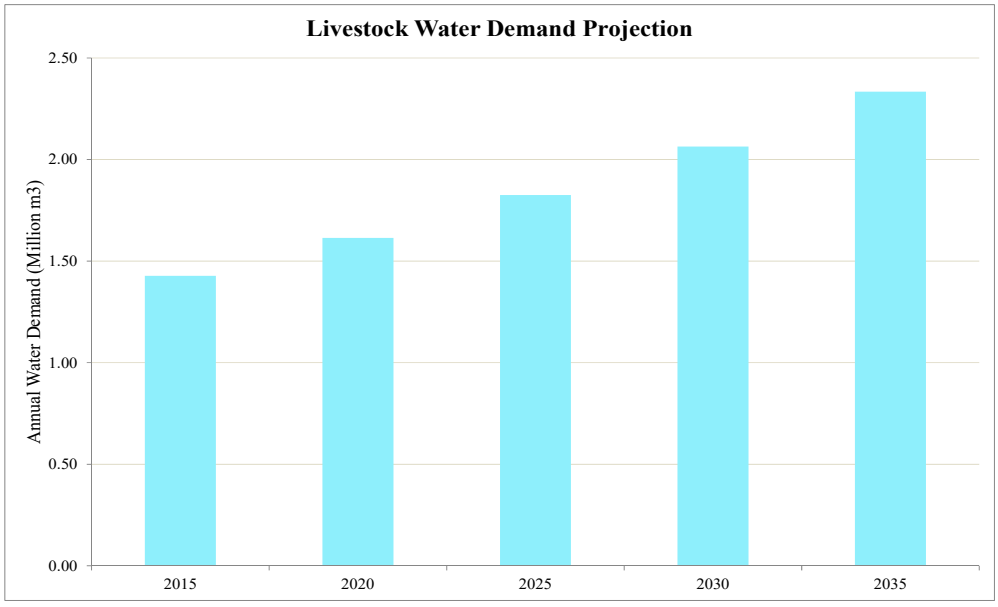

Figure 3.5: Livestock Water Demand Projection for the Rungwa Sub-basin.

Issues and Challenges

Lack of village land use plans in several parts of the sub-basin means there are no formally demarcated areas for livestock grazing. As a result livestock grazing takes place on communal

lands where other socio-economic activities (like farming) are also carried out resulting in conflicts between farmers and pastoralists. During the dry season, pastoralists also encroach on protected areas (i.e., game reserves) resulting in human-wildlife conflicts. Lack of designated livestock watering areas results in livestock drinking directly from water sources used for other users. This often leads to the destruction of water sources and the surrounding catchment areas.

Several areas have exceeded their livestock carrying capacity causing overgrazing, soil erosion, land compaction, destruction of wetlands and river banks, and intense land and water use competition and conflicts. Pollution of surface water sources from cattle dip and slaughter-house effluents has also been reported. Pastoralists often engage in bush burning to create new grass for livestock before the rainy season and to control parasites harmful to herds. Uncontrolled bush burning has been responsible for destruction of forests and other wildlife habitats. This practice also contributes to stripping the soil of vegetation cover causing excessive soil erosion and floods.

3.1.4 Wildlife Water Requirements

The sub-basin is home to the Rungwa and Biti Game Reserves, and therefore wildlife water use and environmental water requirements are important although they have not yet been quantified due to lack of data.

Rungwa Game Reserve

The Rungwa Game Reserve was gazetted in 1951 and its size was enlarged by the addition of the Kizigo Game Reserve in 1972 and the Muhesi Game Reserve in 1995 to form the Rungwa-Kizigo-Muhesi ecosystem, one of the most unique conservation areas in Tanzania. The reserve lies in three important watersheds drained by the Rivers Rungwa, Ugalla, and Ruaha. These rivers flow into three different basins, Lake Rukwa, Lake Tanganyika, and Rufiji basin respectively. The reserve falls in a predominantly semi-arid area characterized by generally low rainfall. Mean annual rainfall is about 870 mm, falling in a single wet season (November to May). August to November is the hottest period of the year with a mean daily temperature of 26.5 °C.

During the wet season, the Rungwa Game Reserve receives adequate water from an extensive network of seasonal rivers, namely, Rivers Rungwa, Miyungo, Musa, Iyonga, Kizigo, and Nzombe. Water scarcity is one of the major challenges faced by the reserve during the dry season. Water shortages in the reserve and surrounding areas are responsible for the recurrent conflicts between the game reserve and neighboring communities. Livestock, humans, and wildlife compete for the limited water sources during the dry season, resulting in human-wildlife conflicts which turn fatal in some cases. The only sources of water for wildlife during the dry season include pools of muddy water that remain in seasonal rivers (**Figure 3.6**) and ten excavated ponds.

During prolonged dry periods, elephants, buffalos, waterbucks, and other wildlife migrate to the Ruaha River and Kizigo crater located in the eastern and northeastern part of the reserve in search of water. These animals migrate seasonally from October to November and return in December or January. Most aquatic biodiversity especially fish die when the rivers dry up except for lung fish which hibernate in river beds and banks. There is no data on wildlife mortality due to water scarcity. The only information available is isolated incidences of wildlife deaths in different parts of the Game Reserve as reported by management. During drought periods, local

communities around the Game Reserve excavate open pits (6 m deep) in dry river beds in search of water. These pits attract thirsty wild animals which end up falling into the pits, get severely injured, and sometimes die.

