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Lake Rukwa Basin IWRMD Plan: Final Report

Volume II (d): Luiche Sub-basin Water Resources Management and Development Plan

by

WREM International Inc.
Atlanta, Georgia, USA

April 2016

Lake Rukwa Basin Integrated Water Resources Management and Development Plan

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Disclaimer

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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.

Table of Contents

List of Figures

List of Tables

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
DWR	Department of Water Resources
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 Luiche 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.

Based on the data and information gathered, several hydrological and water resources assessments were conducted at sub-basin and basin levels. These studies revealed that, the Luiche Sub-basin is beginning to experience water stress especially during the dry season. This is mostly attributed to the high irrigation water demand in the paddy farms and the growing urban water demand for Sumbawanga City. The sub-basin also faces poor water quality due to pollution from various human activities including poor sanitation, especially in peri-urban areas around Sumbawanga Town, heavy river sediment loads due to deforestation and poor agricultural practices, and non-point pollution from fertilizer application on farms. Assessment findings also reveal that the sub-basin is vulnerable to climate change. Projected climate changes are expected to impact the sub-basin hydrology, agriculture, and water resources. This is because increasing temperatures lead to higher evapotranspiration and reduce surface water flows, soil moisture, groundwater recharge, and lake/reservoir levels. Furthermore, higher crop evapotranspiration will further increase irrigation demand. The combined impacts of rising water use levels and climate change portend reduction of natural water supplies and increased stresses on all water related sectors. The water balance assessment findings highlight significant decrease in streamflow in the Luiche River due to the reinforcing impacts of climate change and increasing water demands.

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 Luiche Sub-basin WRMD Plan from 2016 to 2035 is about 6.013 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 Luiche 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 Luiche Sub-basin

2.1 Location

The Luiche is one of the two smallest sub-basins in the Lake Rukwa Basin covering an area of only 913 km^2. The sub-basin covers parts of Sumbawanga MC, Sumbawanga DC, and Nkasi DC (**Figure 2.1**). The sub-basin has a population of about 170,729 (2012 National Census) of which about 65% live in Sumbawanga MC. The main urban center is Sumbawanga Town, headquarters of the Rukwa Region and a major economic and business hub. The sub-basin has an average population growth rate of 3.4% which is higher than the Tanzania national average of 2.9%. The sub-basin population is projected to increase to about 392,045 by 2035 (see **Figure 2.2**).

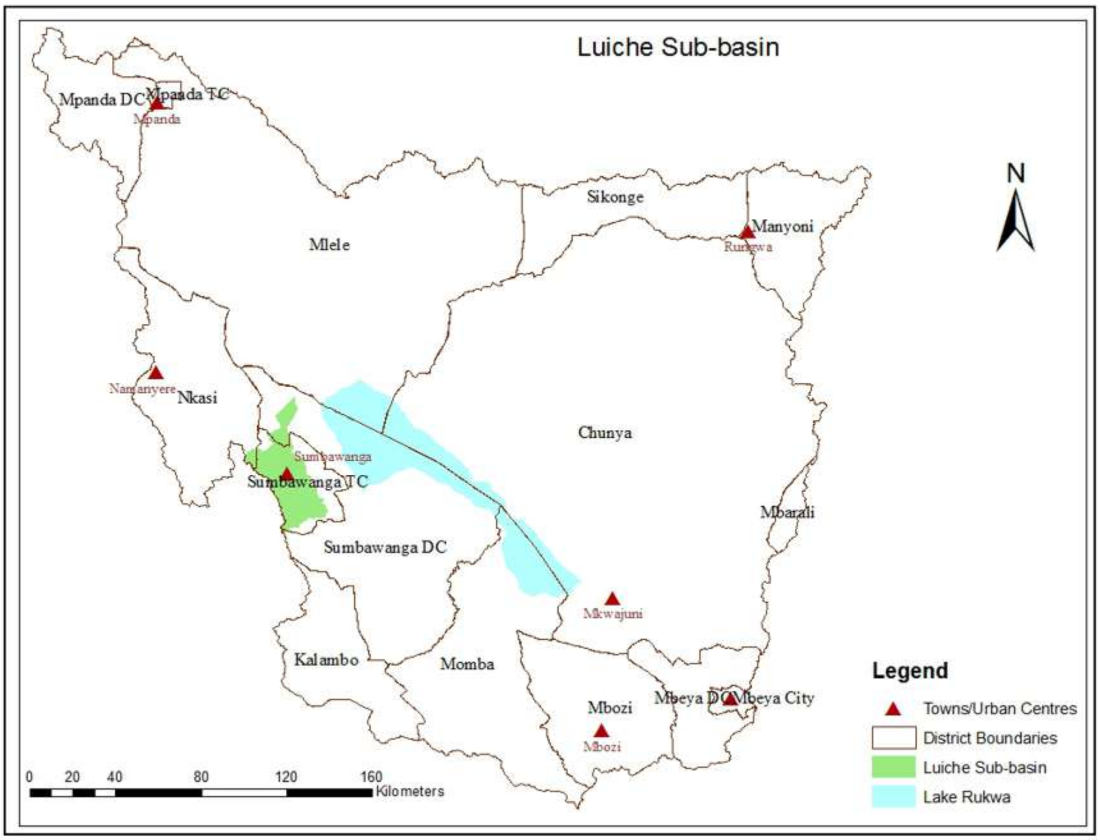


Figure 2.1: Location of Luiche Sub-basin**.**

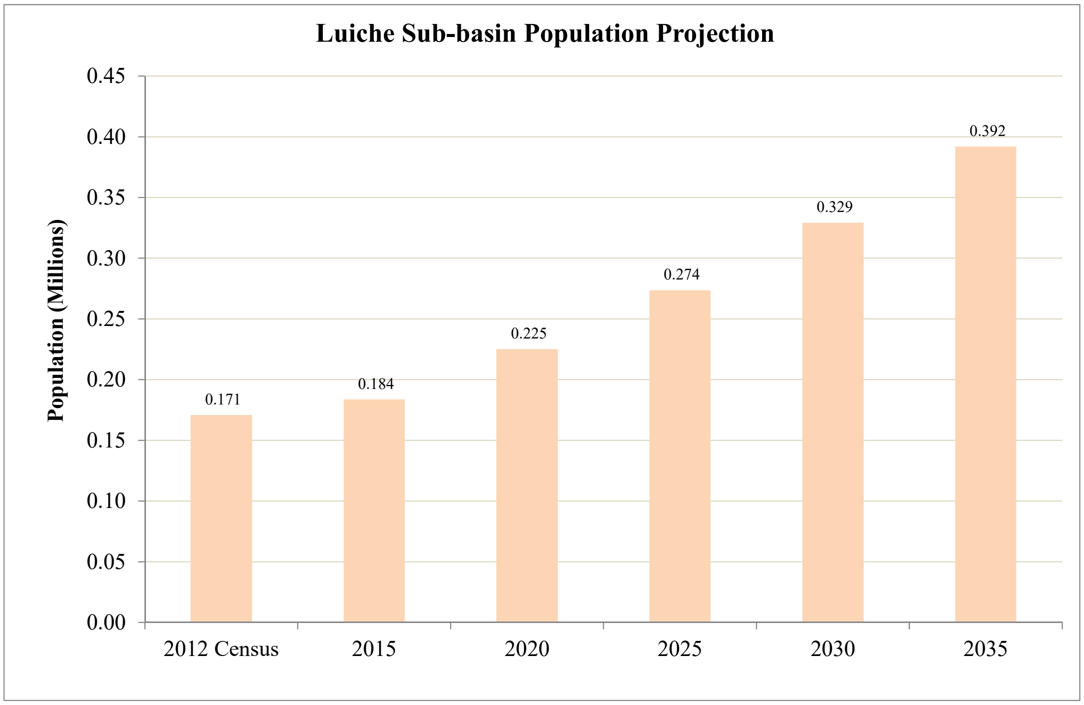


Figure 2.2: Luiche Sub-basin Population Projection.

2.2 Socioeconomic Conditions

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

2.2.1 Socioeconomic Importance

The Luiche Sub-basin lies on the Ufipa plateau, a highly productive area characterized by intensive landuse for both subsistence farming and livestock keeping. The area has good fertile feralitic soils and reliable rainfall ranging from 800 to 1200 mm. The plateau is mostly grassland and considered to be one of the most productive areas in the region. Agriculture is the dominant activity employing about 80% of the population. Major crops grown include maize, beans, finger millet, sunflower, groundnuts, potatoes, and cassava. The vegetation is predominantly grasslands and bushes with woodlands occurring in the hilly areas. The sub-basin has two main forest reserves, the Mbizi Forest Reserve (23,267 ha) and Malangali Forest Reserve (313 ha). Besides these two, there are several community based woodlots covering a total area of about 500 ha scattered throughout the sub-basin. The other important socioeconomic activities include livestock keeping and petty trade in the urban area.

The sub-basin is also home to Sumbawanga Town, an important commercial hub for the Rukwa region and surrounding areas. The heavy concentration of population and water related socioeconomic activities in the town and surrounding areas has serious implications on the management and use of the sub-basin water resources.

2.2.2 Occupation and Source of Household Income

According to a detailed household survey conducted under the study (WREM International, 2013), the majority (63%) of household heads are engaged in agriculture (crop farming and livestock keeping) as their primary occupation (**Figure 2.3**). Other significant occupation categories include formal and self-employment (retail shops, street vending, brick and craft making, charcoal burning, mining, transportation). The major source of household income is the sale of agricultural produce (food and cash crops). About 57% of the households depend on agricultural produce sales as their main household income (see **Figure 2.4**). The other important sources of household income are business (18%) and formal employment (14%).

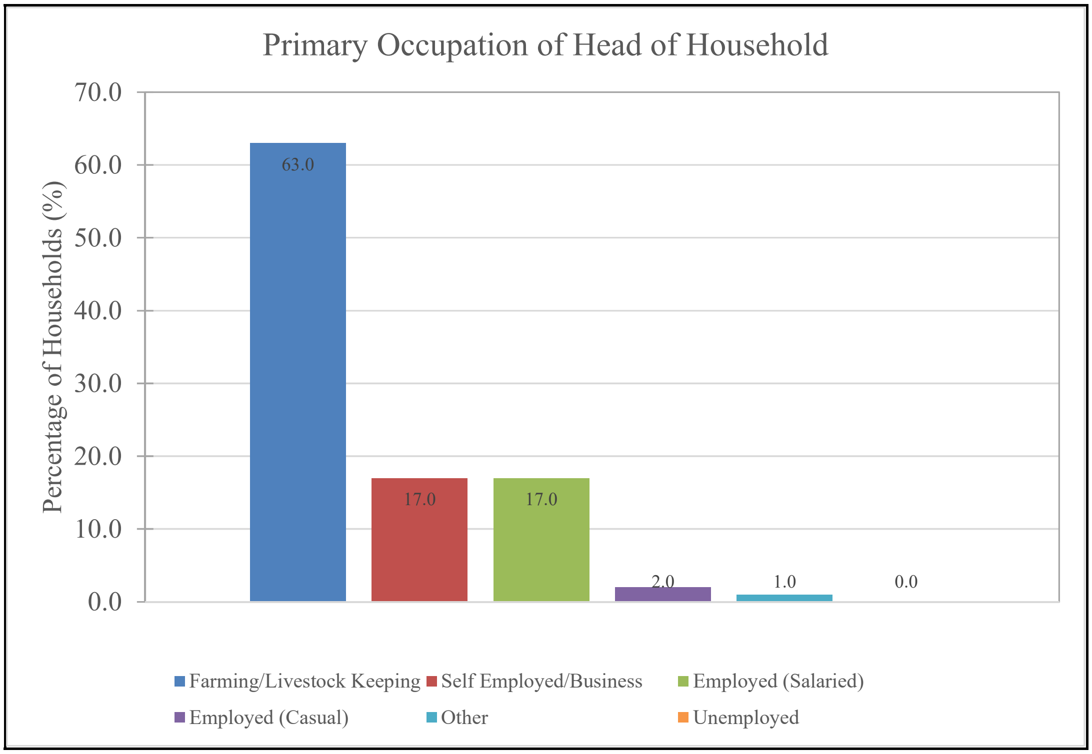


Figure 2.3: Primary Occupation of Head of Household.

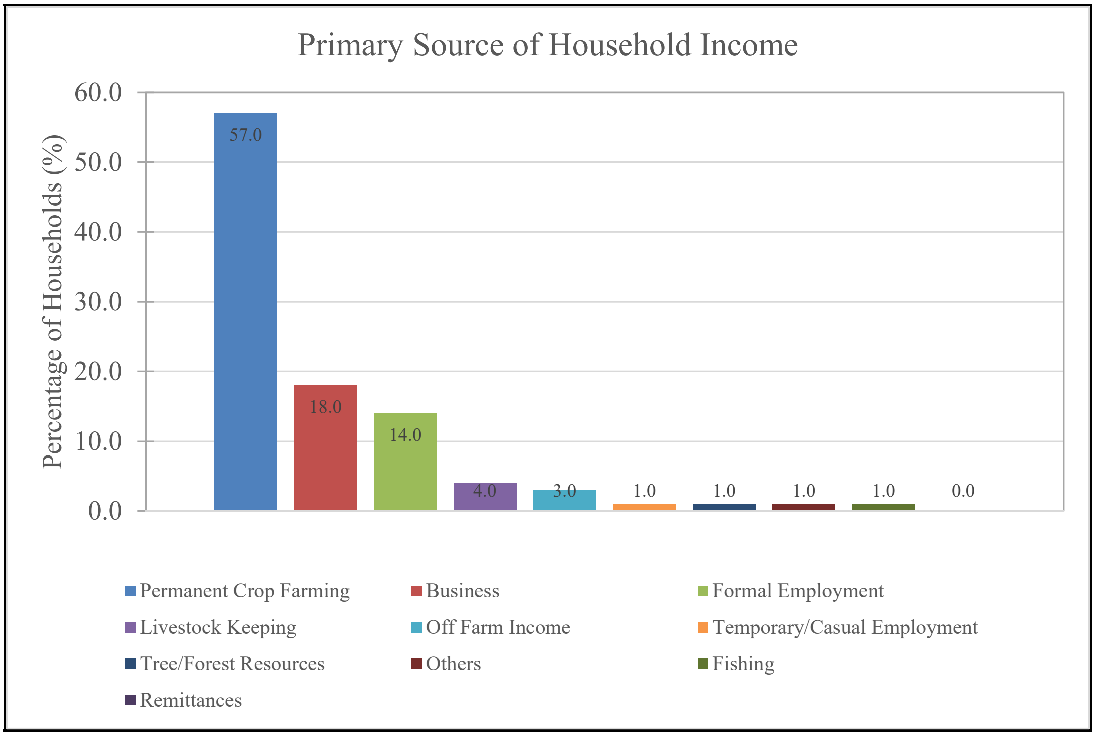


Figure 2.4: Primary Source of Household Income.

2.2.3 Access to Social Services

Domestic Water Supply: Rural and urban water supply coverage is very low in all the sub-basin districts. Access to clean drinking water in rural areas varies from 40% in Sumbawanga MC to 45% in Sumbawanga DC, while access in urban areas ranges from 20% in Nkasi DC to 60% in Sumbawanga MC. These coverage levels are all lower than the 2015 national targets.

Sanitation: The majority (about 70%) 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 80% of the sub-basin population. It is mostly used for domestic cooking and lighting and in diverse subsistence economic activities such as brick making and pottery. 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.

Health Services: The status of health services in the Luiche sub-basin is poor compared to other parts of Tanzania. For example Sumbawanga MC has a high number of people per health facility estimated to be about 7,000. There is also a general shortage of medical staff in all sub-basin districts. For example the mean doctor/population ratio for Sumbawanga DC is about 1:258,375 well below the WHO recommended standard of 1:10,000 and national average of 1:25,000.

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 the Luiche sub-basin are summarized next. For more details please refer to the above report volume.

2.3.1 Climate

The sub-basin is mostly characterized by tropical climate and experiences one long rainy season (November to April). The dry season starts from around June to October with the driest months being July and August (**Figure 2.5**). Annual rainfall ranges from 900mm to 1000mm.

