Ministry of Water

GLOBAL WATER LEADERSHIP PROGRAMME

Global Water Partnership Southern Africa
Tanzania Water Partnership

Global Water Partnership

Identified Barrier #2 to climate-resilient water management in Tanzania

Inefficient irrigation water uses and practices: the case of Ruvu Sub-Basin

A root cause analysis

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Executive summary

Agriculture is the largest single user of freshwater resources in the world, accounting for about 70% of all withdrawals. While the area under irrigated agriculture in Tanzania is currently a reasonable two percent of the potentially irrigable land across all nine river and lake basins, population growth, economic growth, and damage to the environment have all led to a rapid rise in water needs, resulting in high pressure on water resources, which also leads to tensions in water and related sectors.

Inefficient irrigation water use was identified as a major barrier that needs to be addressed for climate-resilient water management in Tanzania. The Global Water Leadership Programme, an initiative supported by the United Kingdom's Foreign, Commonwealth & Development Office seeking to address the most critical challenges for WRM within the framework of the National Multisectoral Forum, sought to investigate the root causes behind inefficient use of irrigated water and assessed that this inquiry would be best conducted by focusing on a specific catchment area.

The Wami-Ruvu basin, one of the most water-stressed basins in Tanzania with competing demands between water supply and irrigation, was identified as the ideal study area. The objective of the study was to assess irrigation practices in the Upper Ruvu catchment of the Wami-Ruvu basin, specifically along the Ruvu river, with the overall aim of understanding the current situation on the performance of irrigation practices and examining root causes of irrigation inefficiencies. The study uses the '5 Why' method of root cause analysis to investigate low irrigation efficiency in the study area. Data were collected through literature review, stakeholder consultations, key informant interviews, focus group discussions, and field visits.

The Problem – The analysis confirmed that the current water-stressed condition of the Upper Ruvu catchment is strongly linked to the high demand for water required for irrigation. Water availability in the Wami-Ruvu basin is adequate to meet the demands if managed effectively, but there is excessive water loss due to the unlined irrigation infrastructure, coupled with a lack of groundwater utilisation.

Root Cause 1 – Financial constraints

High initial capital costs of irrigation systems deter smallholder farmers from investing in precision irrigation techniques, and there are no incentives for users to adopt more efficient systems.

Root Cause 2 – Continued use of unsustainable irrigation techniques

The Upper Ruvu catchment heavily depends on traditional irrigation techniques, such as flood or furrow irrigation, which have been identified as ineffective and unsustainable for proper water resource management. Generally, the performance of these irrigation schemes was found to be inadequate because the technique has low irrigation efficiency and low application efficiency, which affect water-use efficiency. The replication of existing designs and poor scheme leadership, including limited enforcement of by-laws and poor drainage designs, hinders efficient irrigation.

Root Cause 3 – Irrigation user groups have low capacity

The primary cause of inefficient irrigation water use in Tanzania's Mbarangwe and Tulo Konga schemes is the low capacity of Irrigation User Groups (IUGs), as identified by various studies. This low capacity stems from a lack of training and skills in irrigation management, insufficient financial resources, and limited support from government and stakeholders. These deficiencies result in ineffective management, leading to inefficient water use, reduced agricultural productivity, and potential environmental harm.

Root Cause 4 – Inadequate sectoral collaboration

The lack of collaboration between the water and agricultural sectors and the associated institutions further complicates irrigation planning and practice. These sectors often operate with siloed approaches and distinct priorities, leading to a misalignment of efforts and a failure to address the broader challenges of water management and agricultural development.

Recommendations

Overall, the analysis underscores the need for increased investments in irrigation infrastructure, knowledge transfer, and sectoral collaboration to address these challenges and enhance agricultural productivity in the Upper Ruvu catchment and ultimately at the basin and national scale.

The analysis presents a list of proposed interventions, including extending irrigation schemes, constructing lined canals and sluice gates, improving irrigation canals, implementing border irrigation, and using the System of Rice Intensification (SRI). However, the study notes several factors that should be considered before implementing the interventions, such as farmers' needs, their low learning ability, and their willingness to adopt new technology, as well as the higher initial investment required.

Strengthening the capacity of water user associations in the Wami-Ruvu basin to enhance efficient water use and management is a key recommendation, alongside enforcement of by-laws, education on proper irrigation and drainage, river training, and afforestation.

It also suggests increasing collaboration among stakeholders, including irrigation scheme management groups, the water sector, and the agricultural sector, including the irrigation subsector, for sustainable and integrated water resources management.

Acknowledgements

We would like to extend our heartfelt gratitude to all individuals and organisations who contributed to the development of this report. Your dedication and support have been invaluable in addressing the critical challenges in WRM.

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We would also like to express our sincere thanks to the members of the National Multisectoral Forum for their active participation and invaluable insights throughout the process. Your dedication to fostering positive change in the water sector has been instrumental in the success of this endeavour.

Abbreviations and acronyms

GWL	Global Water Leadership
IWRMD	Integrated Water Resources Management and Development
JICA	Japan International Cooperation Agency
MCM	million cubic metres
NMSF	National Multi-Sectoral Forum
SRI	System of Rice Intensification
WUA	water user associations
WUE	water-use efficiency
WUT	water use technologies

Contents

Introduction

Agriculture is a major component of Tanzania's economy and is heavily reliant on water. It accounts for about 68% of the country's total water withdrawals, which is approximately 12 billion cubic meters annually. This high level of water usage is integral for the country's nourishment and economic stability.

A large portion of the water used in agriculture is for irrigation purposes, with around 80% of the irrigated land being used for rice cultivation. Rice production is particularly water-intensive, which exacerbates the water scarcity issue.

The rapid population growth that Tanzania is experiencing is leading to growth in all key economic sectors, putting more pressure on available freshwater resources. Notably, freshwater sources remain the same and in some localities are diminishing due to land degradation, ongoing pollution of water sources, and climate change impacts (URT, 2019). This widens the gap between available water resources and water demands that culminates in conflict among water users.

Despite the existing water challenges in Wami Ruvu specifically and other Basin's like Rufiji which are the country's food baskets, the government intends to increase irrigated area in the country, because of the 41,584 square kilometers of arable land in Tanzania, only 35 percent is currently being used for crop production. This means that there are approximately 14,584 square kilometers of arable land that is not being used for crop production. This is a significant amount of land that could be used to increase agricultural production in Tanzania. The budget speech address by Tanzania's Minister of Agriculture for the fiscal year 2022–2023 indicated that the Tanzanian government intends to further expand the amount of land that is irrigated from 7,272 square kilometers in the fiscal year 2021–2022, to 12,000 square kilometers (an increase of 164 percent) in the year 2025. Expanding irrigated agricultural land will use more water, placing further stress on the existing available water resources to the Wami-Ruvu and Rufiji if deliberate measures are not deployed.