Human-wildlife conflicts are common in the Game Reserve and surrounding villages. Water shortages during the dry season force wild animals to leave the park confines in search of water in nearby villages. In the process, they destroy crops and water sources and occassionaly injure or kill domestic animals and humans they happen to encounter. The situation is exacerbated by the influx of pastoralists who also encroach on the Game Reserve in search of water and pasture for their livestock. The two way movement of wildlife into neighboring villages and of pastoralists into the Game Reserve creates fertile grounds for human-wildlife conflicts causing fatalities and deaths. There are also reported conflicts during the wet season due to fishermen encroaching on the Game Reserve to fish in the several seasonal rivers. Incidences of cultivation, animal grazing, and illegal timber logging in the peripheral areas of the Game Reserve have also been reported. Monitoring all these ongoing illegal activities is not practical given the inadequate personnel compared to the large expanse of the Game Reserve. However, there are a few cases when the encroachers are apprehended by reserve officials and either fined or imprisoned. For example, the Game Reserve collected a total of 13.5 million TShs. in 2012 as fines from encroachers. The Reserve also compensates (100,000 Tshs. per acre) farmers for their crops destroyed by roaming wildlife in the nearby villages.

Figure 3.6: Pools of water in a dry Rungwa river-bed.

The Game Reserve has developed a general management plan (2011) to address water use shortages and human-wildlife conflicts. One of the strategies in the Plan is to improve water availability for both wildlife and humans through construction of additional water supply infrastructure in the Game Reserve and surrounding villages. The Plan also seeks to support education, health, and afforestation programs in the neighboring communities. Other interventions include rehabilitation of the dam on the Rungwa River (**Figure 3.7**) and the ongoing construction of a water supply scheme (borehole drilling) to supply the Rungwa village and Game Reserve headquarters under the Water Sector Development Program.

Individual hunting companies operating in the Game Reserve provide some financial support for community development programs in the villages neighboring the Game Reserve. The Game Reserve also provides other services to the communities including transport in case of emergencies (e.g., taking pregnant women in labour to health centres in neighboring villages). Overall 25% of the total revenue collected by the Game Reserve goes into supporting community activities in neighboring villages.

Figure 3.7: Damaged Dam on the Rungwa River.

3.1.5 Environmental Flow Requirements

The National Water Policy (2002) and Water Management Act (2009) emphasize the importance and need to determine environmental flow requirements and allocate reserves as an integral part of integrated water resources planning and management. The Water Resources Management Act (2009) prioritizes environmental flow requirements (only second to domestic water supply) in the hierarchy of water allocation, and requires that specific minimum flows be maintained to sustain freshwater ecosystems and ecosystem services. Unfortunately, specific environmental flow requirements (EFRs) have not yet been determined for any river section in the sub-basin. Carrying out such assessments to establish applicable EFR requirements at critical sub-basin river sections is a priority recommendation of the sub-basin plan.

3.1.6 Mining Water Use

Mining is not a major socioeconomic activity in the Rungwa sub-basin. Mining water use is therefore insignificant as of now and is projected to remain very low in the long run compared to other water uses (livestock and domestic water use).

3.1.7 Industrial Water Use

There are no industries in the Rungwa sub-basin. Industrial water use is therefore insignificant as of now and is projected to remain very low in the long run compared to other water uses.

3.1.8 Water Use for Hydropower Generation

The sub-basin has no known hydropower potential and thus no hydropower water use requirements.

3.2 Water Balance Assessment

Without significant irrigation activities in the Rungwa sub-basin, the current water demand is generally low. Large parts of the sub-basin watersheds are not habitable, largely because they lie within protected areas. Tentative flows were generated for the Rungwa River using historical rainfall and potential evapotranspiration data and a hydrologic model using parameters calibrated elsewhere in the Lake Rukwa watershed Based on these tentative flows, **Figures 3.8** and **3.9** show that Rungwa is not expected to experience water deficits for all demand targets and either season. However, when seasonal environmental flow requirements are taken into consideration (tentatively estimated using the same proportion of EFR to mean flow as for Katuma), some deficits are observed during the wet season (see **Table 3.2**). The most significant deficits occur during November and December.

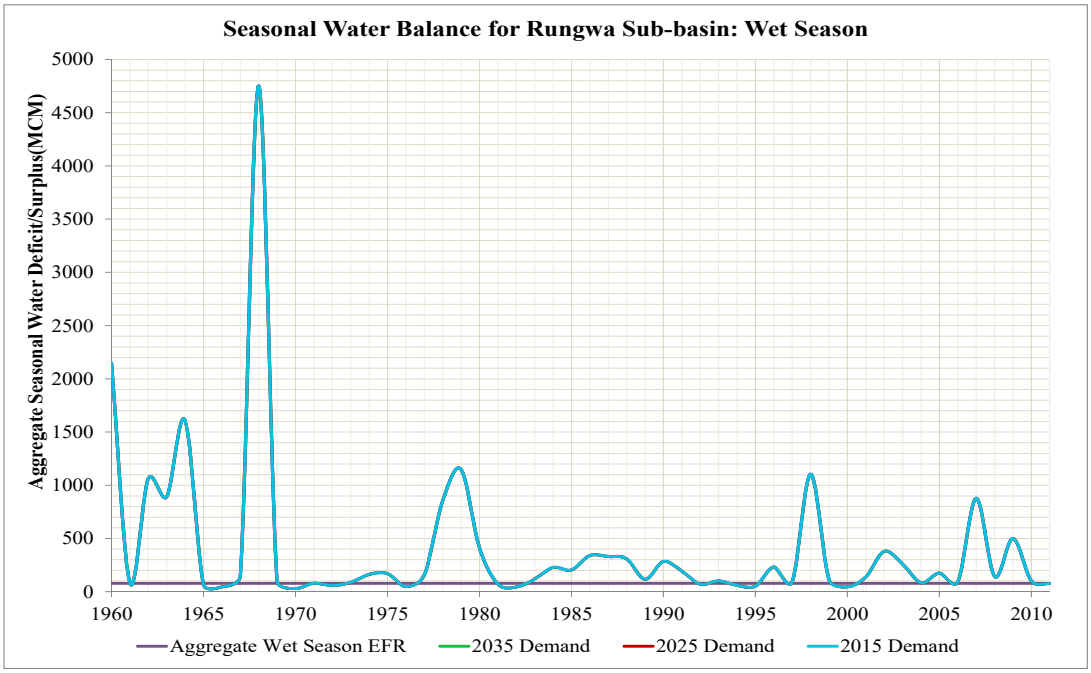

Figure 3.8: Wet Season Water Balance for the Rungwa Sub-basin.