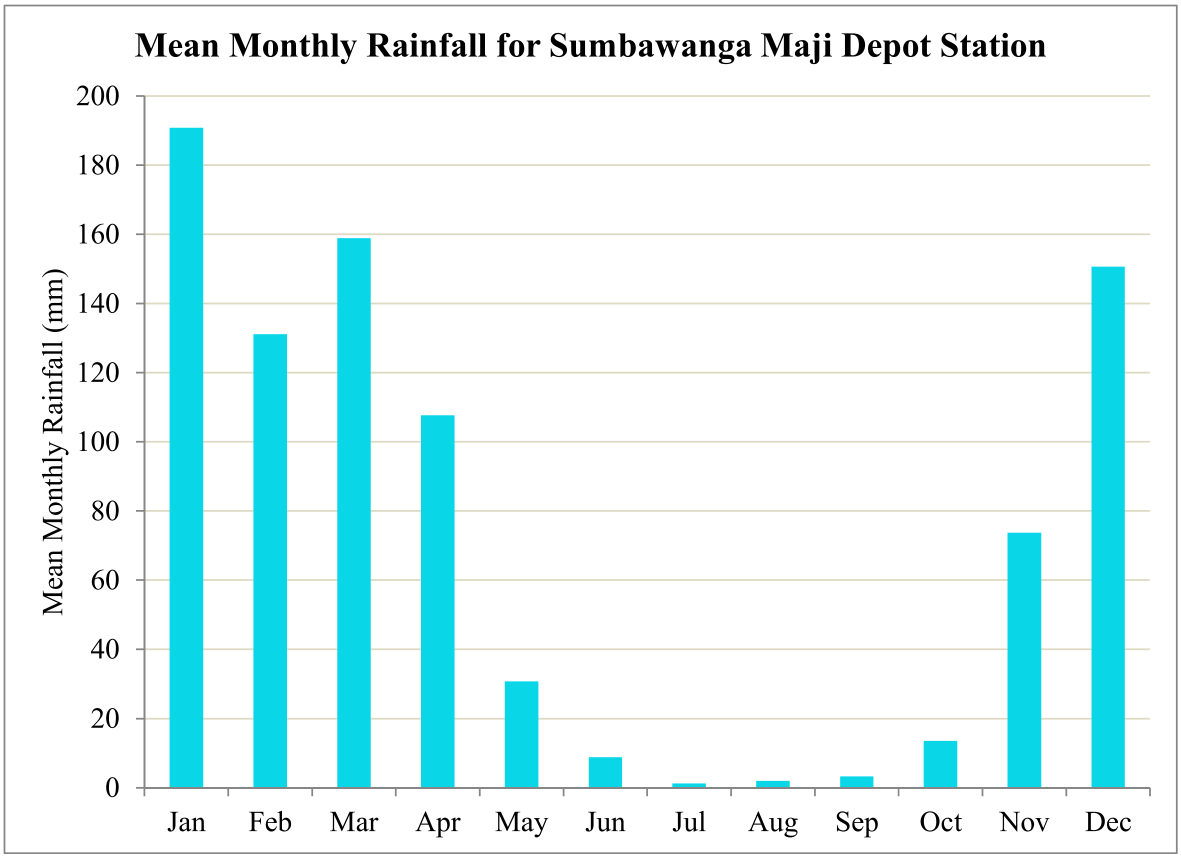


Figure 2.5: Mean Monthly Rainfall for Sumbawanga Maji Depot Station at Sumbawanga Town.

2.3.2 Surface Water Resources

The Luiche Sub-basin is drained by the River Luiche which originates from the southern part of the Ufipa Plateau, traverses a vast expanse of swamps through the *Lyambalyamufipa* escarpment into the Rukwa Valley, and finally discharges into swamps on the northwestern shores of Lake Rukwa. The main Luiche tributaries include, among others, River Nantula draining the eastern part of the sub basin, River Lukangau draining the western part, and Rivers Pande and Matusha draining the northwestern part of the Luiche region.

The Luiche River exhibits strong seasonality, high flows in the rainy season, and significantly low flows the rest of the year (see **Figure 2.6**). The river registers peak flows during February to April and very low flows from August to November.

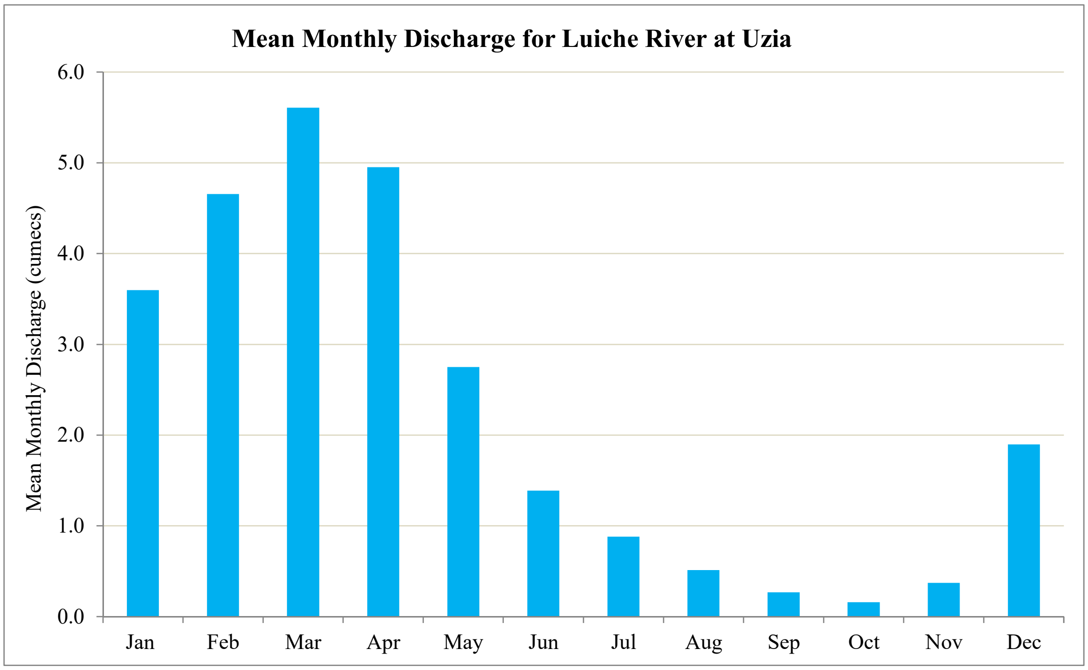


Figure 2.6: Mean Monthly Discharge for Luiche River at Uzia.

The Lake Rukwa Basin Water Board operates and maintains a water resources data collection network for the sub-basin consisting of one hydrometric station (Luiche River at Uzia – 3CD2) and meteorological and water quality stations shown in **Figure 2.7**. The Luiche station has significant data gaps due to inconsistencies in the monitoring program mostly attributed to inadequate funding. Its rating curve is also outdated and needs recalibration.

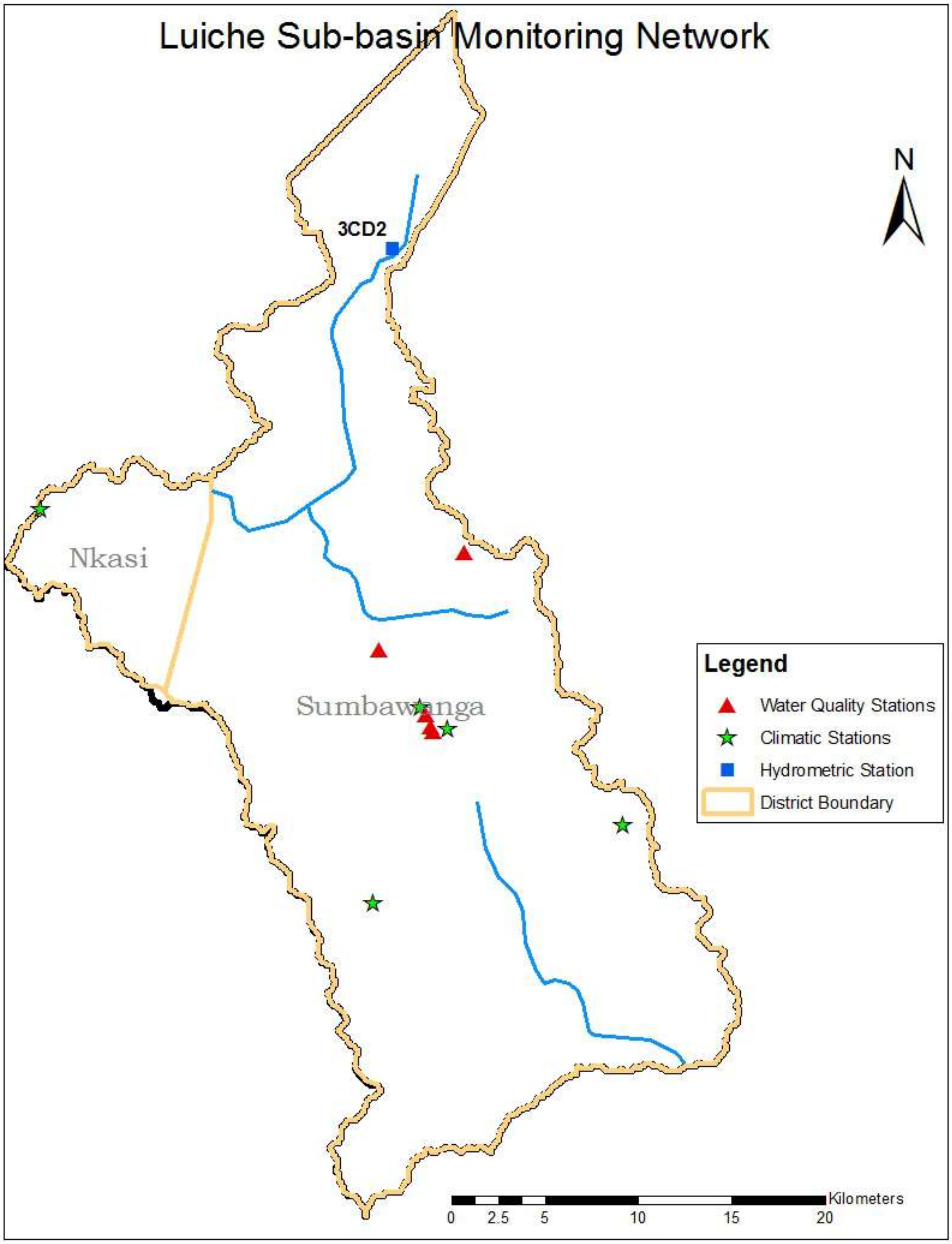


Figure 2.7: Luiche Sub-basin Water Resources Monitoring Network.

2.3.3 Groundwater Resources

There is no existing groundwater monitoring network in the Luiche Sub-basin to provide the necessary data for characterizing the existing aquifers and estimating their groundwater potential. Nevertheless, groundwater is a major source of domestic water supply in most sub-basin rural areas. However, a clearer picture of the sub-basin groundwater potential, yield, and spatial distribution will only be possible after establishing a groundwater monitoring network and collecting the necessary data.

2.3.4 Water Quality

A large part of the Luiche sub-basin lies within Sumbawanga Municipal Council and shows signs of urban pollution (turbidity, colour and faecal coliform problems in surface water and groundwater). There are a number of boreholes with high fluoride levels probably originating from the underlying rocks. Possibly due to the geology of the area, the Luiche is more mineralized than other major rivers in the Lake Rukwa Basin.

3. Sectoral Water Use and Demand Projections

3.1 Water Use and Demand Projections

The total water demand for the Luiche sub-basin is projected to increase from 12.66 MCM in 2015 to 49.03 MCM by 2035, an increase of about 287%. The projected increments in the individual sectors are shown in **Figure 3.1** and **Table 3.1**. Detailed discussion of water demand projections for all the Lake Rukwa sub-basins is contained in a separate report volume (*Interim Report 2, Volume I: Water Demand Projections*). The projected increase in water demand is expected to exacerbate the already high pressure on the sub-basin water resources. This, coupled with increased deterioration in water quality due to pollution and environmental degradation, presents a major challenge to the sub-basin water managers and planners. Sumbawanga Town, being a major regional commercial hub, is going to continue expanding due to urbanization. The sub-basin is expected to experience a surge in urban population and expansion in residential and commercial infrastructure. All these new developments will require access to adequate and reliable water supplies. The major water uses are the irrigation and domestic sectors accounting for 50% and 47% of the total sub-basin consumption respectively. The livestock and industrial sectors account for only 3%. All the sectors mostly rely on surface water sources (rivers, streams, lakes, and reservoirs). Groundwater is an important source accounting for about 60% of total domestic water supply. Potential exists for increased groundwater use in the future, especially once efforts have been made to assess potentialyield and spatial distribution. **Figure 3.2** shows the location of major water uses in the Luiche sub-basin.

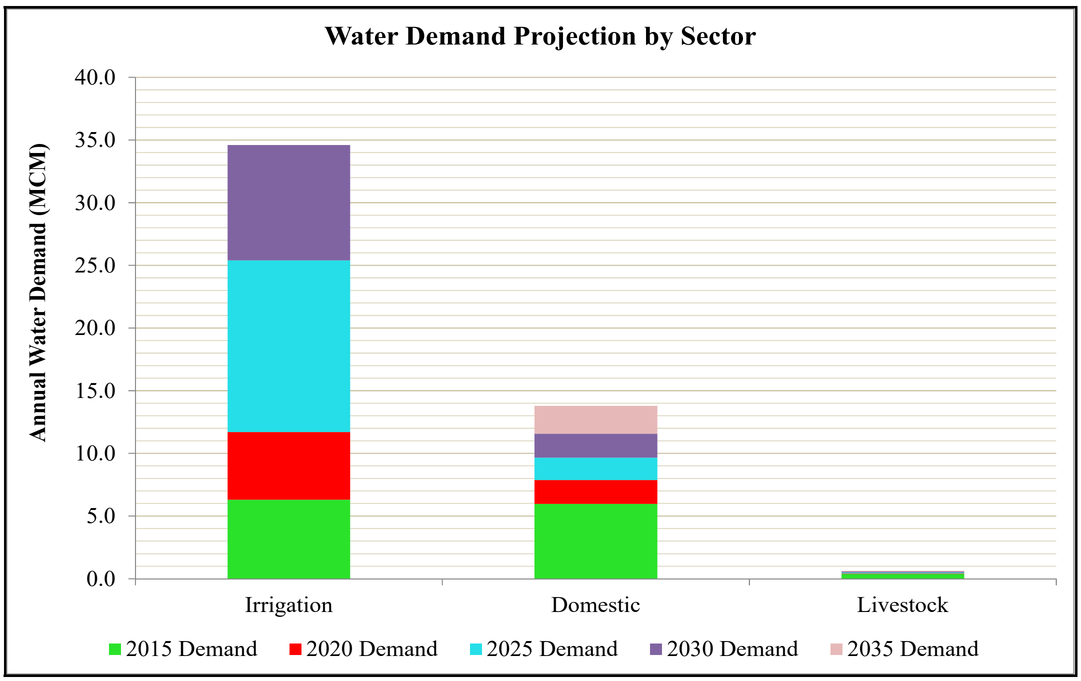


Figure 3.1: Luiche Sub-basin Water Demand Projections.

Table 3.1: Luiche Sub-basin Water Demand Projections.

Sector	Demand Projection (MCM)				
	2015	**2020**	**2025**	**2030**	**2035**
Irrigation	6.30	11.70	25.40	34.60	34.60
Domestic	5.97	7.87	9.65	11.57	13.79
Livestock	0.39	0.44	0.50	0.56	0.63
Sub-basin Total	**12.66**	**20.01**	**35.55**	**46.74**	**49.03**

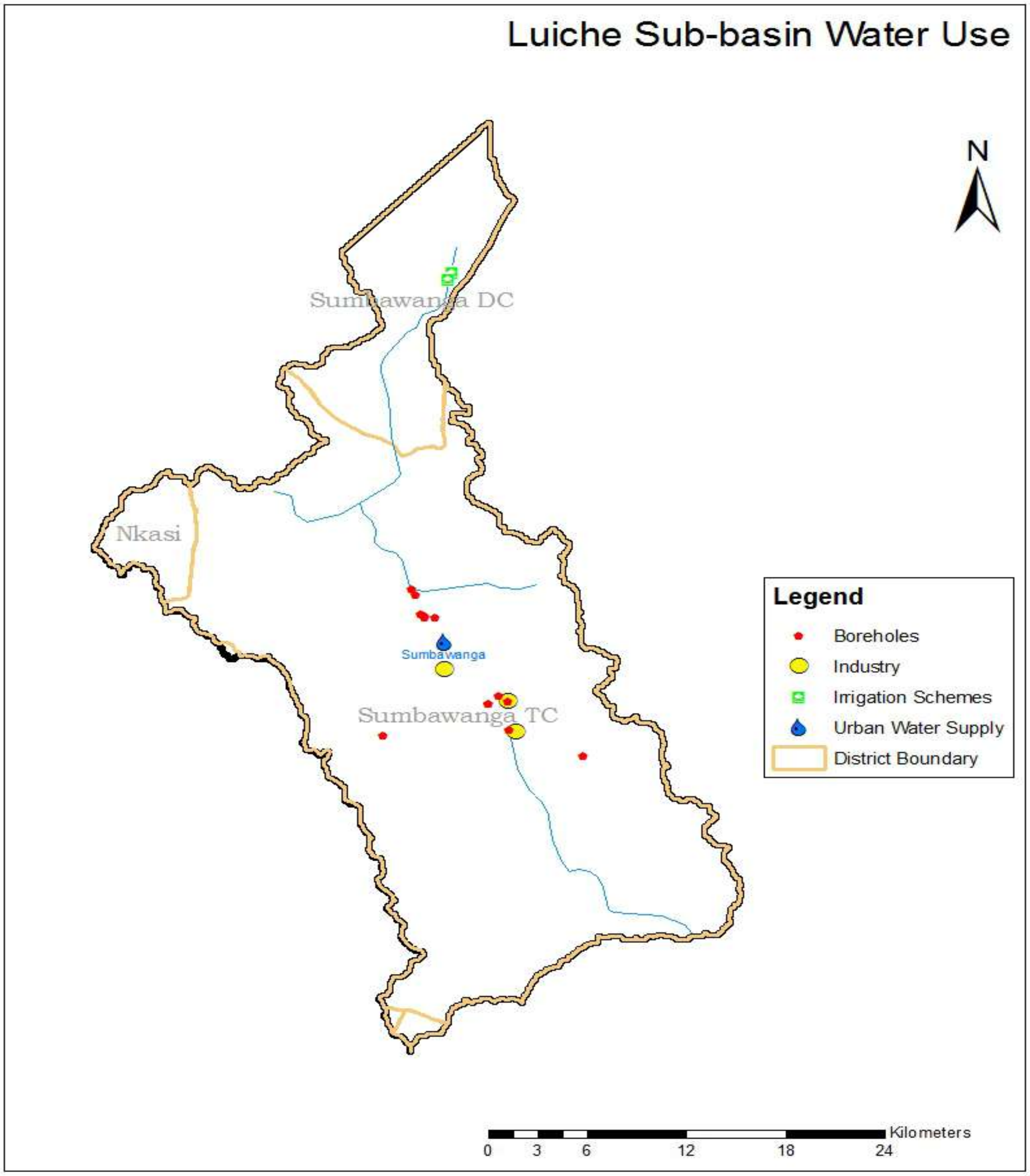


Figure 3.2: Location of Major Water Uses in the Luiche Sub-basin.