Purpose and objective of this report

Due to the multi-faceted use of water for ecological, economic, and social development, water resources management requires a collaborative and stakeholder-driven approach involving the integration of several agencies, coordinated use of water, and cooperation between users. It is with this understanding that the Ministry of Water supported by the 2030 Water Resources Group and the World Bank officially launched a formal National Multi-Sectoral Forum (NMSF) in October 2017. The NMSF has enabled dialogue, coordination, and cooperation among stakeholders in public, private, and civil society for water resources management.

In March 2022, a Multi-Sectoral consultation process was initiated to identify the most critical barriers to climate-resilient water management in Tanzania. That process, anchored in the NMSF and led by the Global Water Leadership Programme (GWL), identified "ineffective or inefficient utilisation of water in irrigation activities in Ruvu river" as one the three biggest barriers that must be addressed. A diverse working group was constituted from within the NMSF taskforce dedicated to *Harnessing Technology and Innovation for Water Resources Conservation and Protection* and guided by GWL to investigate this barrier over the course of one year.

The investigation began with a comprehensive root cause analysis of the barrier, and the findings from this inquiry are shared in this report to fill that knowledge gap. These findings will form the basis for designing appropriate Response Strategies to Tanzania's more urgent challenges to climate-resilient water management as part of the larger GWL programme.

In addition to providing the foundational information for crafting effective response strategies, this report is intended to serve as stimulus for supplementary efforts to address the inefficient irrigation challenge, with the expectation that findings from one of the most water-stressed basins in Tanzania, the Wami-Ruvu basin, can be applied to the country's other water basins.

Overall objective

The primary aim of this inquiry was to a conduct a comprehensive evaluation of the underlying factors contributing to the root causes or drivers of irrigation inefficiencies in the Upper Ruvu catchment of the Wami-Ruvu basin.

Specific objectives

- Assess the performance of the existing irrigation schemes in the Upper Ruvu catchment
- Examine the root cause of the low irrigation efficiency in the Upper Ruvu catchment
- Recommend intervention measures to address the low irrigation efficiency in the Upper Ruvu catchment that ideally can be replicated preventatively across other catchments

Expected outputs, outcome and impact

The findings of this assessment will first feed into the process of preparing a comprehensive 'response strategy', GWL's flagship product (and output) that will contribute to enhancing efficient utilization of water for irrigation. Eventually, the findings will be used to promote the use of efficient water-use technologies and innovations in the Wami-Ruvu basin. Table 1.1 below outlines the planned uses of this assessment.

Impact: Enhanced efficiency of irrigation techniques mainstreamed in the Upper Ruvu catchment, serving as a model for scaling up such practices at basin and national level. Improved water management techniques and catchment conservation through strengthening sustainable and productive smallholder irrigation farming practices. Enhanced capacity of local farmers to increase water-use efficiency.	
Outputs	**Outcome**
Identified and documented performance of irrigation schemes	Areas for improvement targeted for increased performance
Root causes of low irrigation efficiency identified and documented	Solutions that address and respond to the root causes unpacked
Recommended measures to address the identified root causes of low irrigation efficiency	Optimised irrigational water use, increased crop yields, and sustainable irrigation practices promoted

Table 1.1. Expected Outputs and Outcomes

Rationale – risks posed by unmanaged increased irrigation

Tanzania's mainland is endowed with numerous and diverse water resources in the form of rivers, lakes, wetlands, and aquifers, with potential renewable water resources of 125,274 MCM, of which 104,568 MCM is surface and 20,706 MCM is groundwater. Water availability per capita for Tanzania is appro 2,250 m^3 (Tanzania Water Resources Atlas, 2019), which is above the threshold of 1,700 m^3 accepted globally (NAWAPO, 2002).

However, there are large variations in water availability across Tanzania. This is demonstrated in Table 1.2, which shows the total and per capita water availability in the nine river basins in the country.

Basin	Total Water Availability (MCM/yr)	Population 2019 (million)	Water Per Capita (m^3/ca/yr)
Internal Drainage	6,968	7.5	933
Lake Nyasa	12,882	1.9	6644
Lake Rukwa	11,425	3.3	3475
Lake Tanganyika	13,396	6.9	1928
Lake Victoria	13,027	12.2	1066
Pangani	7,970	5.6	1430
Rufiji	40,021	4.3	9330
Ruvuma and Southern Coast	14,947	3.6	4196
Wami/Ruvu	5,127	10.6	484
TOTAL	**125,763**	**55.9**	**2,250**

Table 1.2. Water resources availability and per capita per basin

Source: Tanzania Water Resources Atlas (2019)

According to the IWRMD Plan, the irrigation sector commands more than 65% of all water uses in the basin and irrigation demand is projected to reach 70% of all water uses by 2035. Figure 1.1 illustrates water demand in Tanzania by sector and by each of the nine basins, and Figure 1.2 looks specifically at the areas under irrigation per basin.

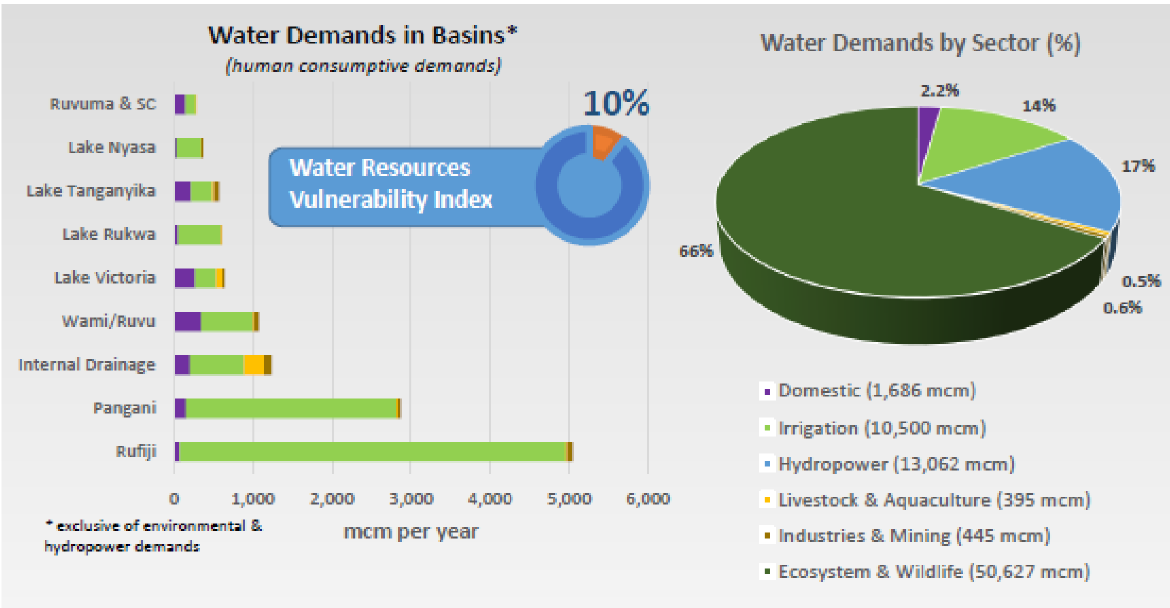

Figure 1.1. Tanzania basin sectoral water demands (Source: *Tanzania Water Resource Atlas,* 2019)