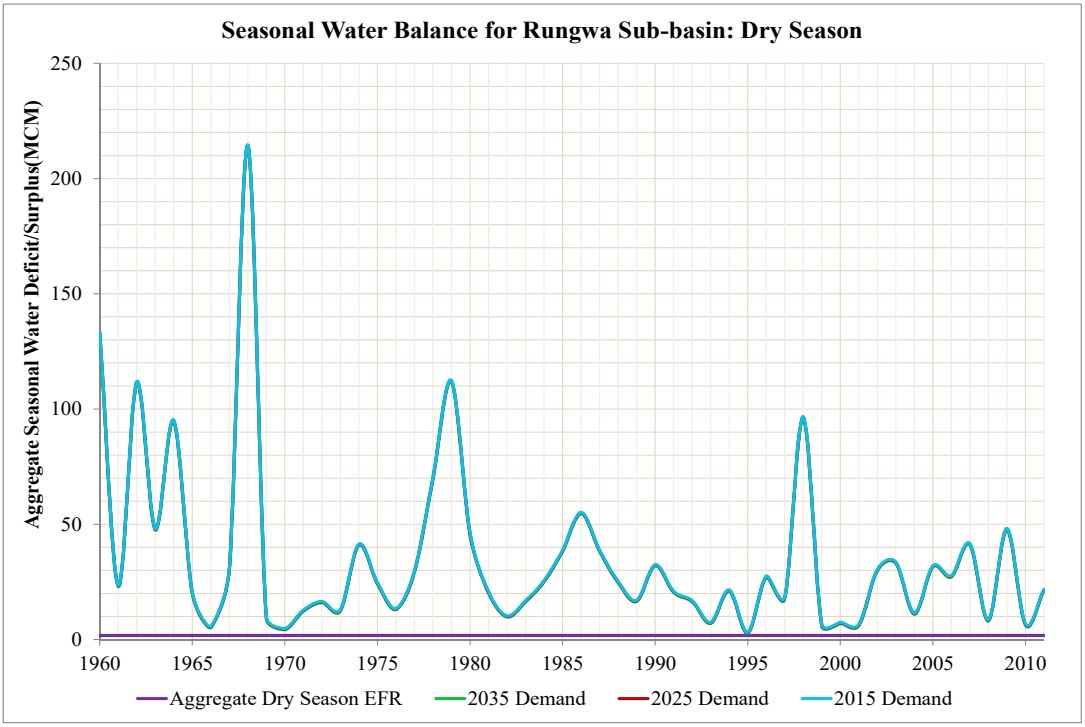

Figure 3.9: Dry Season Water Balance for the Rungwa Sub-basin.

Table 3.2: Frequency of Water Deficits.

Demand	Seasonal Deficits				Monthly Deficits												
		Wet Season	Dry Season			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	Without EFR	0.000	0.000		Without EFR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	With EFR	0.231	0.000		With EFR	0.827	0.635	0.231	0.000	0.000	0.000	0.000	0.000	0.269	0.019	1.000	1.000
2025	Without EFR	0.000	0.000		Without EFR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	With EFR	0.231	0.000		With EFR	0.827	0.635	0.231	0.000	0.000	0.000	0.000	0.000	0.269	0.019	1.000	1.000
2035	Without EFR	0.000	0.000		Without EFR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	With EFR	0.231	0.000		With EFR	0.827	0.635	0.231	0.000	0.000	0.000	0.000	0.135	0.327	0.019	1.000	1.000

3.3 Strategy to address Projected Water Deficits

The biggest challenge for domestic water supply in the Rungwa sub-basin is the localized water shortages due to sparsely distributed human settlements. It is very difficult to plan centralized medium to large scale water supply systems due to these settlement patterns. It is therefore expected that boreholes will remain the most feasible sources for domestic water supply in the short to medium term. Unfortunately, there is no data to assess the sub-basin groundwater potential and spatial distribution. It is thus important that a groundwater monitoring network be established to collect data as soon as possible. Accurate information on the spatial availability of groundwater would help locate future human settlements close to reliable water sources.

Surfacewater will continue to be an important water supply source especially for livestock and wildlife. However, its temporal variability makes it an unreliable water source during the dry season when most rivers dry up. A potential intervention would be construction of water storage to harvest excess water during the wet season and use it to augment low supplies during

prolonged dry periods. However, preliminary topographical analysis conducted for the sub-basin did not identify any reliable water storage sites. The analysis was based on topographic information represented by a digital elevation model (DEM) at 90 m spatial resolution (latitude and longitude). More detailed field studies and analysis should be conducted during the initial phase of the IWRMD Plan implementation to explore if some small storage sites exist in the sub-basin.

4. Strategic Goals, Objectives, and Priority Interventions

4.1 Vision and Mission

The Lake Rukwa Basin Vision and Mission statements define the overall strategic goal for water resources management and development in all the Lake Rukwa sub-basins. The two statements capture in a concise manner what the basin stakeholders collectively aspire to achieve in the short to long term. The basin vision and mission, therefore, provide the strategic context within which the Rungwa Sub-basin WRMD Plan is developed.

LAKE RUKWA BASIN VISION:	***"A well-managed basin with improved standard of living for its people through sustainable utilization of water resources"***
LAKE RUKWA BASIN MISSION:	*"To ensure water resources management is strengthened through integrated water resources management for sustainable utilization of water and other renewable natural resources"*

(*Source: LRBWB, 2015*)

4.2 Strategic Goal

The overall goal of the Rungwa Sub-basin WRMD Plan is to eradicate poverty and stimulate socioeconomic transformation through sustainable management, equitable access, and efficient use of the sub-basin water resources. This goal is to be realized through progressive improvements of existing water resources management and use practices to achieve a sustainable balance between water availability and demand without compromising environmental integrity.