3.1.1 Irrigation Water Use

There are two major irrigation schemes in the sub-basin (Uzia and Ulumi). They are both traditional schemes growing paddy, maize, beans, onions, and potatoes, and they draw water from the Luiche River. The total annual irrigation water use is estimated to be about 6.3 MCM. **Figure 3.3** shows the sub-basin mean monthly irrigation water use. Most irrigation activities take place during the wet season (November to March). This irrigation water consumption pattern is attributed to the intensive supplementary irrigation practiced in paddy growing schemes. Paddy is the most commonly irrigated crop during the wet season. Paddy irrigation starts from November/December to March/April. On average, most paddy varieties require about 150 days to mature. Other crops are usually irrigated during the dry season from May to October. Maize, beans and vegetables are usually planted in May, June and July.

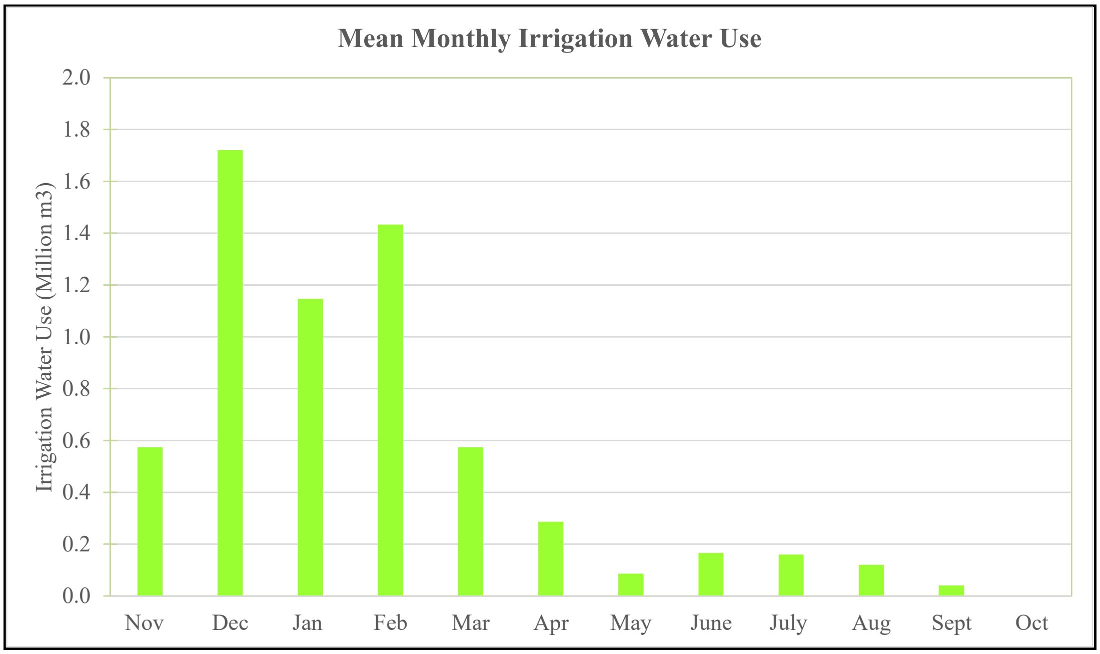


Figure 3.3: Luiche Sub-basin Mean Monthly Irrigation Water Use.

Based on the existing national and local irrigation development plans, the annual irrigation water demand for the Luiche Sub-basin is projected to increase from 6.3 MCM in 2015 to 34.6 MCM in 2035 (**Figure 3.4**). Detailed results of water demand projections for all sectors and sub-basins are presented in ***Interim Report II Volume I***.

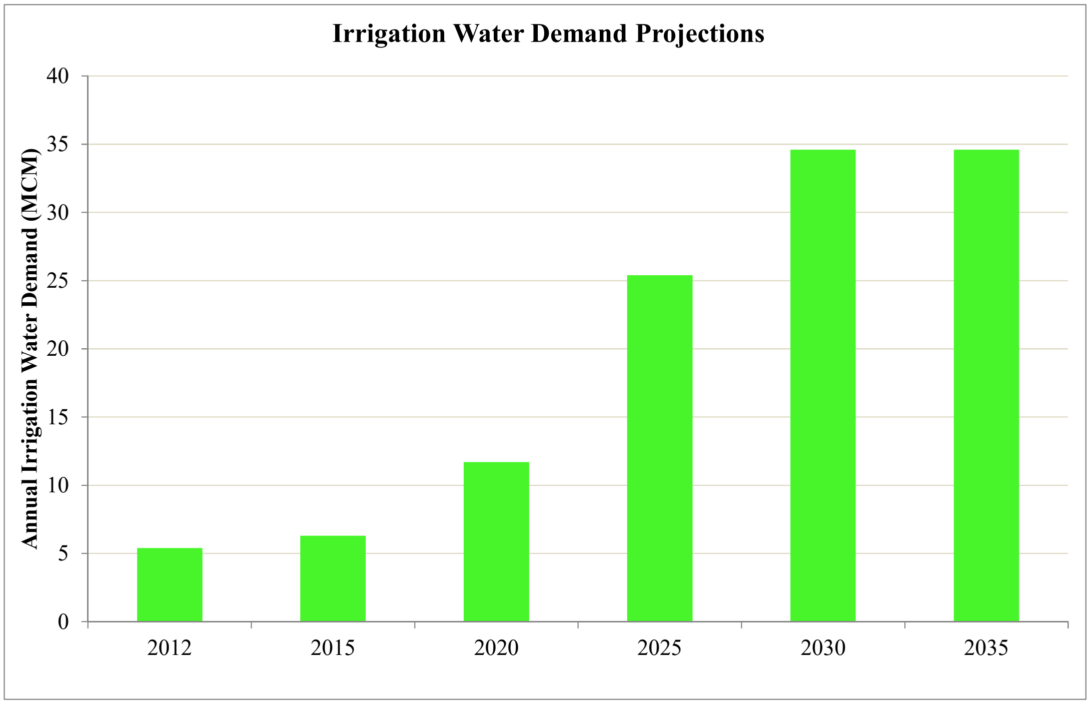


Figure 3.4: Irrigation Water Demand Projections for Luiche Sub-basin.

Issues and Challenges

The projected increase in irrigation water demand under the current inefficient irrigation practices is unsustainable in the long run since the sub-basin is already experiencing water stress. Having an irrigation sector dominated by traditional irrigation schemes is very unsustainable from a water resources management point of view. Traditional schemes have inadequate and poorly constructed infrastructure which result in high water losses and, thus, low water use efficiency. Because of the poor infrastructure, actual water abstractions are often more than the required or permitted allocations. This overuse depletes the water supply source and leads to conflicts with other water users. The priority intervention for the sub-basin is therefore improving irrigation water supply infrastructure in the traditional schemes to reduce water losses and improve irrigation water use efficiency.

3.1.2 Domestic Water Use

Domestic water supply coverage in the Luiche sub-basin is generally low. Access to clean drinking water in rural areas varies from 40% in Sumbawanga MC to 45% in Sumbawanga DC, while access in urban areas ranges from 20% in Nkasi DC to 60% in Sumbawanga MC. These coverage levels are all lower than the 2015 national targets. The Luiche sub-basin domestic water demand is projected to increase from 5.97 MCM in 2015 to about 13.79 MCM by 2035 (see **Figure 3.5**).

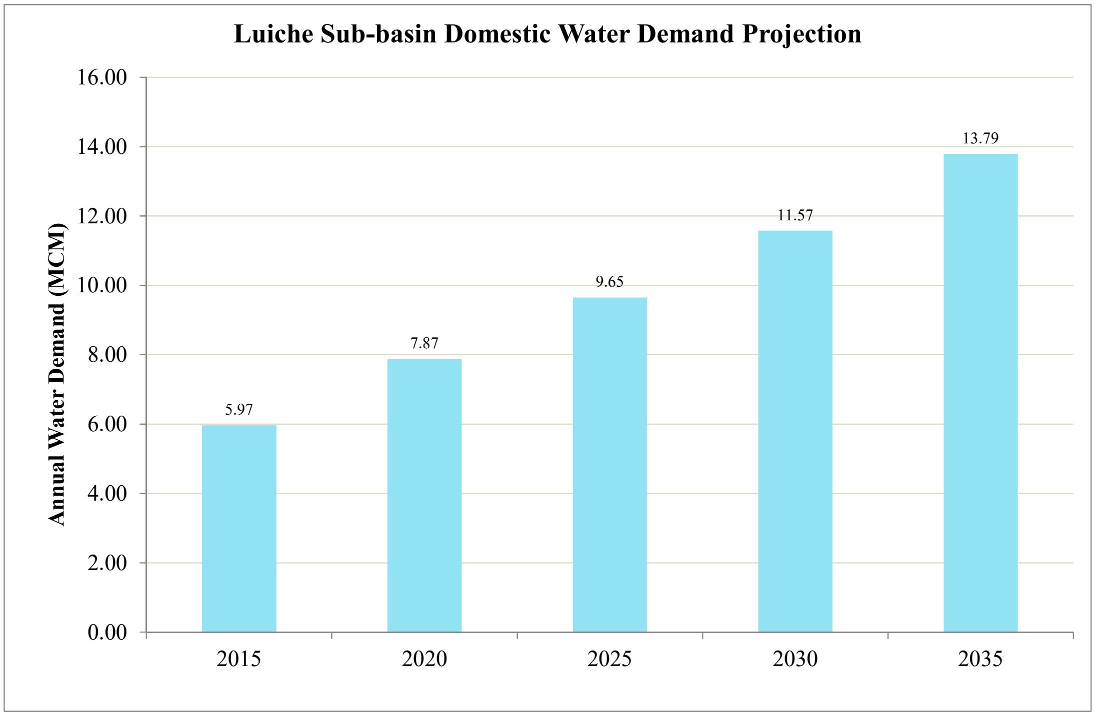


Figure 3.5: Domestic Water Demand Projections.

(1) Urban Water Supply

The Luiche Sub-basin is home to Sumbawanga Town, a major urban and commercial center in the Rukwa Region with population of 111,519 (2012 National Census). Urban water supplies for Sumbawanga Town account for about 90% of domestic water consumption. Domestic water needs for Sumbawanga Town are significant and are expected to rise as the urban population continues to grow. The Town is supplied by Sumbawanga Urban Water Supply and Sewerage Authority (SUWASA), operations of which are discussed next.

Sumbawanga Urban Water Supply and Sewerage Authority (SUWASA)

SUWASA is a category C public water supply authority established in 1998. The service area has a population of about 111,519 (2012 Census) of whom 62,000 are served with water. The authority serves Sumbawanga Town, which is also the headquarters of Rukwa Region. Average water demand for the service area is estimated to be 9,300m^3/day while the installed water production capacity and average actual water production are 6,000m^3/day and 4,575m^3/day respectively. In average years, water production fluctuates from a minimum of about 3,000m^3/day during the dry season to about 6,000m^3/day during the rainy season. During dry years, the yield drops to as low as 1,500m^3/day at the end of the dry season (November). The average hours of service are 15 hours per day. **Figure 3.6** shows the population and water demand growth projection for Sumbawanga Town. The figure shows that the water demand for the town is expected to double by 2020. There is, therefore, urgent need to develop new water sources and increase the water production capacity to meet both current and future water needs for the town.

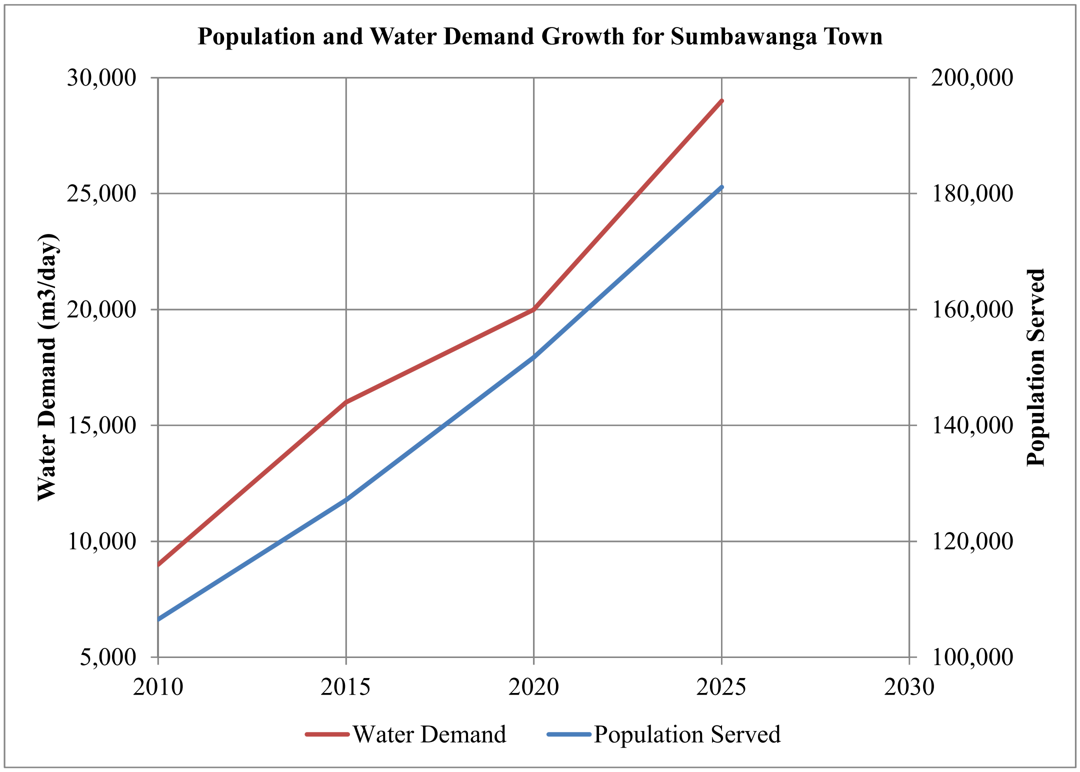


Figure 3.6: Population and Water Demand Growth Projection for Sumbawanga Town.
(Source: Sumbawanga Urban Water Supply and Sewerage Authority, 2009)

The utility draws water by gravity from six streams (**Table 3.2**) originating from Mbizi forest, located 10 km east of Sumbawanga Town. Water from the six streams is transmitted to town by gravity and constitutes 95% of all the water supplied to Sumbawanga Town. In addition to the above sources, there are 16 medium depth boreholes operated by agents as water kiosks. Three of the boreholes are fitted with electric pumps while the rest operate with hand pumps. The utility also had a pumped water supply scheme from shallow wells in Chanji area, but this was abandoned due to poor water quality,vandalism, and drying up of the shallow wells. In order to increase production capacity of the utility, eight new boreholes were drilled (under WSDP-I) which produce an additional 4,000 m^3/day of water. Existing storage facilities consist of 5 tanks located at Katandala (680 m^3), Regional Hospital (90 m^3), Makao Makuu (130 m^3), Kristo Mfalme (225 m^3), and Kizwite (225 m^3) with a combined storage capacity of 1,350 m^3. All storage facilities are in good working condition. Raw water abstracted from the rivers/streams is of poor quality and is characterized by high silt loads and bacteriological contamination, especially during the rainy season, resulting in high water treatment costs. Point source pollution is mainly attributed to poor disposal of domestic waste loads, while non-point pollution comes from run-off originating from developed areas, agriculture farms, and soil-erosion. Pollution from industrial effluent is negligible since there are no major industries in Sumbawanga Town. Significant quantities of effluent from abbatoirs are discharged into River Luiche daily. The utility does not operate a conventional sewerage system, and therefore households rely on pit latrines and septic tanks to dispose of domestic waste loads. A feasibility study for construction of a conventional sewerage system was undertaken by M/S Poyry Environment GMBH under the Seven Towns Upgrading Programme. Sludge from septic tanks and pit latrines are indiscriminately discharged into the River Luiche at different points. The combined impact of the numerous point source pollution discharged into the river is yet to be established.