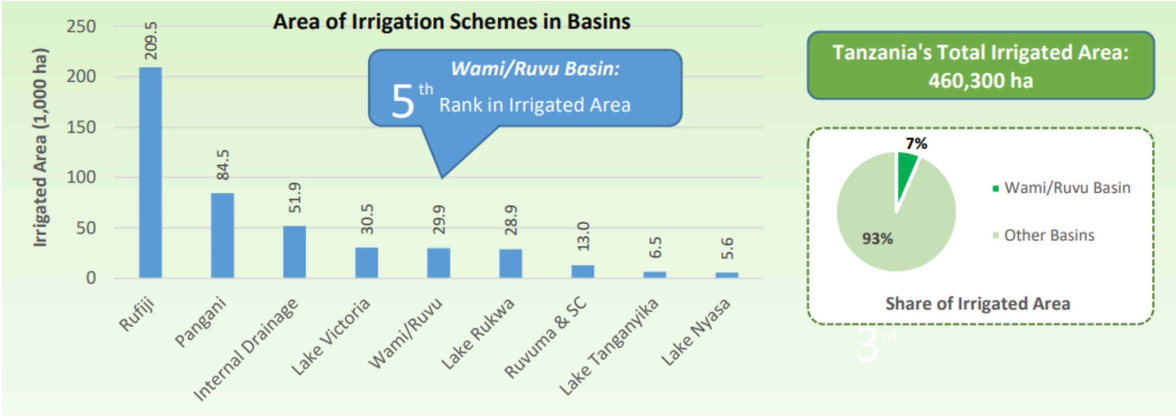

Figure 1.2. Irrigation schemes for all nine Basin Water Boards and their contribution to the total country irrigation share (Source: Water Resources Fact Sheet, 2019)

The selection of Wami-Ruvu basin for in-depth analysis

Despite the ambitious initiatives undertaken by the Wami Ruvu Basin Water Supply and Sanitation Project (WRBWSSSP), set to complete by 2028, the critical issue of water stress in the Wami-Ruvu basin, as highlighted by the Falkenmark Water Stress Indicator in Figure 1.3 below, underscores the urgent need for tackling inefficiencies in irrigation schemes. The basin, with a current capacity of 588 m³ – less than half of the acceptable threshold of 1,700 m³ – grapples with competing demands between water transfers to Dar Es Salaam city and local irrigation activities. This shows that there is not enough water for everyone, and it's a clear sign that we need to find ways to use water more efficiently, especially in water-intensive agriculture.

While Phase I of the WRBWSSSP, ending in 2025, focuses on enhancing water supply and sanitation through new infrastructure in Mvomero, and expanding water access to 20,000 additional people along with sanitation facilities in 200 villages, it's crucial that these efforts also address the inefficiencies in water use. Phase II, culminating in 2028, which emphasizes expanding irrigated land by building a dam on the Wami River and developing irrigation schemes, presents a valuable opportunity to incorporate strategies for more efficient water usage.

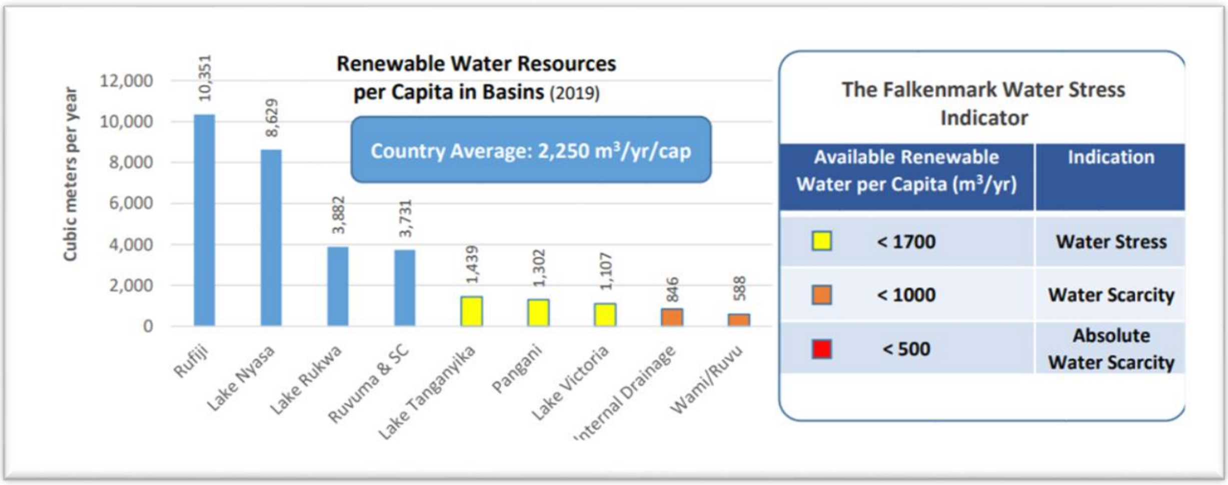

Figure 1.3. The status of water resources in the basins of Tanzania basins expressed as per capita water availability in m³/year (Source: Tanzania Water Resources Atlas, 2019)

Table 1.3 below demonstrates that the existing supplies are sufficient to meet all demands if properly and carefully managed. Currently, this is not the case, as practice shows that water resources are the source of frequent conflicts between various water user groups and some sub-catchments are facing extreme water stress.

Sub-basin Name	Area (km²)	SW (MCM/yr)			GW (MCM/yr)			Demand (MCM/yr)			EFR (MCM/yr)			SW - EFR - Dem (MCM/yr)		
		2015	2025	2035	2015	2025	2035	2015	2025	2035	2015	2025	2035	2015	2025	2035
Kinyasungwe	16,509	289	289	289	129	129	129	118	182	279	0	0	0	171	107	9
Mkondoa	12,964	671	671	671	179	179	179	290	422	502	3	3	3	378	246	166
Wami	14,270	1,408	1,408	1,408	169	169	169	141	209	247	91	91	91	1,176	1,108	1,070
Upper Ruvu	7,623	2,252	2,252	2,252	102	102	102	79	108	127	116	93	93	1,766	1,511	1,121
Ngerengere	2,913	156	156	156	27	27	27	33	50	82	0	0	0			
Lower Ruvu	7,253	54	54	54	283	283	283	62	100	119	70	85	85			
Coast	4,763	35	35	35	250	250	250	353	525	845	17	26	26			

Table 1.3. Water balance for all sub-catchments within the Wami-Ruvu basin.

Source: Irrigation Master Plan 2018.

The Wami-Ruvu IWRMD Plan by YEKOM Consulting Engineers (2020) highlights the growing demand for water in the agricultural sector as a cause for concern because it is occurring in the face of diminishing freshwater resources due to widespread land degradation, pollution, increasing competing demands from irrigation and other production sectors, and the rapidly growing population. Currently, the annual irrigation water requirement is 660 MCM, and by 2035, it's expected to rise to 1,530 MCM. This is an increase of approximately 132%.