4.3 Strategic Objectives

The matrix below presents the strategic objectives and intervention areas to be addressed by the Rungwa Sub-basin WRMD Plan. They describe the broad outcomes expected following implementation of the Plan over the planning horizon (2015 – 2035).

Strategic Objective	Strategic Intervention Areas
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 sub-basin water demands.
Strategic Objective 2: To ensure availability of	• Establish a groundwater resources monitoring network to cover all important sub-basin aquifers.

adequate and reliable water resources data for all watersheds and aquifers.	• Develope rating curve for operational hydrometric stations.
Strategic Objective 3: To identify and register all sub-basin water uses and ensure full compliance with permitting requirements.	• Establish water abstraction and use monitoring network to quantify sub-basin water use. • Strengthen permit enforcement and compliance monitoring mechanisms.
Strategic Objective 4: To determine and ensure compliance with environmental flow requirements for all critical river sections in the sub-basin.	• Undertake detailed environmental flow assessments for all critical sub-basin river sections and establish appropriate environmental flow requirements. • Monitor and ensure compliance with the established environmental flow requirements.
Strategic Objective 5: To promote integrated watershed management and environmental conservation.	• Protect vulnerable watersheds and reverse sub-basin environmental degradation. • Control pollution from point and non-point sources.

4.4 Priority Intervention Measures

GOAL 1: Sustainable balance between water supply and demand achieved by 2035.

The overarching objective for developing the Rungwa Sub-basin IWRMD Plan is to ensure sustainable management and development of the sub-basin water resources to benefit current and future water users. Besides the projected demand growth and future climate change impacts, the Water Management Act (2009) specifically recognizes environment flow requirements as a legitimate water use priority that must be considered and fulfilled in water resources planning and management decisions. Satisfying all sub-basin water use requirements involves balancing water supply and demand, with careful consideration of the underlying trade-offs.

Objective 1: To achieve sustainable water demand growth over the planning horizon.

The Rungwa sub-basin aggregate consumptive water demand is projected to increase from 1.80 MCM in 2015 to 3.03 MCM by 2035. The biggest contributor to the demand growth is the projected increase in livestock and domestic water demand. No significant irrigation developments are expected over the planning period. The principle goal of the Rungwa Plan is to manage the waterdemand of the domestic and livestock sectors and secure the water supply necessary to meet this demand in a reliable and environmentally sustainable manner.

Action 1.1.1: **Comprehensive and routine monitoring of water abstractions/use.**

Routine monitoring of water abstractions and use is important to ensure that water managers have accurate knowledge of how much water is used, where, and when. This information would enable the LRBWB to determine the occurrence of spatial and temporal water deficits and pinpoint their causes and possible remedial measures. There are no systematic measurements of

water use in the Rungwa sub-basin. It is thus difficult to estimate actual water abstractions and accurately reconstruct unimpaired flow series at key sub-basin nodes. There is a need to monitor water uses and abstractions. Establishment of the network should be undertaken in collaboration with the water users. To supplement the self-monitoring program, the LRBWB should install water abstraction/use monitoring devises at a few strategic locations in the system to verify the amounts uses in specific watersheds.

Objective 2: To ensure availability of water resources of adequate quantity and quality to meet current and future sub-basin water demands.

Although water demand in the Rungwa sub-basin is low, due to the absence of irrigation, water stresses may increase due to potential climate change. There is, therefore, a need to implement appropriate adapation measures. Toward this goal, priority actions recommended to ensure availability of adequate water supplies include:

Action 1.2.1: **Construction of water storage infrastructure to increase sub-basin storage capacity**.

The Rungwa sub-basin receives sufficient rainfall during the wet season to sustain all its water use demands. This is evident from the absence of water use conflicts during the wet season. However, during the dry season, the situation changes and water conflicts are a common occurrence among water users in several sub-basin areas. A potential intervention would be construction of water storage infrastructure to harvest excess water during the wet season and use it to augment low supplies during prolonged dry periods. This would help even out the water deficits which cause significant disruptions in water supply. However, preliminary topographical analysis conducted for the sub-basin did not identify reliable water storage sites. More detailed field studies and analysis should be conducted during the initial phase of the IWRMD Plan implementation to explore if some small scale storage sites exist. Any identified sites should be developed as soon as possible to increase sub-basin water storage capacity and help addressdeficits observed during the dry season.

Action 1.2.2: **Conjunctive use of surface and groundwater.**

There is a need to establish a comprehensive groundwater monitoring network to support detailed assessments of the sub-basin groundwater potential. The outcome of the groundwater assessments will be valuable in developing a holistic plan for conjunctive use of surface and groundwater as part of the broader water security program.

GOAL 2: Adequate and reliable water resources data available for all sub-basin watersheds.

Large parts of the sub-basin watersheds are not monitored, largely because they lie within protected areas. There is a need to establish a comprehensive surface and groundwater monitoring network to enable routine collection of data required for quantification and characterization of the sub-basin water resources.

Objective 1: Upgrade and expand the existing water resources monitoring network to cover all important watersheds and aquifers.