Table 3.2: SUWASA Water Sources

Water Source (River/Stream)	Capacity (m^3/day)	Intake Location	Intake Structure
R.Kanatumbi	2,020	Wipanga Village	Concrete weir across R.Kamatumbi. Structure is in good condition though it is susceptible to silting during the rainy season.
R.Mzika	1,050	Wipanga	Concrete weir across R.Mzika. Structure is shared between Wipanga and Kankwale villages and is in good condition.
R.Muva	1,690	Near Senga village	New intake replacing the old abandoned intake.
R.Mwambazi/ R.Momoka	2,750	Near King'ombe village	Concrete weir across Rivers Mwambazi and Momoka. Structure in good condition.
R.Namasapu	340	Kizwite	Concrete weir across R.Namasapu. Structure experiences frequent vandalism.
R.Nduwa	1,200	Kizwite	New intake replacing the old abandoned intake. Structure is in good condition and well protected.

Source: Sumbawanga Urban Water Supply and Sewerage Authority (2009)

Each of the intakes on the six streams is located on surveyed land (more than one hectare each) belonging to SUWASA, and they are protected by watchmen hired by the utility. Thorny trees have been planted around the intakes to protect them from intrusion by people and animals. SUWASA is also actively involved in tree planting, control of bush fires, sensitization of local communities near Mbizi forest, and prohibiting forest encroachment.

Priority issues for the authority include: construction of additional water sources to supplement existing ones; expansion of water supply infrastructure to meet current and future demand; reduction in non-revenue water from the current 40%; and construction of a sewerage system.

Figure 3.7: SUWASA Intake at Momoka River.

Figure 3.8: Mbizi Forest Area – Notice the extensive deforestation that has decimated the forest.

(2) Rural Water Supply

The main sources for rural water supply include bore holes, springs, gravity flow schemes, rivers, streams, and rainwater harvesting from roof-tops. Of the 165 existing rural water supply sources in the Luiche sub-basin, 57 (41%) are improved traditional wells, and 55 (33%) are springs. Most of the existing rural water supply infrastructure was constructed several decades ago and is in overall poor working condition. Most of it was constructed to serve a small population and has not been expanded to cope with the rapid population growth. As a result water production for most schemes is low compared with the demand. Several of the rural water supply schemes have broken down due to poor maintenance and vandalism.

Over the past 20 years, there has been renewed government commitment to invest in rural water supply and sanitation improvement programs to meet development objectives and national targets. Implementation of the rural water and sanitation component of WSDP initially focused on the rehabilitation/construction of small-scale projects in each district that could be financed through the Local Government Capital Development Grant. These "quick-win" projects were either largely already designed or needed simple rehabilitation to improve existing water supply infrastructure and services. This initiative has helped improve rural water supply and sanitation coverage in most of the basin districts over two to three years. With the successful completion of out-standing projects and the execution of rehabilitation work, the WSDP has begun to focus on new projects in villages that do not have a water supply or those which cannot be viably rehabilitated. This second round of rural water supply infrastructure expansion is expected to significantly improve 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 managed and maintained resulting in frequent breakdowns.

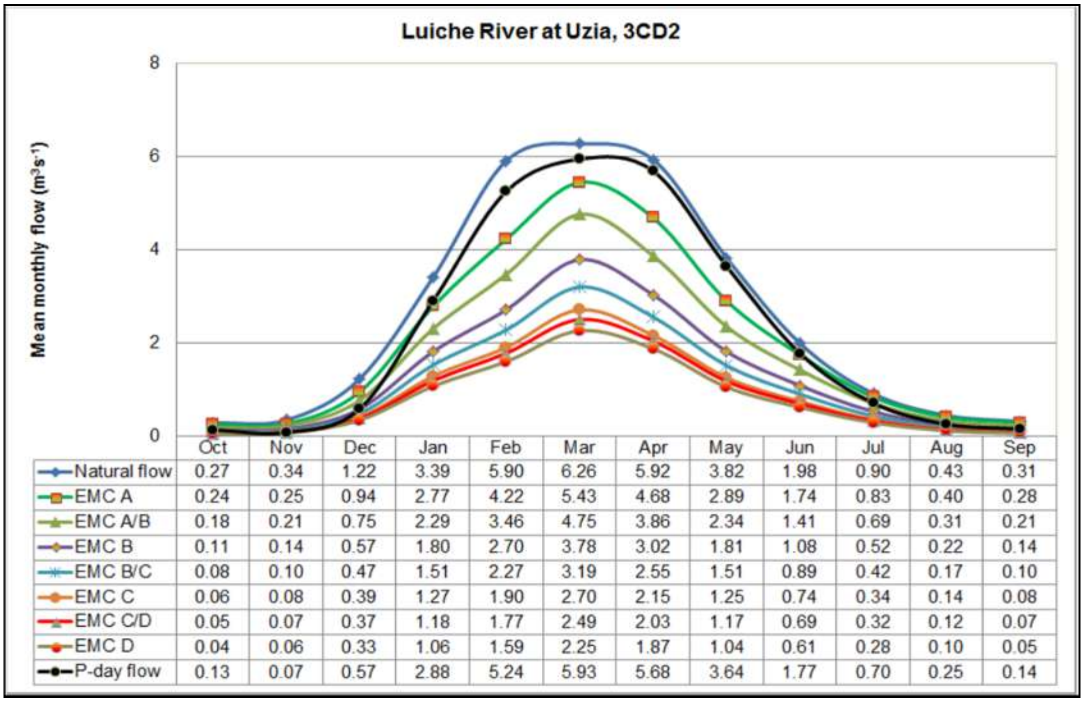
Issues and Challenges

One of the major challenges facing the urban water supply sub-sector is increasing water treatment costs due to pollution and high turbidity levels in raw water. This is attributed to upstream catchment degradation resulting from widespread deforestation and poor farming practices. Incidences of untreated effluent and solid waste disposal into water bodies are also increasing in urban and peri-urban areas. These, and other uncontrolled human activities in the upstream catchment areas, negatively impact water quality in the rivers and streams which serve as water sources for the urban water supply utilities. The increased water treatment costs are often transferred to water users as increased tariffs which discourage water users from paying for the services. As a result users either resort to use of unsafe water sources or engage in illegal water connections. Secondly, SUWSA does not have the capacity to meet the water demand of its supply area due to: inadequate capacity, low production levels, high water losses, inadequate water sources, and general deterioration of scheme infrastructure.

3.1.3 Environmental Flow Requirements

The National Water Policy (2002) and Water Management Act (2009) emphasize the importance and need for determining environmental flow requirements and allocating 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 use) in the hierarchy of water allocation, and it requires that specific minimum flows be maintained to sustain freshwater ecosystems.

The Desktop Reserve Model (DRM) was used to generate initial estimates of Environmental Flow Requirements (EFRs) for the Luiche River at Uzia. The objective was to recommend preliminary estimates of flows required to sustain biodiversity and important ecological processes at Luiche at Uzia, a critical river section. **Figure 3.9** shows the recommended environmental flows for the Luiche River at Uzia for different EMCs. Detailed description of the EFA findings and recommendations are contained in *Interim Report 2, Volume III*. It is recommended that more detailed EFAs be carried out for the Luiche at Uzia to establish more accurate EFRs for water allocation decisions. The detailed EFAs should also be carried out for all the critical sub-basin river sections.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Natural flow	0.27	0.34	1.22	3.39	5.90	6.26	5.92	3.82	1.98	0.90	0.43	0.31
EMC A	0.24	0.25	0.94	2.77	4.22	5.43	4.68	2.89	1.74	0.83	0.40	0.28
EMC A/B	0.18	0.21	0.75	2.29	3.46	4.75	3.86	2.34	1.41	0.69	0.31	0.21
EMC B	0.11	0.14	0.57	1.80	2.70	3.78	3.02	1.81	1.08	0.52	0.22	0.14
EMC B/C	0.08	0.10	0.47	1.51	2.27	3.19	2.55	1.51	0.89	0.42	0.17	0.10
EMC C	0.06	0.08	0.39	1.27	1.90	2.70	2.15	1.25	0.74	0.34	0.14	0.08
EMC C/D	0.05	0.07	0.37	1.18	1.77	2.49	2.03	1.17	0.69	0.32	0.12	0.07
EMC D	0.04	0.06	0.33	1.06	1.59	2.25	1.87	1.04	0.61	0.28	0.10	0.05
P-day flow	0.13	0.07	0.57	2.88	5.24	5.93	5.68	3.64	1.77	0.70	0.25	0.14

Figure 3.9: Comparison between Naturalized flow, present-day (P-day) flow and estimated total maintenance flows for different ecological management classes for Luiche River at Uzia 3CD2 for the period 1982-2011.

3.1.4 Livestock Water Use

Livestock keeping is one of the major socio-economic activities in the Luiche 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, and the surplus is sold to enhance household incomes. Local and regional demand for livestock products is high and there is, therefore, great potential for sustained growth of the livestock industry. The most commonly kept type of livestock include cattle, goats, and sheep, most of which are indigenous and free ranging with a few hybrids and dairy cattle in isolated ranches. Other livestock kept include pigs, donkeys, chicken, ducks, and pigeons.Total livestock population in the sub-basin is approximately 136,175. **Figure 3.10** shows sub-basin population for the different livestock types. Chicken is the most commonly kept accounting for about 55% of the total livestock population. Cattle and goats are also popular and account for 24% and 11% 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. In addition to the natural sources, communities have also invested in other livestock water supply infrastructure including charco and other dams. These are usually multipurpose water storage facilities that serve multiple local community water uses like domestic water supply and irrigation. The annual livestock water consumption for the Luiche sub-basin is projected to increase from about 0.39 million m^3 in 2015 to about 0.63 million m^3 in 2035 (see **Figure 3.11**). The projected increase in livestock population and water demand will lead to increased pressure on the sub-basin's natural resources and exacerbate the ongoing environmental degradation and water use conflicts.

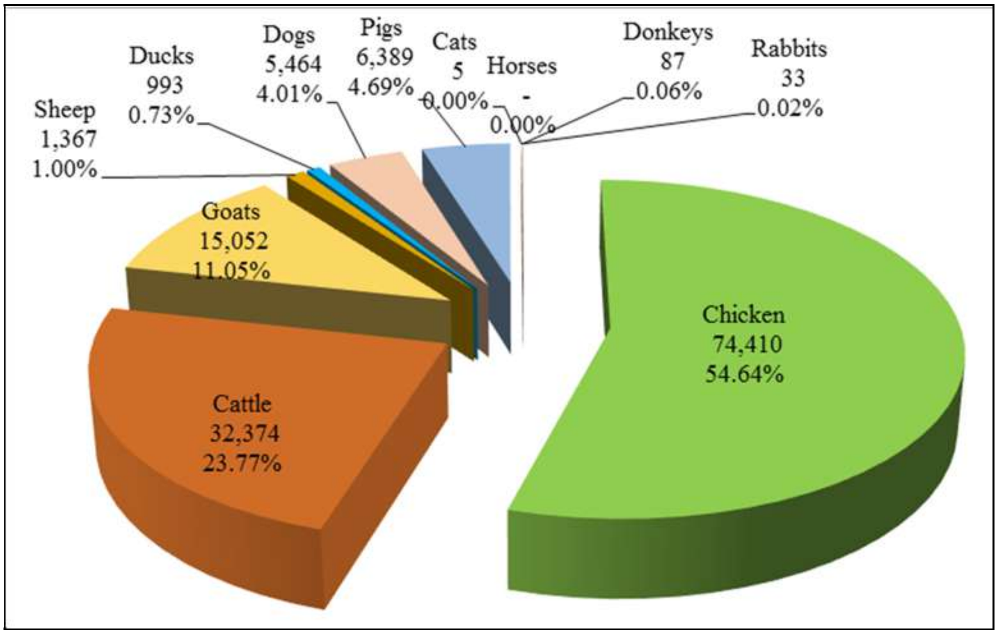


Figure 3.10: Luiche Sub-basin Livestock Population.

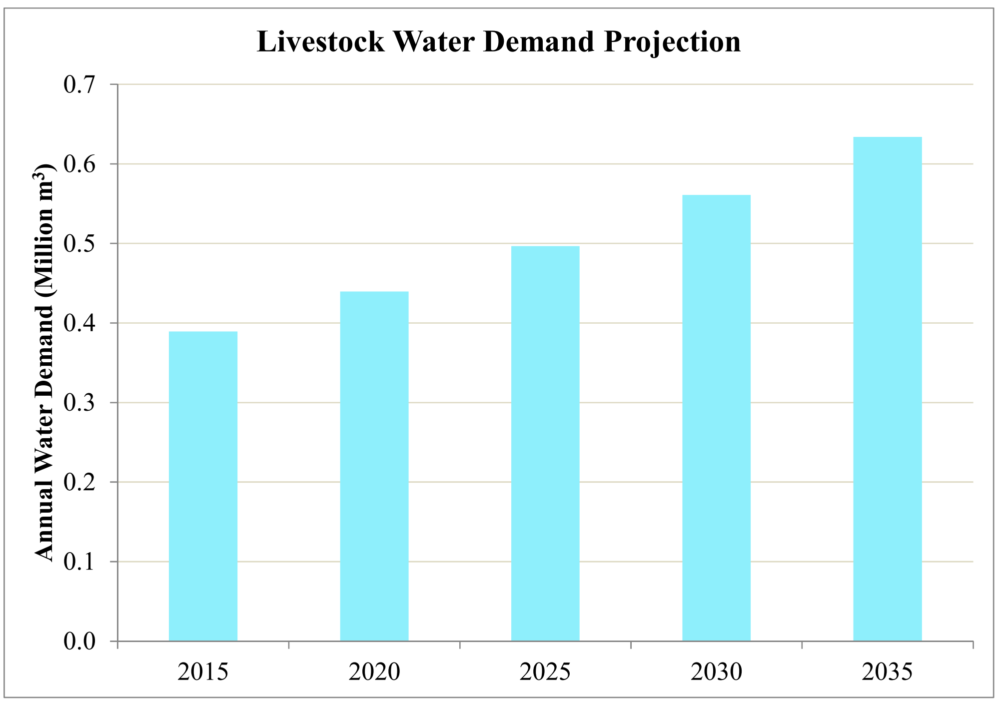


Figure 3.11: Livestock Water Demand Projection for Luiche Sub-basin.

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. The result is conflicts between farmers and pastoralists. Lack of designated livestock watering areas also results in pastoralists watering their animals directly in water sources used for other uses. This often results in destruction of water sources and the surrounding catchment areas. The situation is exacerbated by the uncontrolled influx of livestock from neighboring regions which is putting substantial pressure on the sub-basin's natural resources. Several areas have exceeded their livestock carrying capacity thus resulting in overgrazing, soil erosion, land compaction, destruction of wetlands and river banks, and intense land and water use competition and conflicts. There is also reported pollution of surface water sources from cattle dip and slaughter house effluents. Pastoralists are reported to be engaged in bush burning to create a flush of new grass for livestock before the rainy season and to control parasites harmful to livestock. Uncontrolled bush burning has been responsible for destruction of forests and other wildlife habitats. This practice is also reported to contribute to excessive soil erosion and floods as a result of stripping the soil of all vegetation cover.

3.1.5 Mining Water Use

Mining is not a major socioeconomic activity in the Momba sub-basin. Good potential for coal mining exists in the Rukwa Region with deposits estimated to be about 20 million tons. The coal field is believed to extend from Namwele on the Ufipa plateau to Muze in the Rukwa Valley. If proved to be commercially viable, the coal presents a significant source of energy for both domestic use and potential thermal energy generation. Results from surveys conducted in 1988 (by Ruben a geologist from Norway) indicate availability of significant coal deposits in Kizungu village and Muze Ward in Sumbawanga DC. Preliminary estimates indicate deposits of about 10 million m^3 of coal deposits (Sumbawanga DC, 2011). Large scale commercial caol mining has not yet commenced. In 2004, a company called M/S Upendo Group Ltd ventured into coal mining in the area and identified possible markets for coal products of up to 6,000 tons per month. However, production output has been very low due to inadequate equipment, difficulty in accessing the mines especially during the rainy season, and poor road infrastructure making it very expensive to transport coal products to potential markets. Mining water use in the Luiche Sub-basin is insignificant as of now and is projected to remain very low in the long run compared to other water uses (irrigation and domestic water use).