To address the growing scarcity in the basin, this analysis investigates the root cause of efficient agricultural irrigation in the Basin and recommends options for reducing the amount of water used by irrigated agriculture. The aim is to devise ways of promoting efficient use of water resources for irrigation activities, as they largely contribute to the growing scarcity.

Focus area: the Upper Ruvu catchment

The focus area, the Upper Ruvu catchment, is located upstream of the Ruvu river subbasin with an estimated area of about 3,280 km^2. The Upper Ruvu catchment is an important source of water for the Wami-Ruvu basin, comprising almost 33 percent of the available water resources in the entire Wami-Ruvu basin. It holds an estimated total water resources of about 1,685 MCM, of which 1435 MCM is surface water and 250 MCM is groundwater.

Despite rich water resources supplied by high rainfall intensity, estimated annual rainfall is between 800 and 2000 mm (Ngondo et al., 2022), the Upper Ruvu catchment, according to the IWRMD Plan, is highly vulnerable to climate change and variability, resulting in unpredictable rainfall patterns, which impact socio-economic development, including irrigation. Given that the Upper Ruvu catchment continues to be highlighted in the Master Plan for increased irrigation, proactive measures need to be identified and taken for the Plan to be successful.

Methodology

The root cause analysis sought to understand the irrigation value chain and identify where most water losses originate.

Methodological framework for root cause analysis

The study adopted the '5 Why' method of root cause analysis. This framework is widely used to investigate problems that do not need quantitative analysis. It involves asking 'why' a problem occurred multiple times to drill down the causal chain and identify the underlying causes. The hypotheses uncovered by the analysis are then tested or substantiated by literature review and field observations and interviews, and informed by the practical experience of the study team.

The process begins by identifying the problem and asking 'why' it occurred. The answer to this question is then used to ask the next 'why' question, and so on, until the root causes of the problem are identified. The '5 Why' method is not a rigid process and the number of times the question 'why' is asked may vary depending on the complexity of the problem. The output of the '5 Why' method is a clear understanding of the root cause(s) of the problem, which can then be used to develop effective solutions and prevent the problem from occurring again.

To ensure reliability and credibility, it is also important to involve a cross-functional team with diverse expertise to provide different perspectives and insights into the problem. The diverse task force team involved in this study was comprised of experts from different institutions indicated in Table 2.1 below.

Champion	Institution and Title	Gender
Dr Subira Munishi	University of Dar Es Salaam	Female
Members		
Dr Shadrack M. Sabai	Ardhi University – Engineer, Lecturer, WG 2 Chairperson	Male
James Genga	EQUIPLUS COMPANY LIMITED – Managing Director	Male
Mr Charles Mwafute	Tanzania Forest Service Agency (TFS) – Senior Conservation Officer	Male
Prof Henry Mahoo	Tanzania National Irrigation Commission, Board Chairperson	Male
Sandra Rugina	Simba Pipe Industry – Sales Engineer Corporate	Female
Eva A. Msella	International Union for Conservation of Nature (IUCN) – Governance and Gender Focal Point	Female
Jerome Nchimbi	National Land Use Planning Commission – South Zone	Male
Grace Chitanda	Basin Water Board Director – Lake Rukwa Basin	Female
Tumain Mwamyalla	Ministry of Water – Directorate of Water Resource	Female
Callistus Mponzi	Ministry of Water – Directorate of Water Resources, Economist	Male
Lilian Kapakala	National Environment Management Council, Head Quarters – Senior Environmental Monitoring Officer	Female
Asha Msoka	Global Water Partnership Tanzania, GWL Country Coordinator	Female
Fatuma Mambo	Ministry of Water, Senior Hydrologist	Female
Frank Anderson	GWP Tanzania Program Officer, GWL Intern, GIS, IT, Environment and Water Policy Analyst/ Specialist	Male

Table 2.1. List of Stakeholders that formed Taskforces 2

Data collection methods

The 5 Why framework is applied in a collaborative setting that draws upon data collected from a variety of methods, including field observations, literature review, and assorted formats for stakeholder consultations.

Literature review

Various documents were reviewed to understand the current water resources status, availability, and existing irrigation practices in the Upper Ruvu catchment of the Wami-Ruvu basin. The reviewed documents and standards included, but were not limited to, the following documents:

- National Water Policy (2002), Water Resource Management Act of 2009, Water sector development programme, Integrated Water Resources Management Development Plan and other reports pertaining to the water sector
- National Irrigation Policy (2010), Irrigation Master Plan of 2018, Sustainable Water Resources Management for Agricultural and Industrial Water Sectors, Wami-Ruvu Basin Water Board Capacity Development Plan.

Additionally, desk study was conducted by extensively reviewing secondary data and information. This review included an examination of various project documents, both published and unpublished reports, and other relevant materials focusing on the performance of irrigation schemes in the study area. To collect this information, visits were made to some offices. The key literature reviewed encompassed a wide range of topics and sources. These included the 'Agricultural Climate Resilience Plan (ACRP);' 'Climate Resilient Agriculture in Tanzania: Comprehensive Agricultural Climate Resilience Plan (2014);' 'National Adaptation Programmes of Action (2007);' 'Tanzania National Climate Change Strategy (2012);' 'National Investment Plan (2009);' and the 'National Irrigation Act, 2013 (No. 5 of 2013).' Additionally, assorted documents from the Ministry of Agriculture, Food Security and Cooperatives (MAFC), the Ministry of Water (MoW), and the Tanzania Meteorological Agency (TMA) were reviewed. The study also included an analysis of published and web-based literature specifically related to irrigation in the region and Tanzania at large.

Stakeholder consultations

Stakeholder consultations were conducted with three major groups: the Wami-Ruvu basin management and staff, the National Irrigation Commission Officer, and local communities, particularly water users associations (WUAs) and members of the selected irrigation schemes (Tulo Konga and Mbarangwe) leadership (chairperson and secretary) of. Consultations centered upon three topics: understanding the availability of water resources, the status of water use and associated challenges within the basin. Many of the stakeholder consultations were conducted as part of the field visit, mentioned separately below.

Key informant interviews

Key informant interviews were conducted with the following people, who had specific information and gave both quantitative and qualitative insights into the performance of an irrigation scheme:

- Mr Heaven Jesse, Project Coordinating and Development Officer working for the Irrigation Commission;
- Engineer Elibariki Mmassy, Basin Director; Wami Ruvu
- Basin Water Board Hydologist, Mr. Paschal Qutaw; Wami Ruvu
- Ms Amy R. Mchelle, Corporate Services Manager; Wami Ruvu
- Ms Mishi Kombo, Head of section Water User Association Coordination

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Interviews with Irrigation Scheme Leadership and Farmers

Unstructured interviews were held on-site with irrigation scheme leaders and farmers to determine scheme operation and efficiency, success and failures of the irrigation group's performance, challenges, and possible measures to overcome the challenges.