Given the very poor status of the Rungwa monitoring network, the following specific recommendations are made:

Action 2.1.1: **Upgrade and expand existing surface water resources monitoring network.**

The location of the two existing hydrometric stations at the Rungwa headwaters leaves the sub-basin virtually ungauged. Although most sub-basin areas are protected, it is important that arrangements be made with the wildlife and forestry management authorities to allow the LRBWB staff access to establish and operate a minimal water resources monitoring network. Such arrangements could facilitate the game and forest reserve authorities to take hydro-climatic measurements and transmit them to LRBWB. Particularly, there is a need to establish at least one hydrometric station near the sub-basin exit to estimate the aggregate outflow from the Rungwa River into Lake Rukwa. Additional stations in smaller sub-basin watersheds can be established in time as the LRBWB collaboration with game and forest reserve authorities develops. Other priority interventions pertain to the (a) establishment/re-validadtion of rating curves for the two existing hydrometric station (Musa River at Musisi (**3DA2**) and Rungwa River at Itigi Road Bridge (**3D4**)); (b) consistent and timely collection of data from the existing network; and (c) routine inspection and maintenance of monitoring equipment to minimize data collection gaps.

Action 2.1.2: **Establish a groundwater resources monitoring network.**

It is recommended that a comprehensive groundwater monitoring network be established to ensure consistent, timely, adequate, and relieable data collectionfor sustainable use and management of groundwater resources.

Action 2.1.3: **Undertake consistent and timely collection of water resources data and maintenance of the monitoring network.**

Alhough the monitoring stations should be regularly visited by LRBWB staff for data collection, routine inspections, and equipment maintenance, visits do not happen often due to inadequate funding. Reliance on central government budget allocations alone to sustain the basin water resources monitoring operations has proved unsustainable as the funds are inadequate and rarely disbursed on time. The current revenue generated by the LRBWB from water permit fees is very small to sustain network operations. Pending availability of sufficient funding for its monitoring operations, the LRBWB should explore other potential options to ensure sustainable and consistent data collection. For example, the LRBWB should explore the possibility of training gage readers to take daily gage readings and relay the information by phone text messages. The LRBWB could also collaborate with extension workers or village leaders to receive completed data forms from gage readers and forward them to the LRBWB offices in Mbeya City. Furthermore, the LRBWB should work together with game and forest reserve management authorities to establish and operate a minimal hydro-climatic network in the Rungwa protected areas. Lastly, local communities neighboring the monitoring stations should be sensitized about the importance of the installed monitoring equipment and safeguard them against vandalism.

GOAL 3: All sub-basin water uses registered and fully compliant with permitting requirements by 2035.

Effective monitoring and regulation of water use is of paramount importance to assess the integrity of the water distribution system, issue permits, and collect water user fees. The Water Resources Management Act (2009) mandates the LRBWB to allocate and regulate water use

through water use and wastewater discharge permits. The LRBWB is obliged to ensure that permit holder legal rights are protected and that access to allocated water is not jeopardized by illegal water users.Although illegal water usage is an offence under the Water Resources Management Act (2009) that carries stiff penalties, there are several water users who have either not applied for water use permits or are using water in disregard of the water permit conditions. There is, therefore, a need to strengthen the water use regulatory and enforcement mechanisms and ensure compliance with the law.

Objective 1: Strengthen water resources regulatory and enforcement mechanisms.

One of the main LRBWB challenges is inadequate capacity (technical and financial) to monitor the many water users in the basin. Monitoring water usage and enforcing compliance with water permit conditions fis a challenge that requires cooperation from the water users and the local communities. However, this cooperation is still not forthcoming due to various reasons. It is therefore important that formation of lower level water resources management structures and sensitization of local communities are considered as priority intervention measures to strengthen the regulatory capacity of the LRBWB. The strategy should also include more active engagement with Local Government Authorities (especially at ward and village levels) and local Water User Groups to solicit their active involvement in water permit enforcement and sensitization campaigns.

Action 3.1.1: **Conduct comprehensive annual surveys of all sub-basin water uses to validate legal status, update the water permit database, and apprehend illegal water users.**

Water permit compliance monitoring can be very expensive if LRBWB staff are required to regularly traverse the sub-basin to all water users and validate their legal standing. This kind of activity cannot be planned as a routine undertaking because of budgetary constraints. However, budgetary constraints cannot be the reason for inaction. Other creative ways of performing this function should be explored. For example, the LRBWB could engage all key sub-basin stakeholders to plan an annual event dubbed "*Operation zero tolerance for illegal water use in Rungwa sub-basin*". This would be perceived to be a 'community policing' (or community ownership) activity that could leverage support from sources other than the LRBWB. The annual event should be jointly planned with other key stakeholder agencies including police, Local Government Authorities, local leaders, Water User Associations, Water User Groups, Game and Forest Reserve authorities, NGOs, and CBOs, among others. The LRBWB should ensure that the annual survey is as detailed as possible to capture the required information during the annual event and update the water permit database accordingly. The annual event could be supplemented by a few targeted routine enforcement activities by LRBWB staff as and when resources become available.

Action 3.1.2: **Expedite processing and issuance of water permits as an incentive to attract new permit applicants.**

One of the complaints by water users (especially those in areas far from the LRBWB offices in Mbeya) is the logistical burden of the water permit application process (the requirement to travel long distances to Mbeya City to follow up water permit applications). Another complaint is that the permit application process takes too long, years in some cases, and water users cannot suspend their activities pendingwater permit issuance. These procedural issues serve as a disincentive to water permit applicants and thus exacerbate illegal water use. It is important that the LRBWB expedite the permit application process and make it more efficient and less

cumbersome to permit applicants. Addressing these kinds of "small" concerns could make a big and quick difference as the LRBWB addresses other regulatory challenges that require more significant time and financial resources.

GOAL 4: Environmental Flow Requirements Determined for all Critical River Sections and Compliance Ensured by 2035.

Determination and consideration of environmental flow requirements in sub-basin water allocation decisions is not optional and can no longer be ignored. The environment is a legitimate water user, albeit a silent one, whose needs must be considered and fulfilled in all water allocation decisions.

Objective 1: To determine and ensure compliance with the environmental flow requirements for all critical sub-basin river sections.