3.1.6 Industrial Water Use

There are three medium scale industries in the Luiche sub-basin, all located in Sumbawanga Municipal Council: Energy Milling Company Limited (Flour Processing), SAAFI Company Limited (Meat Processing Factory), and M/s Barwani Investment Company Limited. Small scale industries include carpentry workshops, oil seed extracting mills, saw mills, and maize mills. Only one company has been issued a water abstraction permit for industrial use, the Energy Milling Company Limited. The Company draws water from two boreholes, LRB0150 (10 m^3/day) and LRB0151 (15 m^3/day). Industrial water use is therefore insignificant as of now and is projected to remain very low in the long run compared to other water use sectors in the sub-basin.

3.1.7 Water Use for Hydropower Generation

A mini-hydropower site of 100 KW potential and 10 meters head has been identified on the Luiche River at Uzia village in Sumbwanga District Council. M/S Ulaya Hydro and Windmill Technology Ltd is the prospective developer and is currently undertaking Environmental Impact Assessment studies for the project. The company has been granted a temporary water permit by the LRBWB (LRB 0078) to dam and abstract 15,120m^3/day of water from Luiche River for use in the planned hydropower generation. Structures proposed for construction include: filter dam, diversion furrow, intake, pipeline to turbine, turbine house and a return furrow. Funding for implementation of the project is being sought from the Rural Electrification Agency.

3.1.8 Wildlife Water Use

The only important wildlife sanctuary in the sub-basin is the Luiche wetland, which covers an area of about 33 ha. There are no major wildlife protected areas in the Luiche Sub-basin and therefore wildlife water requirements are not a significant concern.

4. Sub-basin Water Balance and Deficit Management

4.1 Water Balance Assessment

The Luiche Sub-basin does not experience significant water deficits given the current low water demand levels compared to the available water resources. According to **Figure 4.1**, the sub-basin does not experience seasonal water deficits under the current (2015) water demand levels during the wet and dry seasons. This is the case even when the seasonal environmental flow requirements are taken into consideration. However as the demand levels increase, deficits begin to occur during both the wet and dry seasons with increasing frequency. Deficits are mostly observed at a monthly time scale. **Table 4.1** shows that the sub-basin usually experiences some monthly water deficits from August to December with the frequency increasing with increasing water demand targets. The Table also shows that once environmental flow requirements are taken into consideration, the sub-basin could experience more significant water deficits from August to December with the November deficits occurring almost every year under the 2035 demand targets.

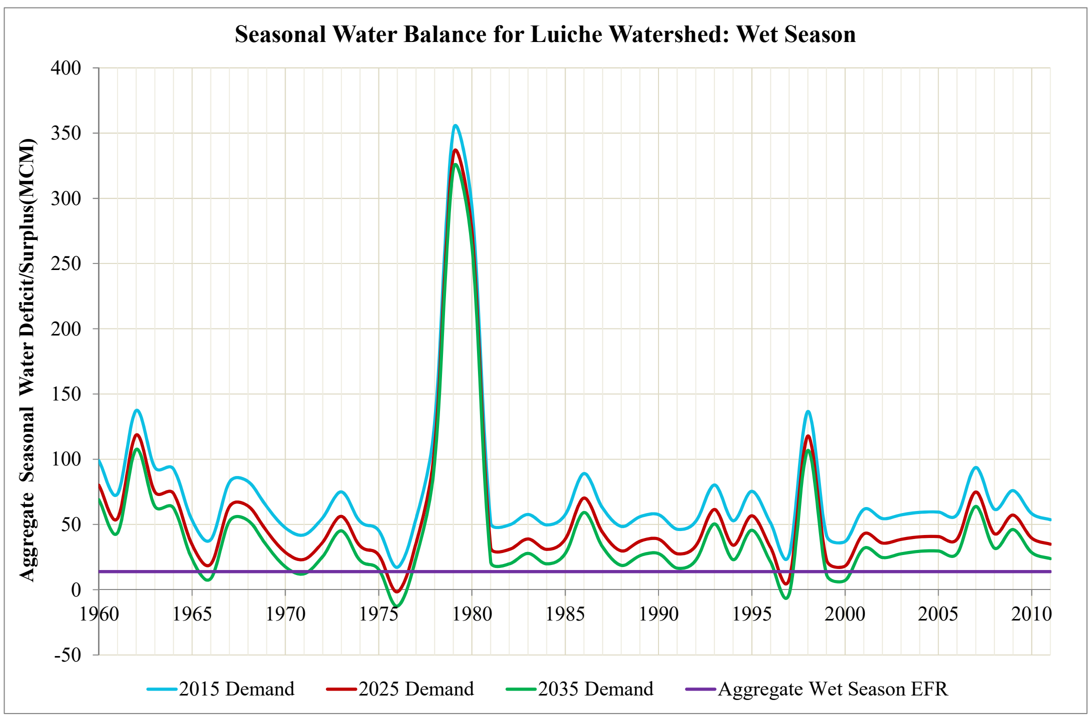


Figure 4.1: Wet Season Water Balance for Luiche Watershed.

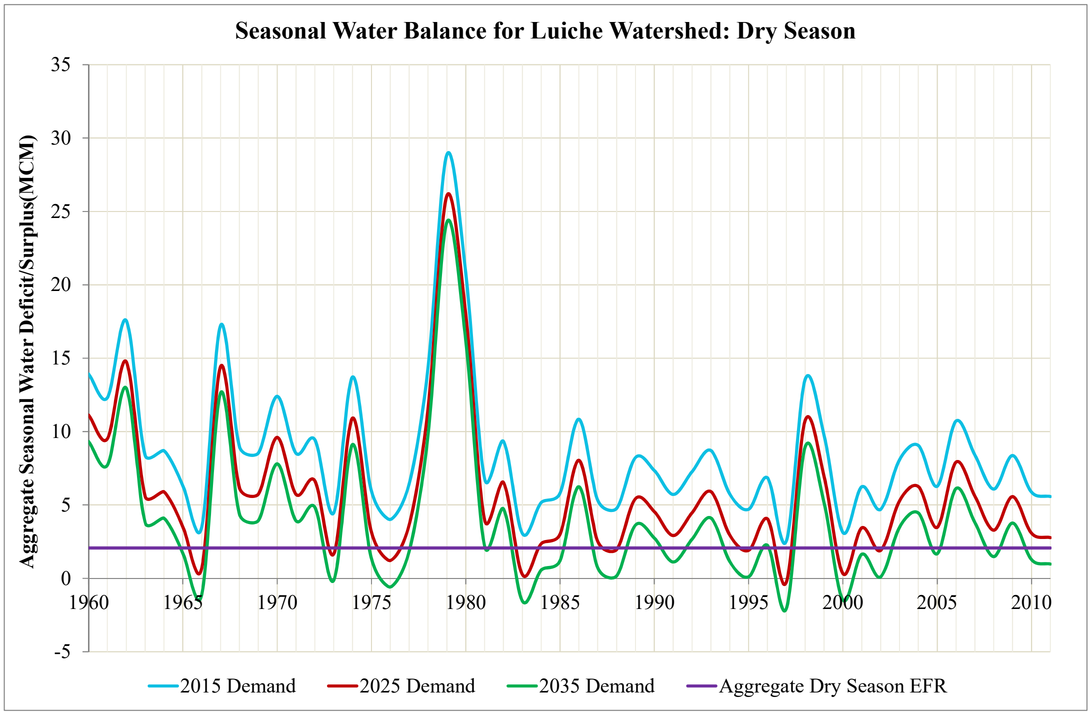


Figure 4.2: Dry Season Water Balance for Luiche Watershed.

Table 4.1: Frequency of Occurrence 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	0.113	0.170	0.038	0.792	0.094
	With EFR	0.000	0.000		With EFR	0.057	0.019	0.019	0.000	0.000	0.000	0.000	0.245	0.321	0.226	0.811	0.264
2025	Without EFR	0.019	0.019		Without EFR	0.113	0.038	0.019	0.000	0.000	0.000	0.075	0.566	0.774	0.509	0.906	0.811
	With EFR	0.038	0.170		With EFR	0.208	0.075	0.019	0.000	0.000	0.000	0.245	0.679	0.774	0.698	0.906	0.811
2035	Without EFR	0.038	0.113		Without EFR	0.245	0.038	0.019	0.000	0.000	0.000	0.170	0.717	0.925	0.943	0.962	0.830
	With EFR	0.113	0.415		With EFR	0.453	0.151	0.057	0.000	0.000	0.019	0.453	0.811	0.962	0.962	0.962	0.830

Figure 4.3 shows an increasing trend in sub-basin water stress in response to increasing water demand. However, the sub-basin water stress level is generally low given that the annual water demand is projected to remain low compared to water availability over the planning period. The figure shows that by 2035, water demand will be met in eight out of every ten years in the dry season.

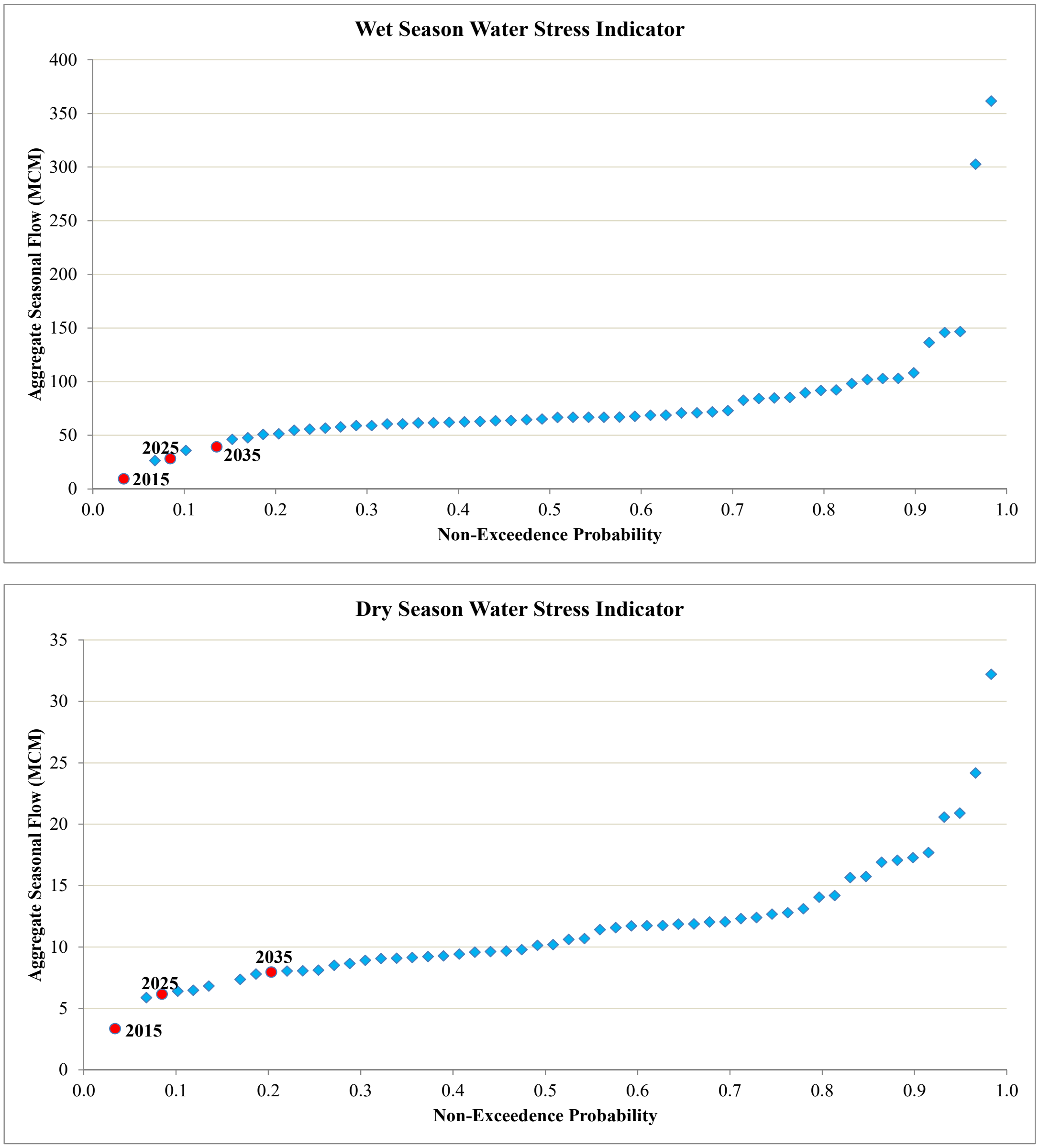


Figure 4.3: Luiche River at Uzia Water Stress Indicator.

4.2 Strategy to Address Projected Water Deficits

Although the current Luiche sub-basin water stress may not be critical, its increasing trend is a cause for concern as this could result in reduced productivity and increased water use conflicts especially during the dry season. The increasing water stress is due to a combination of factors especially the growing irrigation water demand and the significant domestic water demand for Sumbawanga Town (densely populated urban and commercial center). The most significant deficits occur in November, a low flow month, coinciding with the beginning of the paddy growing season, when water intensive activities take place on the Uzia and Ulumi traditional irrigation schemes. The situation is exacerbated by the inadequate and poorly constructed irrigation water supply infrastructure which resulst in significant water losses. These factors combine to aggravate monthly water scarcity from August to December as reflected in the high monthly water deficits observed under all water demand targets. However, with implementation of specific interventions, these challenges can be overcome in the short and long-term. First, improvements in irrigation water supply infrastructure and on-farm irrigation water management practices could reduce irrigation water use by up to 50%. Secondly, construction of strategic water storage infrastructure to harness excess wet season run-off could help even out the observed month-to-month water deficits and result in overall seasonal surpluses. Thirdly, improvements in domestic and industrial water use efficiency could also help slow down overall water demand growth. With this mix of interventions, most of the observed water deficits could be averted. These strategic interventions are discussed next.

4.2.1 Increase Sub-basin Water Storage Capacity

Surface water will continue to be the major source of water supply for the Luiche sub-basin. The main challenge of surface water is seasonality and vulnerability to potential future climate change impacts. However assessments show that with adequate water storage infrastructure in place, the sub-basin should be able to meet the projected water demands and also satisfy the desired environmental flow requirements most of the time. The Luiche sub-basin water storage capacity required to meet the projected water demands from 2015 to 2035 is estimated to be about 29.16 MCM.

Preliminary topographical analysis was conducted for the sub-basin and only one potential storage site was identified at location (31.5731 E; 7.8113 S) as shown in **Figure 4.4**. The potential storage determination was based on information about topography as represented by a digital elevation model (DEM) at 90 m spatial resolution (latitude and longitude). The DEM was analyzed using ArcGIS to evaluate the storage that would be created from the construction of a dam (of a certain height at different locations). The following site-specific information was computed:

(i) The volume and surface area of the inundated land that would result by building a dam at the site.
(ii) The width of the dam.
(iii) The catchment area upstream of the dam site.

Potential dam heights of 10 m to 70 m were assessed at 10 m increments. Three potential development options were identified for the dam site:

(i) **Option 1**: 7.8 MCM reservoir capacity with a surface area of about 0.63 Km^2, dam height and width of 40 m and 360 m respectively, and catchment area upstream of the dam of about 680 km^2.
(ii) **Option 2**: 26.1 MCM reservoir capacity with a surface area of about 1.24 km^2, dam height and width of 60 m and 360 m respectively, and catchment area upstream of the dam of about 680 km^2.
(iii) **Option 3**: 39.9 MCM reservoir capacity with a surface area of about 1.62 km^2, dam height and width of 70 m and 450 m respectively, and catchment area upstream of the dam of about 680 km^2.

Due to potential uncertainties in DEM resolution, the previous reservoir features should be viewed as estimates that need refinement by more detailed field surveys during the follow-up pre-feasibility studies. These caveats notwithstanding, the analysis carried out herein examined practically all potential river locations and provides fairly good guidance on the most promising site for reservoir development.

Option 3 was considered to be most attractive and was used in sub-basin water balance assessments. These assessments included detailed simulations of the identified reservoir site using 52 (1960 to 2011) years of monthly natural flows developed by a hydrologic model driven by historical rainfall and potential evapotranspiration series over the upstream watershed (from the CRU data base).

These assessments indicate significant reduction in observed monthly water deficits. For example, under Option 3 and the 2035 demand targets, the frequency of water deficits reduces from 0.962 to 0.0 and 0.830 to 0.019 respectively for November and December (see **Figure 4.5**). Detailed reservoir operation simulation results are presented in **Annex A**.