Field visits and observations

A field visit was conducted at the Wami-Ruvu basin headquarters and two irrigation schemes along the Ruvu river, the Mbarangwe Irrigation scheme and the Tulo Kongwa irrigation scheme. The selected irrigation schemes were used as a basis for assessing efficiency in water use in the upper stream and the possible impacts on downstream users. Scheme infrastructure and distribution systems, together with the condition of water intakes, and diversions to the irrigation field were observed. In addition to allowing for stakeholder consultations at the local level, the aim of the field visit was to acquire information about irrigation performance, existing conditions, and how irrigation schemes were operated and maintained. Documentation in various forms, such as pictures, videos, and audio, was taken.

An aerial view of the Tulo Kongwa Irrigation system. The system is unlined, a sign of inefficiency.

Situation analysis of the performance of irrigation schemes in the Upper Ruvu catchment

Irrigation practices and infrastructure in the Upper Ruvu catchment

Irrigation practices in the Upper Ruvu catchment

In the Upper Ruvu catchment, which constitutes a significant portion of the water demand within the Wami-Ruvu Basin (M.J. Manyele et all (2021), the predominant users of irrigation water are small-scale farmers. These farmers are responsible for approximately 80% of the total area under irrigation, emphasizing their dominant role in local agriculture (Kombe J. et al 2018). Small-scale in this context refers to agricultural operations on plots typically smaller than 2 hectares, which aligns with the FAO's definition and serves as a standard for distinguishing smallholders in the region.

Small-scale farmers in the Upper Ruvu catchment, primarily reliant on the Ruvu and Mvuha rivers, face significant challenges due to their reliance on traditional irrigation methods such as flood irrigation and unlined canals. These rudimentary techniques, while affordable, fall short in water use efficiency and precision control, contributing to environmental degradation through soil erosion and uneven water distribution. The most common impacts of these irrigation practices are insufficient drainage (resulting in progressive accumulation of salts) and improper organisation and planning, which results in uneven distribution of water, leading to overwatering as well as underwatering in parallel. Additionally, post-harvest practices, such as animal trampling, and deforestation in the catchment area, further degrade the soil structure and increase susceptibility to floods, highlighting the urgent need for sustainable water management and infrastructure development.

Figure 2.1. Flood irrigation practiced in the Upper Ruvu catchment

According to the Ministry of Water and Irrigation (MoWI, 2009), water-use efficiency in these areas is alarmingly low, with estimates by the World Bank (2014) ranging from a mere 15% to 30%. The International Water Management Institute (IWMI) reinforces these findings, pinpointing water-use efficiency in the Upper Ruvu at the lower end of this spectrum, around 15%. This inefficiency is largely due to significant water losses within the intake and conveyance canals, resulting in unreliable water allocations for downstream farmers. The compounding effect of poor on-field water management and the lack of robust infrastructure further exacerbates the reduction in yields, underscoring the critical need for improvements in both water distribution systems and agricultural practices.

Selected representative irrigation infrastructure in the Upper Ruvu catchment

The Upper Ruvu catchment, particularly along the Mvuha/Ruvu river, has two irrigation schemes: the Mbalangwe irrigation scheme and the Tulo Kongwa irrigation scheme. These schemes are mainly for paddy farming but differ in terms of infrastructure, as well as capacity of water supply and irrigable area.

Mbalangwe irrigation scheme

Mbalangwe is a modern irrigation scheme in Tanzania situated on the slopes of the Uluguru mountain range along the Ruvu river in Msonge village of Mvuha ward. The scheme has the potential to irrigate up to 1,000 ha, but the current surveyed and developed scope covers only about 230 ha, covering Magogoni, Msonge, Tununguo, and Bwakira Chini villages. The irrigation system uses both lined and flood irrigation methods, with the intake and conveyance canal being lined in a rectangular shape (Figure 3.2), while the lower end of the canal and farm outlets are completely unlined. Flood irrigation is dominant, as shown in Figure 3.3. Rice and sunflowers are the main crops grown under this irrigation scheme.

Figure 3.2. Mbalangwe weir

Figure 3.3. Conveyance outlet to farms

Tulo Kongwa irrigation scheme

The Tulo Kongwa irrigation scheme, which mainly covers Tulo and Kongwa villages in Mvuha wards, is one of the largest irrigation schemes along the Mvuha and Ruvu rivers. It has the potential to irrigate an area of approximately 5,000 ha, but the current capacity is around 2,500 ha. The scheme is characterised by two concrete weirs, as illustrated in Figure 3.4, that can regulate the amount of water allocated for irrigation. The opening of the weirs depends on the season, with both weirs being opened during the high-rain season, but only one weir operating during the dry season to balance irrigation water use. The conveyance canals in this irrigation scheme are lined for some distance from the weirs, but unlined canals are used at the lower end (Figure 3.5). This irrigation scheme is used for cultivating rice paddy, sunflower, and sugar cane.

Figure 3.4. Tulo Kongwa weir 1

Figure 3.5. Conveyance canals at the lower end

Mbalangwe irrigation scheme and Tulo Kongwa irrigation scheme are generally similar in terms of infrastructure, with small distinct differences, as highlighted in Table 3.1.

Infrastructure	Mbalangwe irrigation scheme	Tulo Kongwa irrigation scheme
Inlet points	Originating from mountain range and constructed along the river	Originating from the two rivers (Mvuha and Ruvu rivers)
Weir/ gates	Installed with only one weir near the intake	Installed with two weirs near the intake and the conveyance canals
Transmission lines	Open trenches that are either partially or fully lined with cement slabs, with water flow wholly dependent on gravity	
Distribution lines	• Open trenches that are fully unlined causing high levels of sedimentation and plant growth • Water stagnation is very common along these lines as a result	
Water storage facilities	Practically non-existent, no water is stored during the rainy season, which causes high pressure on the water supply during dry and low flow seasons of the year	
Facilities management	WUAs are fully responsible for the management, operation, and maintenance of distribution lines	

Table 3.1. Structures used in the Mbalangwe and Tulo Kongwa irrigation schemes.

Performance of Mbalangwe and Tulo Kongwa irrigation schemes

Observation made during field visit to the irrigation schemes indicated that furrow surface irrigation coupled with lined and unlined canals are being used in the Upper Ruvu catchment. It was noted that both Mbalangwe and Tulo Kongwa irrigation schemes are utilizing surface irrigation techniques where water flows over the soil surface by gravity, either by flooding or in furrows. This technique is proved inefficient in terms of irrigation inefficiency; application inefficiency (uneven/excessive application depths). The irrigation inefficiency, which affects water use efficiency, was found to be low, with literature indicating that furrow irrigation has a low water use efficiency of 5 to 10 Kg/m3, as seen in Figure 3.6. Additionally, the potential application efficiencies for well-designed and well-managed irrigation systems in Figure 3.7 showed that furrow surface irrigation has a low potential application efficiency when compared to other irrigation techniques.