Provisions for environmental flow requirements present a significant water use tradeoff with far reaching socioeconomic implications. Unfortunately, specific EFRs have not yet been determined for critical sub-basin river sections. It is, therefore, important that applicable environmental flow requirements be established through a transparent and technically robust procedure to ensure credibility of the recommended flows.

Action 4.1.1: **Conduct detailed EFAs for all critical sub-basin river sections to establish the applicable EFRs.**

Detailed Environmental Flow Assessments should be carried out for all critical sub-basin river sections to establish realistic EFRs for water allocation decisions.

Action 4.1.2: **Monitoring compliance with environmental flow requirements.**

Once the EFRs have been determined for all critical river sections, the LRBWB should undertake routine surveillance and monitoring to ensure compliance. The LRBWB should also carry out periodic review of the EFRs for different river sections and modify them in response to increased water demands, where necessary.

GOAL 5: Integrated Watershed Management and Environmental Conservation Achieved by 2035.

The Rungwa sub-basin is a fairly protected area with vast expanses of undisturbed forests. Large sub-basin areas fall within protected areas (game reserves, forest reserves, and game controlled areas) that are mostly uninhabited and dominated by vast miombo woodlands. Cultivation takes place in a few isolated and densely populated settlements scattered throughout the sub-basin. The sub-basin does not, therefore, suffer from large scale deforestation and environmental degradation to levels observed in other Lake Rukwa sub-basins. However, there are several localized incidences of deforestation and environmental degradation in the few settled areas. Particularly, there is a worrying trend in the tobacco growing areas where trees are being cut indiscriminately for tobacco curing, charcoal burning, and opening new settlements and farm land.

Objective 1: To protect vulnerable watersheds and reverse environmental degradation.

This intervention will target critically degraded areas, especially the tobacco growing areas, where specific integrated watershed management measures will be implemented to reverse the ongoing deforestation and environmental degradation.

Action 5.1.1: Promote sustainable management and utilization of sub-basin forestry resources.

This will focus on reversing the ongoing deforestation in the settled areas, especially the tobacco growing areas, through tree planting, agro-forestry, soil and water conservation, and river bank protection initiatives using community based forestry management practices. Local communities should be sensitized and trained on sustainable management and exploitation of forest resources. Local communities should also be encouraged to participate in forest management through development of comprehensive community based forest management plans.

Action 5.1.2: Preparation and enforcement of implementation of village land use plans.

Preparation of village land use plans in settled areas will ensure demarcation of specific areas for livestock grazing and watering. Strict enforcement of land use plans will ensure that livestock stay away from communal lands where other socio-economic activities (like farming) are carried out, thus minimizing conflicts between farmers and pastoralists. Similarly, provision of designated livestock watering areas will ensure that pastoralists do not water their animals directly in water sources used for other uses.

Action 5.1.3: Identify, demarcate, and protect recharge areas for important groundwater supply aquifers.

Groundwater recharge areas should be protected from encroachment and degradation due to human activities. The Water Resources Management Act (2009) Section 37 (1) provides for establishing groundwater controlled areas for water supply and commercial, industrial, or agricultural development. All important groundwater controlled areas should be identified during the groundwater assessment and mapping exercise and protected accordingly.

Objective 2: To control pollution from point and non-point sources.

Action 5.2.1: Improve sanitation and hygiene in rural households

Most sub-basin households use traditional pit latrines, which if poorly located or constructed, can lead to contamination of nearby water sources with fecal bacteria and pathogens. One of the consequences is the high incidence of water borne diseases in the region. Diarrhoea—a common water borne disease—ranks among the top five causes of illness and death in the sub-basin. Funds should be availed at the local community level to train local artisans in sanitation technologies; construct pilot demonstration facilities; help construct community sanitation facilities (in schools, health centers, and other places); and support communities improve existing latrines.

5. Strategic Action Plan and Budget

5.1 Strategic Action Plan

The Rungwa Sub-basin Strategic Action Plan (SAP) is based on the specific goals, objectives and actions discussed in detail in the previous chapter. The SAP shows the proposed sequencing and duration 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 Rungwa Sub-basin SAP is presented in the matrix below.

Rungwa Sub-basin Strategic Action Plan

FIVE YEAR PHASE	Jul 2016 - Jun 2020					Jul 2020 - Jun 2025					Jul 2025 - Jun 2030					Jul 2030 - Jun 2035				
YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PROGRAM 1: Water Security Enhancement Program																				
COMPONENT 1: Water Resources Infrastructure Development																				
OBJECTIVE: To enhance basin water storage and supply capacity																				
TASK 1.1.1: Preliminary assessment and ranking of potential water storage sites																				
TASK 1.1.2: Prefeasibility studies of priority potential water storage projects																				
TASK 1.1.3: Feasibility studies of priority water storage projects																				
TASK 1.1.4: Construction of priority water storage projects																				
PROGRAM 2: Environmental Flow Assessment and Monitoring Program																				
OBJECTIVE: To ensure compliance with environmental flow requirements for all critical sub-basin river sections																				
TASK 2.1: Conduct environmental flow assessments and determine the environmental flow requirements for all critical sub-basin river sections.																				
TASK 2.2: Monitor compliance with the established environment flow requirements																				
PROGRAM 3: Water Resources Monitoring and Assessment Program																				
OBJECTIVE: To ensure availability of adequate and reliable water resources data and information.																				
COMPONENT 1: Strengthen water resources monitoring capacity																				
TASK 3.1.1: Establish a sub-basin groundwater monitoring network																				
TASK 3.1.2: Establish a sub-basin water quality monitoring network																				
TASK 3.1.3: Coordinate establishment of water abstraction/use monitoring network																				
TASK 3.1.4: Establish/re-validate rating curves for all sub-basin hydrometric stations																				
TASK 3.1.5: Conduct routine and timely collection of water resources data.																				
COMPONENT 2: Strengthen water resources assessment																				
TASK 3.2.1: Conduct groundwater resources assessment and mapping																				
TASK 3.2.2: Conduct water quality baseline survey																				