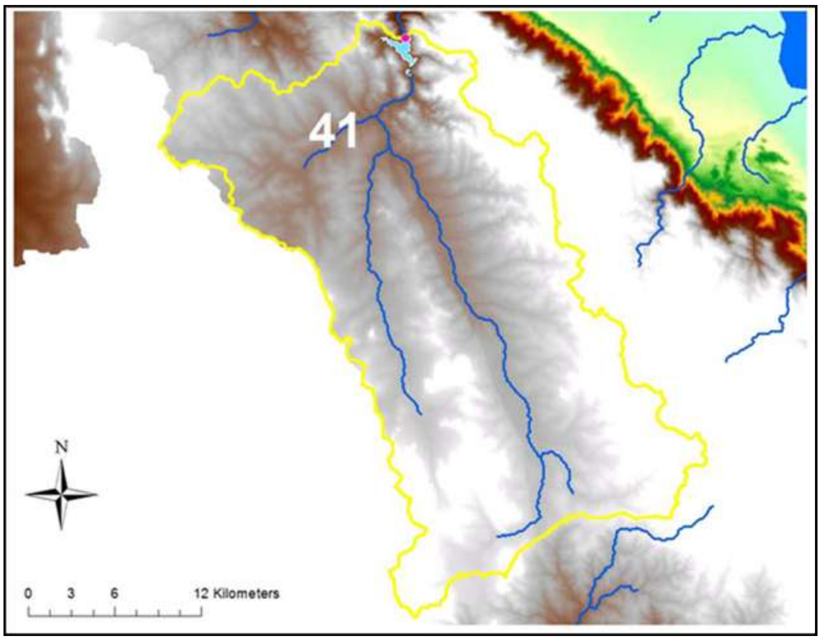
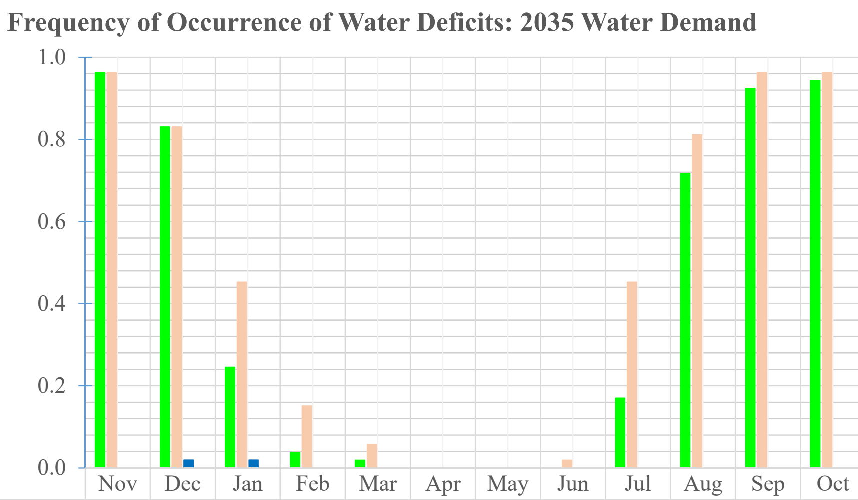


Figure 4.4: Location of Potential Water Storage Reservoir in Luiche Sub-basin

4.2.2 Improvements in Irrigation Water Use Efficiency

Uzia and Ulumi traditional irrigation schemes, like most other schemes in the Lake Rukwa Basin, are characterized by inadequate and poorly constructed infrastructure with high water losses and low water use efficiency. The schemes have temporary and poorly constructed water intake works and unlined irrigation canal systems that cannot supply adequate water to all areas. Any strategy to address the projected irrigation water demand should first focus on improving irrigation water use efficiency before exploring options to increase irrigation water supply. Studies in other basins (Great Ruaha sub-basin) have demonstrated that modest improvements in traditional irrigation infrastructure can result in appreciable water use efficiency gains and reduction in irrigation abstractions (SMUWC, 2001). Improving irrigation infrastructure improves irrigation water use efficiency and demand management. Such improvements should include well designed concrete water intake structures, well lined primary/secondary/tertiary canals, and provision of well planned drainage/return canals.

As part of the water balance assessments, a specific scenario was run to evaluate the benefits of improvements in irrigation water use efficiency. A consumption rate of 1liter/sec/ha was assumed corresponding to the planned irrigation infrastructure improvements. Simulations under historical hydrological conditions (1960 to 2011) indicate that under Option 3, improvements in irrigation water use efficiency (from 1.56 l/s/ha to 1.0 l/s/ha) would potentially eliminate all projected monthly water deficits under all water demand targets (see **Figure 4.5**). Detailed simulation results are presented in **Annex A**.



	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Without EFR	0.962	0.830	0.245	0.038	0.019	0.000	0.000	0.000	0.170	0.717	0.925	0.943
With EFR	0.962	0.830	0.453	0.151	0.057	0.000	0.000	0.019	0.453	0.811	0.962	0.962
EFR + Reservoir	0.000	0.019	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EFR + Reservoir + Irr Eff	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Figure 4.5: Frequency of Occurrence of Water Deficits in the Luiche Sub-basin.

4.2.3 Recommended Interventions

The Luiche Sub-basin has sufficient water resources to meet its projected water demand growth. However, it is recommended to develop some water storage in the sub-basin to address some projected water deficits. A potential storage site has been identified and recommended for further study to establish its feasibility regarding its construction. This should be complemented by appropriate water conservation measures. Specifically, it is recommended that irrigation infrastructure in all traditional schemes be upgraded to improve irrigation water use efficiency and reduce water losses.

5. Strategic Goals, Objectives, and Priority Interventions

5.1 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 Luiche 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*)

5.2 Strategic Goal

The overall goal of the Luiche 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 making progressive improvements to existing water resources management and use practices with the objective of achieving sustainable balance between water availability and demand without compromising environmental integrity.

5.3 Strategic Objectives

The matrix below presents the strategic objectives and intervention areas to be addressed by the Luiche 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. • Achieve sustainable water demand growth over the planning horizon.
Strategic Objective 2: To	• Establish a comprehensive sub-basin groundwater

ensure availability of adequate and reliable water resources data for all watersheds and aquifers.	monitoring network to cover all important aquifers.
Strategic Objective 3: To identify and register all sub-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 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.

5.4 Priority Intervention Measures

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

The overarching objective for the Luiche Sub-basin WRMD Plan is to ensure sustainable management and development of the sub-basin water resources currently and in the foreseeable future. The main challenge of the Plan is to balance water supply and demand without compromising environmental integrity. A complicating factor associated with this management goal is the uncertainty associated with future climatic conditions which may have potentially adverse impacts on water resources availability and demand. Besides the projected demand growth and future climate change impacts, the Water Management Act (2009) specifically recognizes the environment water requirements as a legitimate water use priority that must be considered and fulfilled in all 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. This is a challenging proposition since it entails implementing a mix of measures to provide sustainable water supply, improve water use efficiency, and meet the environmental flow requirements. To achive this goal, the Basin Plan must look beyond traditional structural measures of constructing storage reservoirs and consider a wide range of structural and non-structural water supply augmentation and water demand management measures.

Where applicable, water demand management presents the most cost-effective intervention in the short to medium term, after which reservoir construction can be considered where topography allows.

The four objectives to be achieved under this goal are discussed next.

Objective 1: To ensure availability of water resources of adequate quantity and quality to meet current and future sub-basin water demands.

Sub-basin water assessments indicate that generally the Luiche sub-basin has adequate water resources and is currently not water stressed, except for localized water shortages during prolonged dry periods. However, the projected water demand growth and potential climate change impacts are expected to change the situation. Assessment findings highlight potential future decrease in the Luiche River flows due to reinforcing impacts of climate change and increasing water demands. There is, therefore, need for implementation of appropriate adaptation measures to cope with the projected water demand growth.

Action 1.1.1: **Construct water storage infrastructure to increase sub-basin storage capacity**.

Preliminary topographical analysis was conducted for the Luiche sub-basin and a specific potential storage site identified with storage capacity up to 39.9 MCM. It is recommended that the identified site is assessed in more details to establish its feasibility before a decision can be taken regarding its construction.

Action 1.1.2: **Conjunctive use of surface and groundwater.**

Currently groundwater is being exploited on a small scale in several parts of the sub-basin mostly for domestic consumption. However, large scale groundwater use in irrigated agriculture has been limited for a number of reasons including the paucity of aquifer potential and yield data. Considering that groundwater in the Luiche sub-basin may be the key to improving the water supply coverage in many areas under the changing climate and increasing water demand, the need for sustainable groundwater management and development cannot be overstated. A comprehensive groundwater monitoring program has been recommended to help develop the required groundwater data. Upon availability of adequate data, detailed groundwater assessments shall be conducted to identify areas with high groundwater potential for future development and use. The outcome of the basin-wide groundwater assessments will be valuable in developing a comprehensive plan for the conjunctive use of surface and groundwater as part of the broader sub-basin water security program.

Objective 2: To achieve sustainable water demand growth over the planning horizon.

The Luiche sub-basin aggregate consumptive water demand is projected to increase from 12.66 million m^3 in 2015 to about 49.03 million m^3 in 2035. This rate of demand growth is unsustainable in the long run. The two sectors contributing the most to this growthare irrigation water demand and urban water demand for Sumbawanga Town. Managing water demand growth in these sectors should be a key management priority for achieving sustainable balance between supply and demand.

Action 1.2.1: **Rehabilitation and upgrading of irrigation water supply infrastructure in traditional irrigation schemes.**

Irrigation water supply infrastructute in traditional schemes should be upgraded to minimize water losses and improve irrigation water use efficiency. Assessment results show that improvements in irrigation water use efficiency from 15% to 30% would translate up to 50% water savings (other factors being constant). This activity requires coordination from the

LRBWB to ensure the intended objective of irrigation efficiency improvements and reduction in irrigation water use is achieved. As a condition for irrigation water permit renewal, the LRBWB should require that permit holders demonstrate substantive and verifiable progress toward improving irrigation water use efficiency. The LRBWB should set efficiency improvement targets to be met by existing permit holders prior to permit renewal. For new irrigation water permit applications, the LRBWB should require that the applicants commit to a 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 agree to a self-monitoring water abstraction program with mandatory periodic submission of water abstraction data to the LRBWB.

Action 1.2.2: **Rehabilitation and upgrading of urban water supply infrastructure to reduce water losses.**

One of the major challenges associated with urban water demand management is how to deal with high water losses (non-revenue water) associated with aging and poorly maintained water supply infrastructure. Potential non-revenue water reduction measures include the following increased vigilance in detecting and fixing water leaks; increased metering; timely rehabilitation of water supply infrastructure; and curbing illegal water connections. Reduction in urban water supply losses is achievable over the planning horizon given the ongoing investments in rehabilitation and expansion of urban water supply infrastructure under WSDP.
This particular activity is ongoing and only requires coordination from the LRBWB to ensure water losses in urban water supply systems is reduced. The loss reduction measures should be complemented by other demand management measures such as setting deterrent tariffs to minimize water wastage, encouraging water recycling and re-use, and water rationing.

Action 1.2.3: **Comprehensive and routine monitoring of water abstractions/use.**

Routine monitoring of water abstractions and use is important for sustainable water resources management and development. Unless water managers know how much water is being taken out of the system, the location, and timing, it is difficult to determine spatial and temporal deficits and pinpoint system inefficiencies. Lack of accurate and consistent water abstraction and use data is a major setback for any meaningful water supply-demand balance assessment. There are no systematic measurements of water use/withdrawals in the Luiche sub-basin. It is thus difficult to estimate actual water abstractions and accurately reconstruct unimpaired flow series at key sub-basin nodes. There is need for a comprehensive water abstraction/use monitoring network to ensure routine data collection. Establishment of the network should be undertaken in collaboration with water users. For example, as part of the special conditions implied under water permits issued under Section 48 of the WRM Act (2009), the LRBWB should require that all water permit holders install water abstraction/use measuring devises, keep records of their daily water abstractions/use, and submit this data regularly to the LRBWB. The LRBWB should then, as part of its compliance monitoring program, undertake random spot checks to cross check the validity and reliability of the water abstraction/use records of individual permit holders. The LRBWB should make it known to permit holders that failure to install water abstraction/use monitoring devises or deliberate recording or submission of false data would carry stiff penalties. To supplement the self-monitoring program, the LRBWB should install water abstraction/use monitoring devises at a few strategic locations for monitoring verification.

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

Reliable, consistent, and contemporaneous data is needed to quantify river flows at selected locations; estimate rainfall and evapotranspiration over the watersheds upstream of where river flow is measured; and determine groundwater levels and fluxes in different sub-basin aquifers. Review of the available data for the hydrometric station at Luiche at Uzia shows large gaps and questionable data quality due to inconsistencies and irregularities in the existing data collection and quality control procedures. The existing rating curve is outdated and needs updating and re-validation. Additionaly, there is currently no groundwater monitoring network. There is a need to establish a comprehensive groundwater monitoring program for routine data collection and corresponding groundwater characterization. With regard to water quality monitoring, for several of the monitored sites only few water quality parameters are being analyzed (an average of just 12 parameters per sample). Namely, the available information is incomplete, making it difficult to carry out comprehensive water quality assessments. The most significant gap is with respect to heavy metal monitoring where only a few samples have been analyzed. Furthermore, there is no systematic monitoring of sediment transport and deposition, and no related studies have ever been carried out. This makes any attempt to estimate sediment yield from upstream watersheds a purely hypothetical excerise.

Put simply, without reliable water resources monitoring, there can be no *sustainable* water resources management and development.

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

The existing monitoring network was carefully reviewed during the study and found inadequate to meet the data and information requirements. Specific recommendations to improve the existing monitoring network are indicated below.

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

Given the small size of the Luiche sub-basin, the existing surface water monitoring network is sufficient. However, the most urgent needs pertain to (a) updating and re-validating the rating curve for the Luiche River at Uzia; (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.**

Groundwater is a major source of domestic water supply in most sub-basin rural areas and its use is expected to intensify as the population increases. There is a need to establish a comprehensive groundwater monitoring network to ensure sustainable use and management of the sub-basin groundwater resources. As part of the study, a minimum monitoring network of 21 boreholes has been proposed for the entire Lake Rukwa basin as shown in **Figure 5.1**. One of the proposed stations is located in the Luiche sub-basin near the rainfall station in Sumbawanga (at coordinates9 118 423; 346 741). The sub-basin groundwater monitoring needs will have to be reviewed again in the next planning cycle, and if necessary, additional monitoring boreholes should be established as more detailed information becomes available on the basin aquifer characteristics.

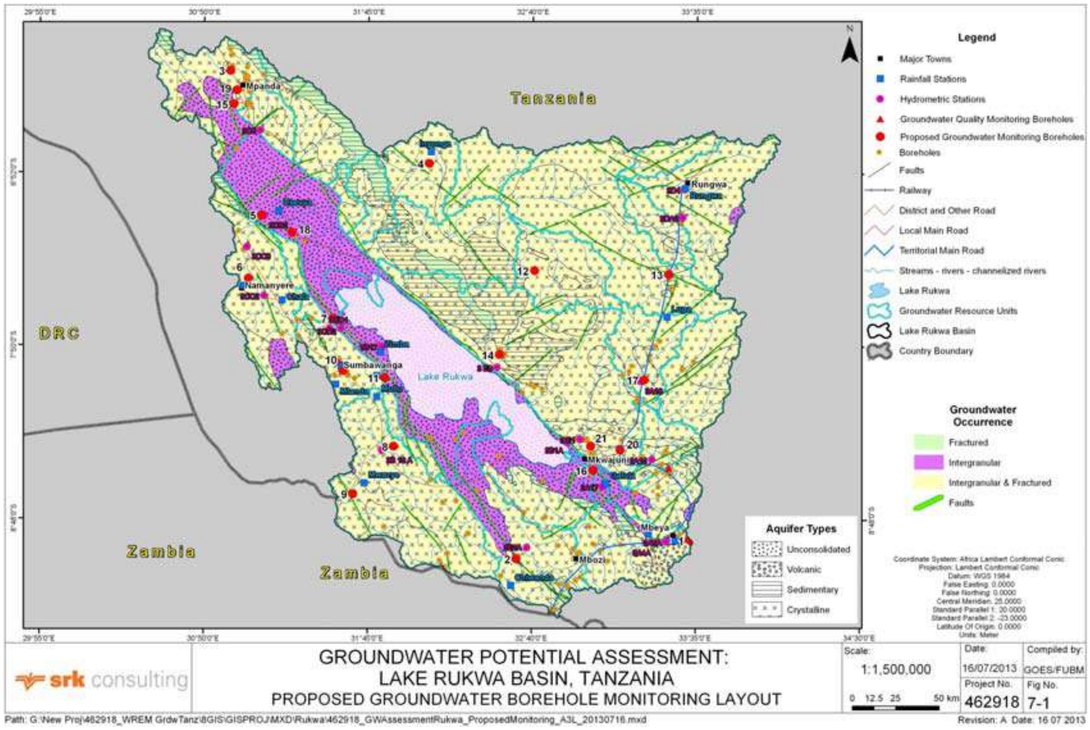


Figure 5.1: Location of proposed groundwater monitoring points.

Action 2.1.3: **Strengthen and expand the basin water quality monitoring program.**

Based on the existing water quality monitoring challenges identified during the study, the priority intervention measures to strengthen the sub-basin water quality monitoring program pertain to identification and monitoring of all pollution "hotspots" in Sumbawanga Town; monitoring sediment transport and deposition (i.e., suspended solids and bedload); and conducting sub-basin wide water quality surveys to bridge data gaps.