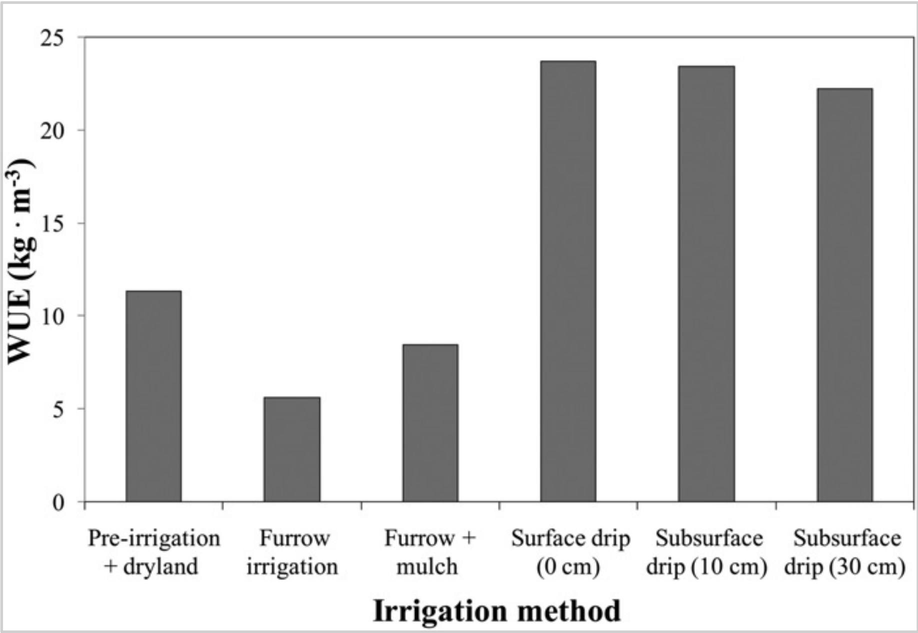

Figure 3.6. Water-use efficiency (WUE) of different irrigation methods

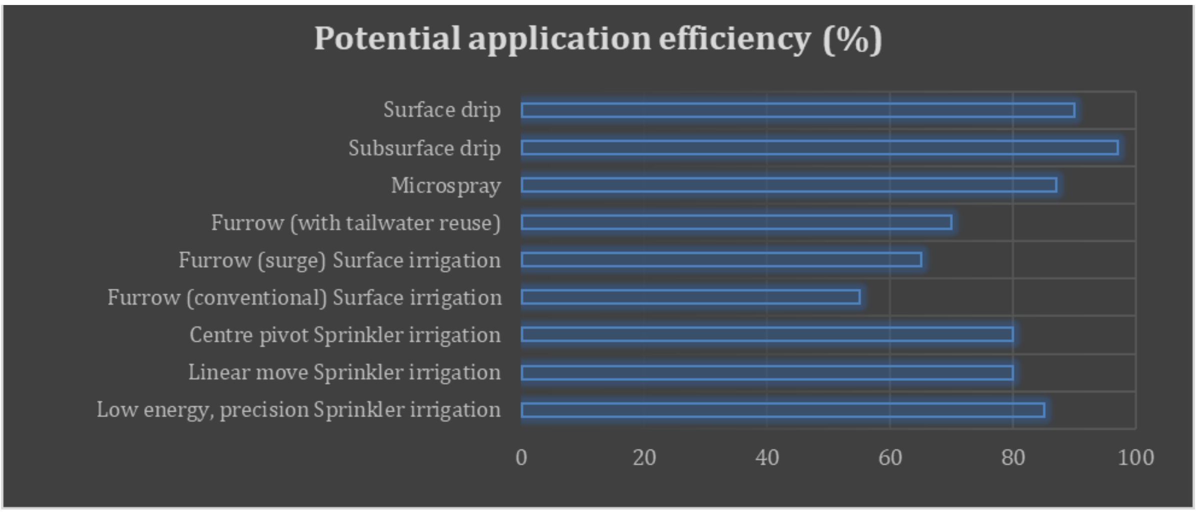

Figure 3.7. Potential application efficiencies for well-designed and well-managed irrigation systems (modified from Irmak et al., 2011)

Challenges facing management, operationalisation, and maintenance of the Mbalangwe irrigation scheme and Tulo Kongwa irrigation schemes

The National Irrigation Commission is responsible for managing the Mbalangwe and Tulo Kongwa irrigation schemes but, at the lower level, user groups, particularly irrigation associations, are solely responsible for managing such schemes. The Mbalangwe Irrigation Scheme has 10 irrigation associations, while the Tulo Kongwa Irrigation Scheme has 12 irrigation associations. A 2015 study by the Food and Agriculture Organization of the United Nations (FAO) found that only 32% of Water User Groups members in the Tulo Konga scheme were actively involved in management activities. The study also found that Water User Groups had difficulty resolving conflicts among members and making decisions about how to invest in irrigation infrastructure. A 2012 study by the International Water Management Institute (IWMI) found that only 18% of Water User Groups members in the Mbarangwe scheme were actively involved in management activities. The same study also found that Water User Groups had difficulty collecting water fees and making decisions about how to use water resources. This attests that the capacity of user groups is key in ensuring effective management practices for such schemes. However, as of 2023, user group capacity in terms of management, operation, and maintenance of irrigation schemes has remained unchanged because there have not been capacity-building initiatives despite the need being known.

Drainage systems are absent, meaning that water does not flow directly back to the river, and there are no tertiary drains leading to secondary drains and back to the river. The consequences of this lack of drainage systems are waterlogging, salinity, and the long-term degradation of land.

The inadequate funding and limited dedication of farmers have led to subpar management and maintenance of the schemes. The Irrigation Commission has mandated that each scheme collect a percentage of annual harvests from farmers for maintenance purposes. However, this bylaw is often not followed, resulting in a shortfall of funds necessary for the improvement and upkeep of the schemes.

Improved or officially recognized irrigation schemes require farmers to be registered with the government as an association or cooperative to obtain a water-use permit to divert water from the main River and be able to access external funding; for example, loans from banks. The Mbalangwe and Tulo Kongwa irrigation schemes, both of which are officially among the improved irrigation schemes, have concrete intake structures that do not require frequent maintenance, but do require canal cleaning and dredging. Members may have to contribute money for furrow cleaning, and users are technically responsible for cleaning narrower and more shallow canals. However, operational challenges, including limited financial management capacity, and poor leadership and organisational skills, including the limited enforcement of scheme by-laws, often result in this maintenance not being conducted.

Enabling environment

Government legislation, policy frameworks and plans are in place in Tanzania to guide the planning and implementation of irrigation development. These include the National Irrigation Act No.4 of 2013, the National Irrigation Master Plan, the Water Resources Management Act No. 11 of 2009 and its amendment act No. 8 of 2022, Tanzania Development Vision 2025, and the National Water Policy of 2002. These aim to improve agricultural productivity and enhance food security by encouraging the formation of WUAs, including irrigators' associations, and strengthening their capacity to effectively manage irrigation systems. Furthermore, these legal frameworks include specific clauses dedicated to promoting water use efficiency, underscoring the government's commitment to sustainable irrigation practices.