Rungwa Sub-basin Strategic Action Plan (continued)

FIVE YEAR PHASE	Jul 2016 - Jun 2020					Jul 2020 - Jun 2025					Jul 2025 - Jun 2030					Jul 2030 - Jun 2035				
YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PROGRAM 4: Water Permit Compliance Monitoring Program																				
OBJECTIVE: To register water use and ensure compliance with permit conditions.																				
TASK 4.1: Conduct comprehensive annual water use surveys and register all water uses																				
TASK 4.2: Conduct routine processing of permit applications, compliance monitoring, and update of water permit database																				
PROGRAM 5: Integrated Watershed Management and Environmental Conservation																				
OBJECTIVE: To ensure that all vulnerable watersheds are protected and environmental degradation reversed.																				
TASK 5.1: Promote and support development/implementation of village land use plans.																				
TASK 5.2:Identify, demarcate, and protect recharge areas for important groundwater supply aquifers.																				
TASK 5.3: Provide technical and financial support for catchment afforestation activities in critical watersheds.																				
TASK 5.4: Support and promote improved sanitation and hygiene in rural households.																				

LEGEND

- Duration of time-bound Program
- Continuous Program
- Duration of time-bound Program Component
- Continuous Program Component
- Duration of time-bound Task
- Continuous Task

5.2 Budget Estimates

The total estimated budget required for implementation of the Rungwa Sub-basin WRMD Plan from 2016 to 2035 is about 4.17 Billion TShs. The budget estimates are derived using unit costs from several planning documents including the Lake Rukwa Basin Business Plan (2010/11 – 2014/15), WSDP—Programme Implementation Manual, District Development Plans, Five Year Development Program-1 and several other sources. **Table 5.1** and **Figures 5.1** and **5.2** show a summary of the budget estimates by program and by implementation phase. Program 1 (Water Security Enhancement) has the highest budget allocation (51%) 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 (31%) because of the initial investments in the water resources monitoring network and the several initial technical studies to be undertaken under most programs. The detailed budget breakdown is presented in **Table 5.2**.

Table 5.1: Budget Estimates by Program and Implementation Phase.

Rungwa Sub-basin WRMD 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	0.47	0.32	0.35	0.44	**1.57**
PROGRAM 2: Environmental Flow Assessment and Monitoring Program	0.57	0.20	0.20	0.57	**1.56**
PROGRAM 3: Water Resources Monitoring and Assessment Program	1.72	0.50	0.60	0.62	**3.44**
PROGRAM 4: Water Permit Compliance Monitoring Program	0.58	0.56	0.56	0.56	**2.26**
PROGRAM 5: Integrated Watershed Management and Environmental Conservation Program	0.42	0.42	0.42	0.42	**1.70**
TOTAL	**3.77**	**2.01**	**2.14**	**2.62**	**10.53**

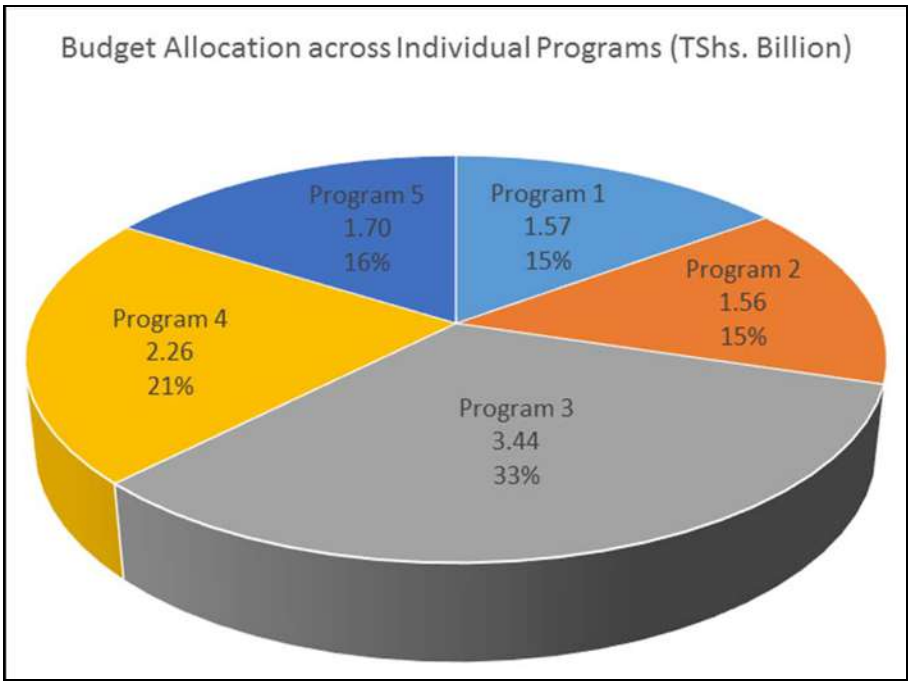

Figure 5.1: Budget Allocation across Individual Programs.