Action 2.1.4: **Undertake consistent and timely collection of water resources data and maintenance of the monitoring network.**

Although the monitoring stations should be regularly visited by LRBWB staff to collect water resources data and conduct routine equipment inspections and 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. Furthermore, 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 consider training gage reader for Luiche River at Uzia to take daily gage readings and relay the information by 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 sub-basin offices in Sumbawanga Town. Local communities neighboring the monitoring station should be sensitized about the importance of the installed monitoring equipment and help in safeguarding them against vandalism.

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

There are several competing water uses in the Luiche sub-basin including irrigation, domestic, livestock, and environmental flow requirements. Effective monitoring and regulation of water use is important to assess the integrity of the water distribution system, issue permits, and collect water use 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 required 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, the LRBWB still faces the challenge of illegal water abstractions and non-compliance with water permit conditions. The pactice of water use registration has not yet been appreciated and taken seriously by many water users. This is mostly attributed to lack of awareness and weak enforcement of the law. There are several water users who have either not applied for water use permits or who are using water in disregard of their permit conditions. Thus, water use regulatory and enforcement mechanisms need to be strengthened and used to ensure compliance.

Objective 1: Strengthen water resources regulatory and enforcement mechanisms.

Monitoring water usage and enforcing permit compliance for the many water users scattered across the sub-basin is a challenge requiring cooperation from the water users and the local communities. However, this cooperation is still not forthcoming due to various reasons. The Water Resources Management Act (2009) provides for establishing local level water management structures (e.g., WUAs, CWCs, SCWCs) to assist LRBWB combate illegal water abstractions and support equitable water allocation and use. However, establishing these structures is very slow due to funding constraints. The LRBWB is supposed to conduct routine public awareness and sensitization campaigns on water resources management and environmental protection. These campaigns are intended to educate the local communities on water resources management issues, protection of water sources, and general environmental management and conservation issues. The ultimate aim of the campaigns is to ensure that the communities are enlightened and become more vigilant in reporting illegal water users and other offenders (for example illegal cutting of trees, wetland drainage, and cultivation around water sources and close to river banks). However, the awareness campaigns are seldom conducted due to funding constraints. The formation of lower level water resources management structures and sensitization of local communities should be 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. There is also need for the LRBWB to routinely review and update the Water Permit Register to ensure timely follow up with pending applications and those that require renewal. A major concern of existing permit holders is that they do not receive the privileges of being permit holders, since they donot get adequate protection against illegal water users (as stipulated in the law). The impunity with which illegal water users continue to abuse the system and the lack of capacity by the LRBWB to enforce the law is a major disincentive for potential permit applicants and cause for non-compliance. It is unfair to expect permit holders to comply with permit conditions when they are surrounded by illegal water users who are not held accountable for their actions. It is important to sageguard the value of holding a permit versus not having one. It is not enough to quote the law or issue threats regarding non-compliance. Prevailing over illegal water users would be an incentiveto abide by legal permit status.

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

Water permit compliance monitoring can be expensive if LRBWB staff are required to regularly traverse the sub-basin and reach out to all water users. This kind of activity cannot, therefore, be planned as a routine undertaking because of budgetary constraints. Creative budgetary ways of performing this function should be explored. For example, the LRBWB could engage all key sub-basin stakeholders to plan an annual basin event dubbed "*Operation zero tolerance for illegal water use in Luiche sub-basin.*" This would be perceived as a 'community policing' (or a community ownership) activity and could attract corporate sponsorship and leverage support from sources other than the LRBWB. Under such an arrangement, the LRBWB would play a coordination role and leverage the strength of the different stakeholders toward successful implementation. The process would also be viewed by stakeholders as being transparent and not manipulated by powerful interest groups (big commercial irrigation farmers, politicians, and others). Being an annual event would ensure adequate planning and resources mobilization for its effective implementation. In the final analysis, comprehensive permit compliance monitoring should go beyond a few under facilitated LRBWB staff and become a community responsibility jointly planned with the involvement of all key stakeholder agencies including police, local government authorities, local leaders, water user associations, water user groups, NGOs, and CBOs. The LRBWB should ensure that the annual survey is as detailed as possible to capture and verify the required monitoring information during the annual survey event and to update the water permit database accordingly. This 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 for years pending issuance of a permit. These procedural issues serve as a disincentive to water permit applicants and exacerbate illegal water use. It is important that the LRBWB expedites the permit application process and make it more efficient and less cumbersome to applicants. Addressing these kinds of "small" concerns could make a quick difference as the LRBWB addresses other regulatory challenges that require significant time and financial resources.

Action 3.1.3: **Develop appropriate technical tools for objective assessment of water permit applications and compliance monitoring.**

Processing a permit application is complexand requires careful consideration of water abstraction impacts on downstream water users including the environment. This kind of assessment cannot be carried out through a simple visual inspection of the proposed water abstraction site or spot stream flow measurements at the time of inspection. There is a need to developtechnical tools for objective and defensible assessments of permit applications to ensure consistency in the allocation decisions. Such tools can be incorporated in the Rukwa DSS and can help give credibility to the permitting process and instill stakeholder confidence in the water allocation decisions.

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 should notbe ignored. The environment is a legitimate, albeit silent, water user whose needs must be considered and fulfilled in water allocation decisions.

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

Environmental flow requirements present a difficult water use tradeoff with socioeconomic implications for the local population which is mostly dependent on irrigated agriculture for survival and household income. Unfortunately, specific EFRs have not been determined for all critical sub-basin river sections. It is, therefore, important that environmental flow requirements be established through a transparent and technically robust procedure to ensure credibility of the recommendations.

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

The Desktop Reserve Model (DRM) was used to generate initial Environmental Flow Requirements (EFRs) for the Luiche River at Uzia. It is recommended that more detailed Environmental Flow Assessments be carried out at this site to establish more accurate EFRs for water allocation decisions. This exercise should be conducted for all other critical sub-basin watersheds to determine their environmental flow requirements.

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 will also carry out periodic review of the EFRs for different river sections and modify the estimates in response to increased water demands for other sectors, where necessary.

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

The Luiche Sub-basin Rivers have been observed to carry significant sediment load, usually during the rainy season. This is attributed to the widespread deforestation especially in the upstream watersheds due to agricultural expansion, illegal logging, charcoal burning, and wild fires. Poor agricultural practices and overgrazing are also contributing to increased river erosion and siltation. These factors combined with the heavy seasonal rains produce runoff with high loads of sediments and organic matter resulting in turbidity, colour, odour, and taste problems in surface waters. Poor household sanitation and unregulated use of agrochemicals are other causes of pollution of surface and groundwater.

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

This intervention will target critically degraded watersheds where specific integrated watershed management measures will be implemented to reduce erosion and sediment loads from upstream watersheds.

Action 5.1.1: Demarcation and protection of catchments upstream of important water sources.

Rampant deforestation, over grazing, and wetland degradation are responsible for destroying important catchments and undermine their capacity to sustain downstream water sources. The Water Resources Management Act (2009) Section 37 (1) provides for the establishing protected zones on land draining to or above important water sources. There is a need to undertake systematic identification, survey, acquisition, and protection of catchments draining to important water sources that serve large populations, especially urban areas. This initiative should also be complemented by intensified enforcement of Section 34 of the Act regarding prohibition of human activities near water sources (i.e., restriction of human activities to within sixty meters from river banks, lake shores, dams, and other important water sources).

Action 5.1.2: Identify, demarcate, and protect recharge areas for important groundwater supply aquifers.

The Water Resources Management Act (2009) Section 37 (1) provides for establishing groundwater controlled areas for water supply and commercial, industrial or agricultural development. The groundwater controlled areas should be identified through detailed groundwater aquifer mapping, assessment, and characterization.

Action 5.1.3: Preparation and enforcement of village land use plans.

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

Action 5.1.4: Promote sustainable management and utilization of sub-basin forestry resources.

This measure will focus on reversing the current trend in sub-basin deforestation through implementation of a sub-basin-wide tree planting, agro-forestry, soil and water conservation, and river bank protection initiative using community based forestry management practices. This activity will also support a sub-basin-wide forest survey, classification, and mapping program to establish the extent and severity of forest encroachment and degradation. Local communities will be sensitized and trained on sustainable management and exploitation of forest resources. Local communities will also be encouraged to participate in forest management through development of comprehensive community-based forest management plans.

Action 5.1.5: Promote sustainable management and utilization of sub-basin wetland resources.

A comprehensive sub-basin-wide wetlands inventory should be undertaken to establish the spatial distribution of wetlands and extent of their degradation. Communities will be sensitized and facilitated to develop community based wetlands management plans that will be the basis for sustainable use and management of local wetland resources.

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

Action 5.2.1: Regulate and control pollution from agrochemical use.

Agrochemicals can be a big source of non-point pollution if not applied in a controlled manner. Except for a few medium scale commercial farms, agrochemicals are not widely used in the sub-basin. However, there is need for increased vigilance to monitor agrochemical usage, ensure its proper application, and minimize its pollution risks. There is need for extension workers to sensitize farmers on proper handling (storage and application) of agrochemicals to minimize their misuse.

Action 5.2.4: 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 of this problem is the high incidence of water borne diseases. 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 and construct demonstration facilities; help in the construction of community sanitation facilities (i.e., schools, health centers, and others); and support communities improve the existing latrines.

6. Strategic Action Plan and Budget

6.1 Strategic Action Plan

The Luiche 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 monitoring progress against budget expenditures. The Luiche Sub-basin SAP is presented in the matrix below.

Luiche 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																				
COMPONENT 2: Technical Support for Water Use Efficiency Improvement																				
OBJECTIVE: To provide technical support for water use efficiency improvements in traditional irrigation schemes and urban water supply																				
TASK 1.2.1: Provide technical assistance to Irrigation associations in planning and implementation of irrigation water supply infrastructure improvements																				
TASK 1.2.2: Monitoring and evaluation of water use efficiency improvements in irrigation schemes and urban water supply systems.																				
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: Upgrade and expand water quality monitoring network																				
TASK 3.1.3: Coordinate establishment of water abstraction/use monitoring network																				
TASK 3.1.4: Update and re-validate rating curve for Luiche River at Uzia hydrometric station																				
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																				

Luiche 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 all sub-basin 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: Develop technical tools for evaluation of water permit applications and compliance monitoring																				
TASK 4.3: 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 the development and implementation of village land use plans.																				
TASK 5.2: Identify, demarcate, and protect watersheds upstream of major water supply sources.																				
TASK 5.3:Identify, demarcate, and protect recharge areas for important groundwater supply aquifers.																				
TASK 5.4: Provide technical and financial support for catchment afforestation activities in critical watersheds.																				
TASK 5.5: Provide technical and financial support for wetland restoration and conservation activities in critical watersheds.																				
TASK 5.6: Construct appropriate facilities for management and disposal of municipal waste water and solid waste in Sumbawanga Town and surrounding peri-urban areas.																				
TASK 5.7: Regulate and control pollution from agrochemical use.																				
TASK 5.8: 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

6.2 Budget Estimates

The total estimated budget required for implementation of the Luichee Sub-basin WRMD Plan from 2016 to 2035 is about 6.013 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 6.1** and **Figures 6.1** and **6.2** 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 6.2**.

Table 6.1: Budget Estimates by Program and Implementation Phase.

Luiche 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	0.94	0.64	0.70	0.88	**3.14**
PROGRAM 2: Environmental Flow Assessment and Monitoring Program	0.14	0.05	0.05	0.14	**0.39**
PROGRAM 3: Water Resources Monitoring and Assessment Program	0.26	0.08	0.09	0.09	**0.52**
PROGRAM 4: Water Permit Compliance Monitoring Program	0.23	0.22	0.22	0.22	**0.90**
PROGRAM 5: Integrated Watershed Management and Environmental Conservation Program	0.26	0.26	0.26	0.26	**1.06**
TOTAL	**1.83**	**1.25**	**1.33**	**1.60**	**6.01**

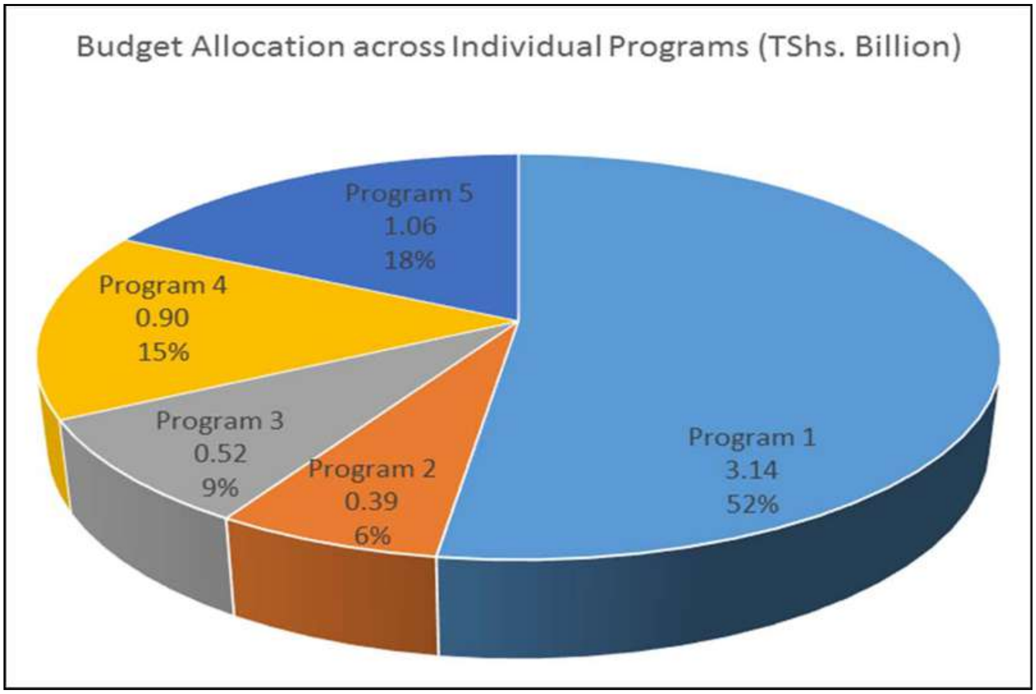


Figure 6.1: Budget Allocation across Individual Programs.

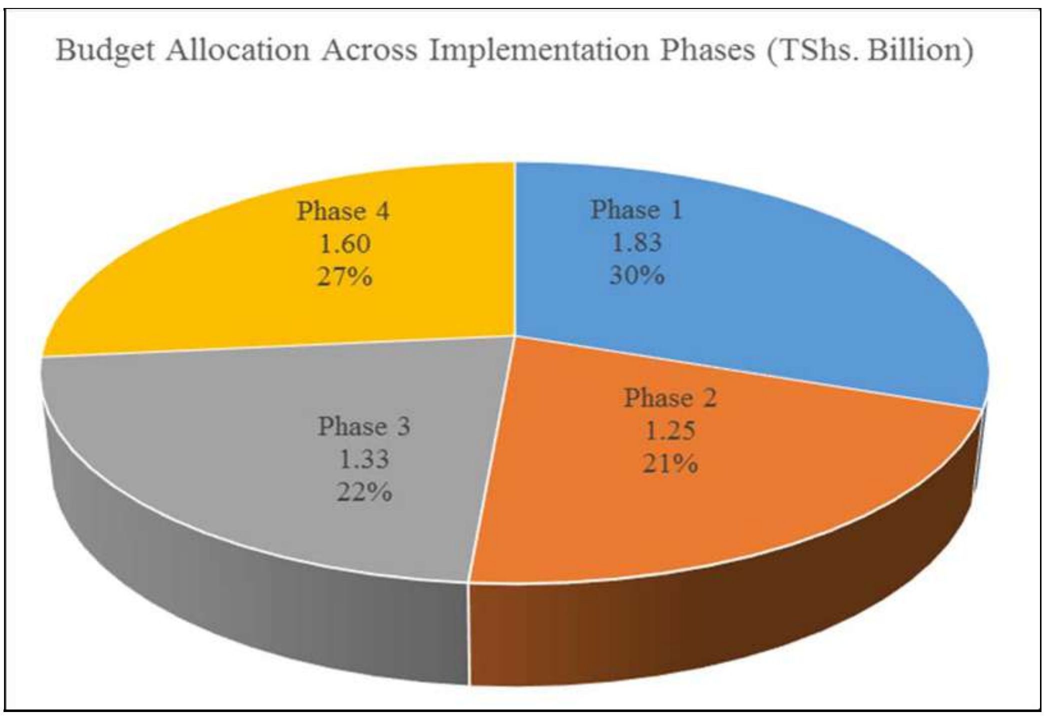


Figure 6.2: Budget Allocation across Implementation Phases.