The National Irrigation Act, 2013 makes provisions concerning the management, use, and maintenance of irrigation systems. It established the National Irrigation Commission and defined its functions and powers. The Commission is responsible for coordination, promotional, and regulatory functions in the development of the irrigation sector. Among other things, the Commission advises the government on the implementation and review of the National Irrigation Policy and other policies. It invests in irrigation and drainage systems in collaboration with the minister responsible for local government and may, in consultation with the minister, establish an Irrigation Department in a district authority.

Irrigation associations are solely responsible for managing and maintaining irrigation schemes at the local level. The National Irrigation Act of 2013 requires the National Irrigation Commission to work with local government authorities to establish irrigators' associations. These are responsible for creating awareness about water conservation, maintaining irrigation schemes, and ensuring efficient and cost-effective use of water to maximise crop production. These irrigators' associations are also required to develop plans for the operation and maintenance of irrigation schemes at the end of every cropping season. However, the implementation of these well crafted plans, strategies and policies is insufficiently carried out. The National Irrigation Commission which was established in 2013 has in few years managed to accomplish a lot, however, there are still gaps. Field findings reveal that the selected Irrigation Schemes has not been receiving the guidance, monitoring and follow ups they need.

An aerial view of a different section of the Tulo Kongwa irrigation scheme. This section is also unlined.

Root causes of low irrigation efficiency in the Upper Ruvu catchment

Introduction

This section summarises the major study findings of the root cause analysis from rapid field visit observations and a focus group discussion that was held at the Wami-Ruvu Basin Office, supplemented with relevant literature and secondary data.

Root causes of low irrigation efficiency in Upper Ruvu catchment

This study sought to identify the root causes of irrigation inefficiency in the Wami-Ruvu basin, with a focus on the Upper Ruvu catchment. In this analysis, the term "irrigation efficiency" pertains to the proportion of water that is beneficially (in a way that maximizes contribution to agricultural production, minimizing waste and inefficiency) utilised for production. Water use efficiency represents the ratio between effective water use and actual water withdrawals.

In field surveys of the operations of the Mbalangwe and Tulo Kongwa irrigation schemes, the efficiency was observed to be very low because the volume of water that is needed and used by the crop far exceeds the volume delivered to the field, as most withdrawals did not consider the crop water requirements but the infrastructure capacity.

Efficiency can also be measured by the term "application efficiency" signifying the volume of water that is delivered to the field as determined by the amount of water required to replace the farm soil water deficit or meet the evapotranspiration rate. This too was similarly observed to be very low.

In particular, irrigation efficiency in the selected schemes in the Wami-Ruvu basin varied between Tulo 29% and Mbalangwe 32%, roughly the same as the basin efficiency average of 30 percent estimated by the sectoral water plans report for the basin (i.e. WRB IWRMD Plan, 2020).

This short study identified four major root causes of irrigation inefficiency, considered in different ways presented in Table 4.1 and Figure 4.1. and discussed in more depth below.

Farmers in the Kilombero Valley, part of the Rufiji river basin, practicing the System of Rice Intensification (SRI), an agricultural methodology that is being promoted to increase efficiency and productivity.

Problem	Symptoms	Direct cause	Possible root cause	Actual root cause
Water-use inefficiency in irrigation	Standing water or puddles	Poor operation and maintenance	Inadequate monitoring and feedback	Limited sectoral collaboration
				Poor enforcement of by-laws
			Limited resources	Lack of productive farming
				Poor enforcement of by-laws
			Limited local knowledge and awareness of farmers	Lack of basic infrastructure repair knowledge
			Lack of motivation	Uneven distribution of water
			Poor infrastructure design	Financial constraints and replicating an existing design
		Unlined distribution canals		
		No sluice gates		
	Uneven crop growth	Unlined distribution canals		
		Dedication to longstanding agriculture practices	Limited local knowledge and awareness of farmers	Lack of knowledge of basic water-efficient agricultural methods

	No infrastructure for return flow	Weak enabling environment	Uncoordinated sectoral efforts	Conflicting legal frameworks
			Poor enforcement	Limited integrity of scheme leadership, including irrigators associations
	Soil compaction	Unlined distribution canals	Poor design	Financial constraints and replicating an existing design
		Traditional agriculture practices	Limited local knowledge and awareness of farmers	Lack of knowledge of basic water-efficient agricultural methods
	Illegal abstraction	inadequate water-use monitoring network	Uncoordinated sectoral efforts	Conflicting legal frameworks
			Lack of coordination between key stakeholders	Limited sectoral collaboration

Table 4.1. Root causes of irrigation inefficiency in the Upper Ruvu catchment

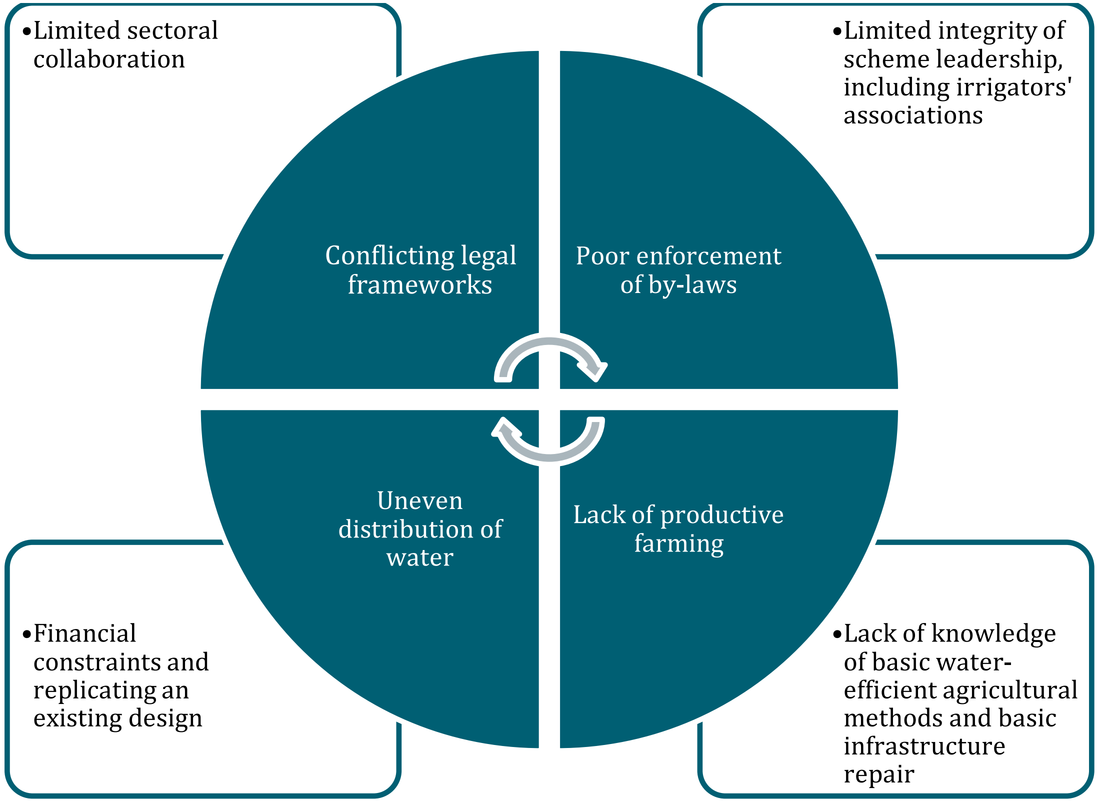

Figure 4.1. A summary of root causes of irrigation inefficiency in the Upper Ruvu catchment

A lack of financial incentive to increase efficiency.