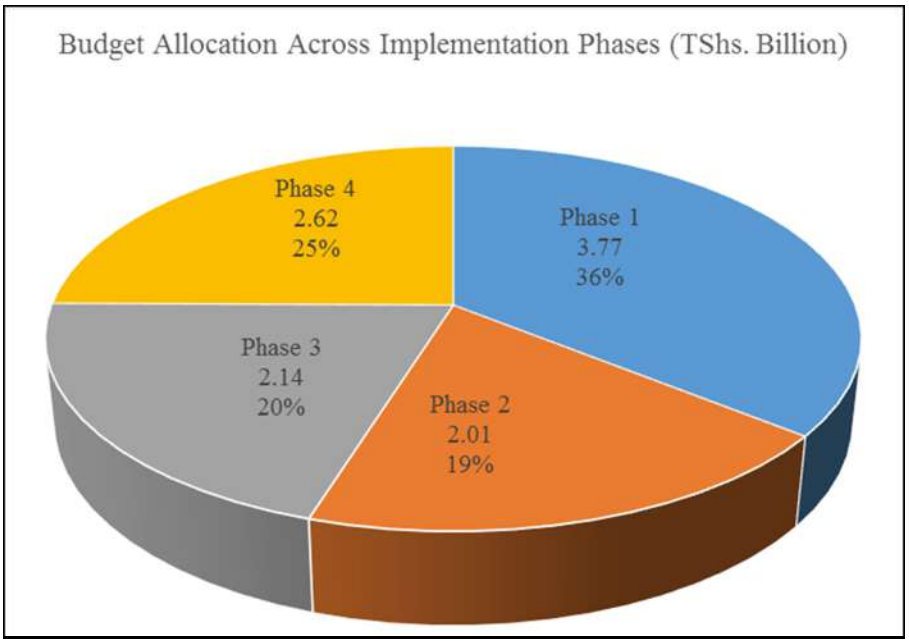

Figure 5.2: Budget Allocation across Implementation Phases.

Table 5.2: Budget Estimates for the Rungwa Sub-basin WRMD Plan Implementation.

	Rungwa Sub-basin WRMD PLAN BUDGET ESTIMATES (TShs. Millions)			
	Jul 2016 - Jun 2020	Jul 2020 - Jun 2025	Jul 2025 - Jun 2030	Jul 2030 - Jun 2035
PROGRAM 1: Water Security Enhancement Program				
COMPONENT 1: Water Resources Infrastructure Development				
Strategic Action 1.1.1: Assess potential for and construct surface water storage infrastructure to increase sub-basin water storage capacity.	468	318	318	318
Strategic Action 1.1.2: Assess potential for and construct medium to large scale groundwater supply schemes to increase sub-basin water supply capacity.	-	-	30	120
Program 1 Sub-total	***468***	***318***	***348***	***438***
PROGRAM 2: Environmental Flow Assessment and Monitoring Program				
Strategic Action 2.1: Conduct environmental flow assessments and determine environmental flow requirements for allcritical sub-basin river sections.	369	-	-	369
Strategic Action 2.2: Conduct routine field visits to monitor compliance with established environmental flow requirements.	160	160	160	160
Strategic Action 2.3: Conduct regular public awareness raising campaigns on the importance of maintaining environmental flow requirements and consequences of violations.	45	45	45	45
Program 2 Sub-total	***574***	***205***	***205***	***574***
PROGRAM 3: Water Resources Monitoring and Assessment Program				
COMPONENT 1: Strengthen water resources monitoring capacity				
Strategic Action 3.1.1: Update/rehabilitate existing surface water resources monitoring networkand update and re-validate rating curves for all functional hydrometric stations.	640	200	200	200
Strategic Action 3.1.2: Establish network of groundwater level monitoring boreholes to cover all major sub-basin aquifers.	840	-	200	200
Strategic Action 3.1.3: Establish sub-basin water quality monitoring network	20	-	-	20
Strategic Action 3.1.4: Conduct routine and consistent network visits for data collection and equipment maintenance.	160	160	160	160
Strategic Action 3.1.5: Conduct routine training for technicians and gage readers to ensure collection of reliable data and proper maintenance of monitoring equipment.	40	40	40	40
COMPONENT 2: Strengthen water resources assessment capacity				
Strategic Action 3.2.1: Conduct sub-basin groundwater assessments and mapping	-	100	-	-
Strategic Action 3.2.2: Conduct sub-basin water quality baseline survey.	20	-	-	-
Program 3 Sub-total	***1,720***	***500***	***600***	***620***

Table 5.2: Budget Estimates for Rungwa Sub-basin WRMD Plan Implementation (continued)

	Rungwa Sub-basin WRMD PLAN BUDGET ESTIMATES (TShs. Millions)			
	Jul 2016 - Jun 2020	Jul 2020 - Jun 2025	Jul 2025 - Jun 2030	Jul 2030 - Jun 2035
PROGRAM 4: Water Permit Compliance Monitoring Program				
Strategic Action 4.1 : Conduct comprehensive annual water use surveys to locate, verify, map, register and regularize all water withdrawals, waste water discharges and hydraulic infrastructure.	220	220	220	220
Strategic Action 4.2 : Conduct routine processing of new water permit applications and renewals.	40	40	40	40
Strategic Action 4.3 : Undertake routine update of the water permit database.	-	-	-	-
Strategic Action 4.4 : Conduct routine field visits to check compliance with permit conditions and apprehend illegal water users.	160	160	160	160
Strategic Action 4.5 : Conduct regular public awareness raising campaigns on the dangers of illegal water abstraction and non-compliance with permit conditions.	160	160	160	160
Program 4 Sub-total	***580***	***580***	***580***	***580***
PROGRAM 5: Integrated Watershed Management and Environmental Conservation Program				
Strategic Action 5.1 : Provide technical and financial support for preparation and implementation of village land use plans	104	104	104	104
Strategic Action 5.2 : Identify, demarcate, and protect important groundwater recharge areas.	120	120	120	120
Strategic Action 5.3 : Provide technical and financial support for catchment afforestation activities in critical watersheds	160	160	160	160
Strategic Action 5.4: Support and promote improved sanitation and hygiene in rural households.	40	40	40	40
Program 5 Sub-total	***424***	***424***	***424***	***424***
GRAND TOTAL	3,766	2,027	2,157	2,636

6. References

WREM International 2013: Lake Rukwa Basin Integrated Water Resources Management and Development Plan, Interim Report I: Lake Rukwa Basin Socioeconomic Profile and Water Resources Management Framework. Technical Report prepared for the Ministry of Water, United Republic of Tanzania, by WREM International Inc., Atlanta, Georgia, USA, 163 pp.