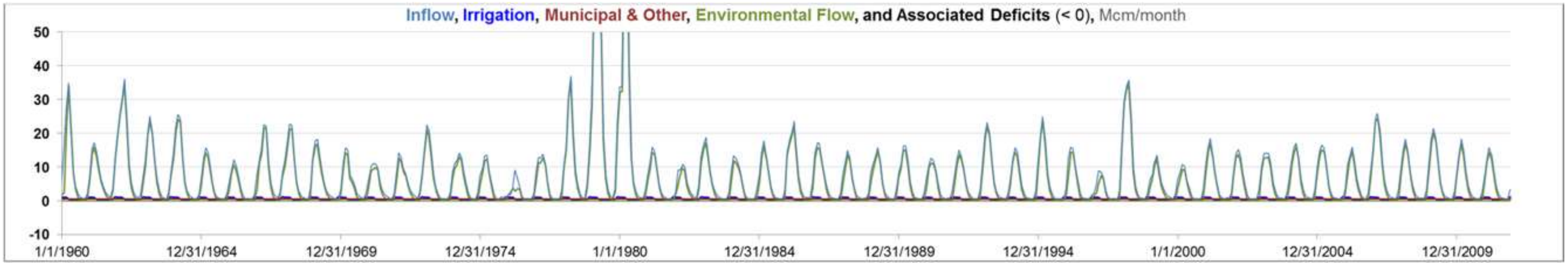
Table 6.2: Budget Estimates for Luiche Sub-basin WRMD Plan Implementation.

	Luiche 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.	900	600	600	600
Strategic Action 1.1.2 : Assess potential for and construct medium to large scale groundwater supply schemes to increase sub-basin water supply capacity.	-	-	60	240
COMPONENT 2: Technical Support for Water Use Efficiency Improvement	-	-	-	-
Strategic Action 1.2.1 : Provide technical assistance to Irrigation associations in planning and upgrading of irrigation water supply infrastructure and monitor water use efficiency improvements.	24	24	24	24
Strategic Action 1.2.2 : Provide technical assistance and monitor water use efficiency improvements in Sumbawanga Urban Water Supply and Sewerage Authority.	12	12	12	12
Program 1 Sub-total	***936***	***636***	***696***	***876***
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.	92	-	-	92
Strategic Action 2.2 : Conduct routine field visits to monitor compliance with established environmental flow requirements.	40	40	40	40
Strategic Action 2.3 : Conduct regular public awareness raising campaigns on the importance of maintaining environmental flow requirements and consequences of violations.	11	11	11	11
Program 2 Sub-total	***144***	***51***	***51***	***144***
PROGRAM 3: Water Resources Monitoring and Assessment Program				
COMPONENT 1: Strengthen water resources monitoring capacity				
Strategic Action 3.1.1 : Rehabilitate existing surface water resources monitoring networkand update and re-validate rating curves for all functional hydrometric stations.	96	30	30	30
Strategic Action 3.1.2 : Establish network of groundwater level monitoring boreholes to cover all major sub-basin aquifers.	126	-	30	30
Strategic Action 3.1.3 : Establish additional water quality sampling sites to cover all important pollution prone areas.	3	-	-	3
Strategic Action 3.1.4 : Conduct routine and consistent network visits for data collection and equipment maintenance.	24	24	24	24
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.	6	6	6	6
COMPONENT 2: Strengthen water resources assessment capacity				
Strategic Action 3.2.1 : Conduct sub-basin groundwater assessments and mapping	-	15	-	-
Strategic Action 3.2.2 : Conduct sub-basin water quality baseline survey.	3	-	-	-
Program 3 Sub-total	***258***	***75***	***90***	***93***

Table 6.2: Budget Estimates for Luiche Sub-basin WRMD Plan Implementation (continued)

	Luiche 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.	80	80	80	80
Strategic Action 4.2 : Conduct routine processing of new water permit applications and renewals.	16	16	16	16
Strategic Action 4.3 : Develop technical tools for evaluation of water permit applications and compliance monitoring	8	-	-	-
Strategic Action 4.4 : Undertake routine update of the water permit database.	-	-	-	-
Strategic Action 4.5 : Conduct routine field visits to check compliance with permit conditions and apprehend illegal water users.	64	64	64	64
Strategic Action 4.6 : Conduct regular public awareness raising campaigns on the dangers of illegal water abstraction and non-compliance with permit conditions.	64	64	64	64
Program 4 Sub-total	***232***	***224***	***224***	***224***
PROGRAM 5: Integrated Watershed Management and Environmental Conservation Program				
Strategic Action 5.1 : Identify, demarcate, and protect watersheds upstream of major water supply sources	50	50	50	50
Strategic Action 5.2 : Identify, demarcate, and protect important groundwater recharge areas.	50	50	50	50
Strategic Action 5.3 : Provide technical and financial support for catchment afforestation activities in critical watersheds	100	100	100	100
Strategic Action 5.4 :Provide technical and financial support for wetland restoration and conservation activities in critical watersheds	25	25	25	25
Strategic Action 5.5: Construct appropriate facilities for management and disposal of municipal waste water and solid waste in Sumbawanga Town and neighbouring peri-urban areas	-	-	-	-
Strategic Action 5.6 : Regulate and control discharge of industrial effluent into water sources.	5	5	5	5
Strategic Action 5.7 : Provide technical and financial support for preparation and implementation of village land use plans.	25	25	25	25
Strategic Action 5.8: Regulate and control pollution from agrochemical use.	10	10	10	10
Strategic Action 5.9: Support and promote improved sanitation and hygiene in rural households.	-	-	-	-
Program 5 Sub-total	***265***	***265***	***265***	***265***
GRAND TOTAL	**1,835**	**1,251**	**1,326**	**1,602**

7. ANNEX A: Assessments of Potential Reservoir Sites



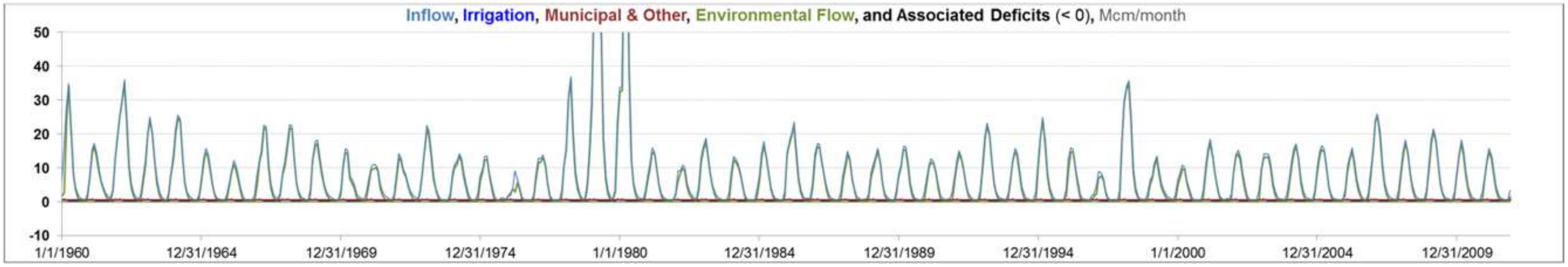
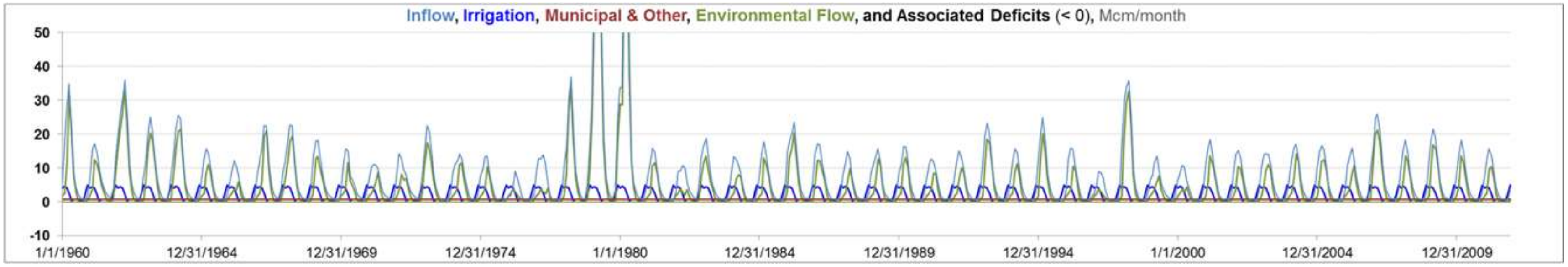


Figure 25: Luiche catchment simulated sequences (Mcm/month) of watershed inflow, irrigation water supply, municipal and other water supply, environmental flow, and associated deficits (negative values) for irrigation efficiencies 1.56 (*top graph*) and 1.00 (*bottom graph*) l/sec/ha. The simulations assume existence of 39.9 Mcm reservoir storage and are based on 1960–2011 hydrologic conditions and 2015 water demand targets. A potential storage site of up to 39.9 Mcm has been identified in this catchment, and the above storage is likely feasible.

Table 25: Luiche catchment monthly irrigation, municipal and other, and environmental flow water use deficits from 2015 demand targets, and potential annual hydropower production for irrigation efficiencies 1.56 (*top*) and 1.00 (*bottom)* l/sec/ha. The simulations assume existence of 39.9 Mcm reservoir storage and are based on 1960–2011 hydrologic conditions.

Luiche				Water Demands:		2015		Storage Capacity:			39.9	Mcm
Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Irrigation Dfcts, Mcm/m:				Irrigation Efficiency:		1.56	lt/sec/ha					
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal & Other Dfcts, Mcm/m:												
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Env Flow Dfcts, Mcm/m:												
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hydropower, GWh/yr:		15.908										
Irrigation Dfcts, Mcm/m:				Irrigation Efficiency:		1	lt/sec/ha					
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal & Other Dfcts, Mcm/m:												
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Env Flow Dfcts, Mcm/m:												
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hydropower, GWh/yr:		15.915										



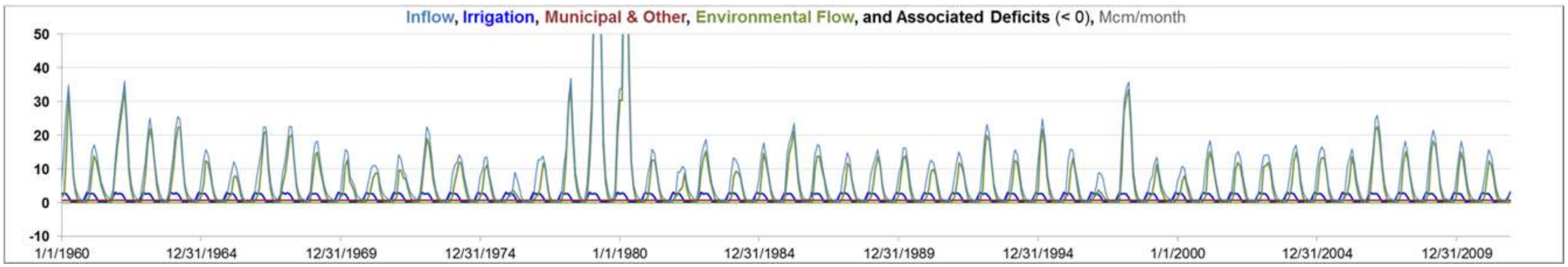


Figure 26: Luiche catchment simulated sequences (Mcm/month) of watershed inflow, irrigation water supply, municipal and other water supply, environmental flow, and associated deficits (negative values) for irrigation efficiencies 1.56 (*top graph*) and 1.00 (*bottom graph*) l/sec/ha. The simulations assume existence of 39.9 Mcm reservoir storage and are based on 1960–2011 hydrologic conditions and 2025 water demand targets. A potential storage site of up to 39.9 Mcm has been identified in this catchment, and the above storage is likely feasible.

Table 26: Luiche catchment monthly irrigation, municipal and other, and environmental flow water use deficits from 2025 demand targets, and potential annual hydropower production for irrigation efficiencies 1.56 (*top*) and 1.00 (*bottom)* l/sec/ha. The simulations assume existence of 39.9 Mcm reservoir storage and are based on 1960–2011 hydrologic conditions.

Luiche					**Water Demands:**	**2025**				**Storage Capacity:**	**39.9**	Mcm
Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Irrigation Dfcts, Mcm/m:					Irrigation Efficiency:	1.56	lt/sec/ha					
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal & Other Dfcts, Mcm/m:												
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Env Flow Dfcts, Mcm/m:												
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hydropower, GWh/yr:		15.656										
Irrigation Dfcts, Mcm/m:					Irrigation Efficiency:	1	lt/sec/ha					
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal & Other Dfcts, Mcm/m:												
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Env Flow Dfcts, Mcm/m:												
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hydropower, GWh/yr:		15.831										

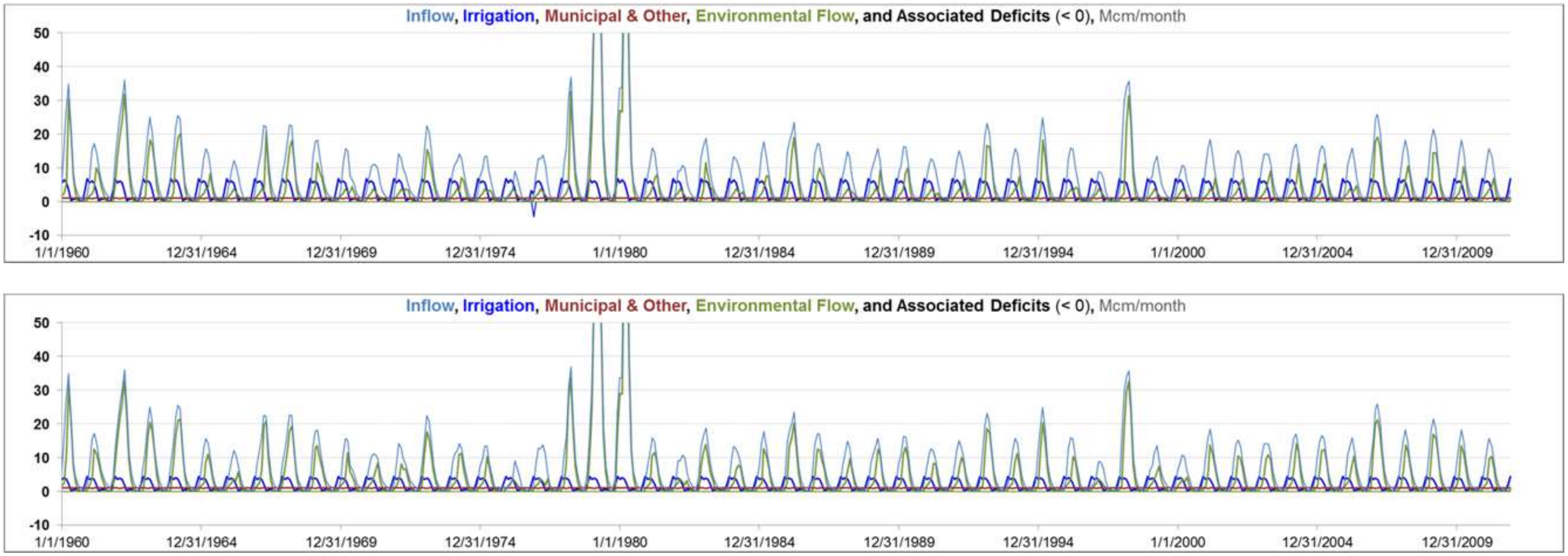


Figure 27: Luiche catchment simulated sequences (Mcm/month) of watershed inflow, irrigation water supply, municipal and other water supply, environmental flow, and associated deficits (negative values) for irrigation efficiencies 1.56 (*top graph*) and 1.00 (*bottom graph*) l/sec/ha. The simulations assume existence of 39.9 Mcm reservoir storage and are based on 1960–2011 hydrologic conditions and 2035 water demand targets. A potential storage site of up to 39.9 Mcm has been identified in this catchment, and the above storage is likely feasible.

Table 27: Luiche catchment monthly irrigation, municipal and other, and environmental flow water use deficits from 2035 demand targets, and potential annual hydropower production for irrigation efficiencies 1.56 (*top*) and 1.00 (*bottom)* l/sec/ha. The simulations assume existence of 39.9 Mcm reservoir storage and are based on 1960–2011 hydrologic conditions.

Luiche			**Water Demands:**			**2035**			**Storage Capacity:**		**39.9**	Mcm
Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Irrigation Dfcts, Mcm/m:			**Irrigation Efficiency:**			**1.56**	lt/sec/ha					
Dfct Freq	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019
Avg Dfct (> 0)	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.490
Max Dfct	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.490
Municipal & Other Dfcts, Mcm/m:												
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Env Flow Dfcts, Mcm/m:												
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hydropower, GWh/yr:		15.012										
Irrigation Dfcts, Mcm/m:			**Irrigation Efficiency:**			**1**	lt/sec/ha					
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Municipal & Other Dfcts, Mcm/m:												
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Env Flow Dfcts, Mcm/m:												
Dfct Freq	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg Dfct (> 0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max Dfct	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hydropower, GWh/yr:		15.641										