The initial capital cost of irrigation systems is a key deciding factor in the choice of irrigation systems. As noted, smallholder farmers mainly make use of open ditches as the cheapest irrigation method with almost no additional pumping costs, and minimal operation and labour costs.

Furthermore, in Tanzania, the cost of water is low. The cost of installing new technology far outweighs the potential savings accrued from a reduction in the water bill, so there is no motivation for users to employ precision or smart irrigation techniques to save water. There are currently no incentive mechanisms that are attached to initiatives for improving irrigation efficiency or installation of more efficient systems. Until excessive use of water translates into a direct increase in operational cost of the irrigation schemes or water allocations to each user are firmly applied and enforced, appropriate irrigation practices that essentially mean increased initial capital cost are unlikely to be adopted.

Replication of already existing designs.

The current situation, where irrigation schemes have not incorporated improved irrigation practices, is exacerbated by the replication of existing designs without considering innovative and emerging capabilities. This systemic challenge, a default tendency to design irrigation schemes solely based on the existing master design, has been overlooked. Consequently, irrigation schemes have been constructed without addressing existing design challenges, such as unlined distribution canals with few sluice gates, resulting in water overallocation, puddles, and uneven distribution, ultimately leading to low agricultural productivity. The survey of irrigation schemes revealed that the designs were alike and based on traditional irrigation techniques, despite variations in location and circumstances.

Limited integrity of scheme leadership, including irrigators' associations.

Irrigation inefficiency in the Upper Ruvu catchment is, to a large extent, due to poor drainage design, which impairs hydraulic efficiency of the irrigation schemes, but also limits cleaning, repair, and maintenance. The team witnessed poorly designed and operated irrigation infrastructure that were mainly open earthen ditches, filled with sediment and vegetation, which then affected water distribution. Poor drainage and distribution also increased the risk of puddles, which lead to increased evaporation (i.e. water loss). It was noted that the scheme leadership were aware and informed about the need to clean ditches; in fact, there are by-laws with a provision for cleaning and maintenance of the scheme by all user groups. Unfortunately, the enforcement seems to be minimal, partly due to a lack of will, where decisions do align with the values, principles, and set regulations. As indicated in the IWRMD Plan, the Wami-Ruvu basin is prone to erosion and sedimentation due to the soil type and texture, as well as high rate of deforestation. Irrigators' groups lack an obligation to conduct periodic maintenance, including cleaning and removing sediments from canals contributing to the inefficiency of water use.

Inadequate soil moisture monitoring and excessive sedimentation.

Efficient irrigation requires continuous and consistent monitoring of soil moisture that informs irrigation water requirements, which eventually guides the water allocation to various schemes. Only commercial large-scale irrigation schemes have attained such efficiency and precision. There is a need to improve the capacity of smallholder farmers to use appropriate water-saving techniques, as they form the majority of the farmers in Tanzania. This will enhance agricultural productivity, and, in turn, will enhance the willingness to pay for maintenance and repair of irrigation schemes.

In both Mbalangwe and Tulo Kongwa irrigation schemes, excessive sediment load in the irrigation canals and intakes was observed. This may be the cause of sedimentation, which is the common challenge in the Wami-Ruvu basin.

Conclusion and recommendations

Conclusions

1. The primary reason for water stress in the Upper Ruvu catchment is the high demand for water for irrigation coupled with inefficient irrigation practices.
2. The high initial capital costs for precision irrigation techniques and low cost of water (use and misuse) deter smallholder farmers, who predominantly rely on traditional methods like flood or furrow irrigation, from updating their inefficient irrigation practices.
3. The capacity of Irrigation User Groups (IUGs) is inadequate, leading to inefficient water use, reduced agricultural productivity, and potential environmental harm.
4. There is a lack of collaboration between the water and agricultural sectors, leading to misaligned efforts and failures in addressing broader challenges.
5. Irrigation scheme infrastructure is mostly unlined open channels, contributing to excessive water loss.

Recommendations

The following are recommended:

- Prioritize a holistic understanding of farmers' needs and contexts, and acknowledge the natural apprehension towards new technologies. Engage with local communities to tailor technological solutions that complement and enhance indigenous practices. Implement inclusive, hands-on mentorship programs that respect and build upon existing knowledge and skills. This integrated approach will facilitate practical learning and encourage the gradual adoption of new practices.
- Encourage collaboration among stakeholders, including irrigation scheme management groups, the water sector, and the agricultural sector, for sustainable and integrated water resource management. Implement robust systems for monitoring water use and enforcing regulations to ensure sustainable use of water resources. Develop clear guidelines for dividing responsibilities, establish joint coordination mechanisms, and amend the existing Acts for clarity. Foster a participatory approach where farmers are actively involved in the decision-making process.
- Address the challenge of higher initial investments in water-use technologies with a well-planned resource mobilization strategy. This should include exploring various funding options, such as grants, tax incentives, and low-interest loans, ensuring that financial barriers do not hinder the adoption of sustainable practices. Integrate with policy reforms that incentivize the adoption of efficient irrigation systems and provide financial support to farmers for initial investments.
- Increase investments in irrigation infrastructure, such as lined canals and sluice gates, to minimize water loss. Include strategies for adapting irrigation practices to changing climatic conditions to ensure long-term sustainability. Encourage research into new, cost-effective technologies for water-efficient agriculture, tailored to the needs of smallholder farmers.
- Review and revise the price of water to encourage more efficient use.

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Ministry of Water

GLOBAL WATER LEADERSHIP PROGRAMME

Global Water Partnership Southern Africa

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Effective and equitable water management is becoming increasingly complex, and increasingly important, as climate change impacts add new uncertainty to policy decisions and financial investments. The Global Water Leadership in a Changing Climate programme (GWL) is working intensely in ten countries, bringing together key stakeholders and decision makers from two water management pillars – water resources and water and sanitation – to develop holistic, integrated policies and plans to enhance national water and climate resilience. The programme is funded by the UK Foreign, Commonwealth and Development Office (FCDO) and implemented by Global Water Partnership (GWP), the United Nations Children's Fund (UNICEF), the Sanitation and Water for All Partnership (SWA) and the World Health Organization/UNICEF Joint Monitoring Programme (JMP). In Tanzania the programme has been implemented by Global Water Partnership Tanzania.

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