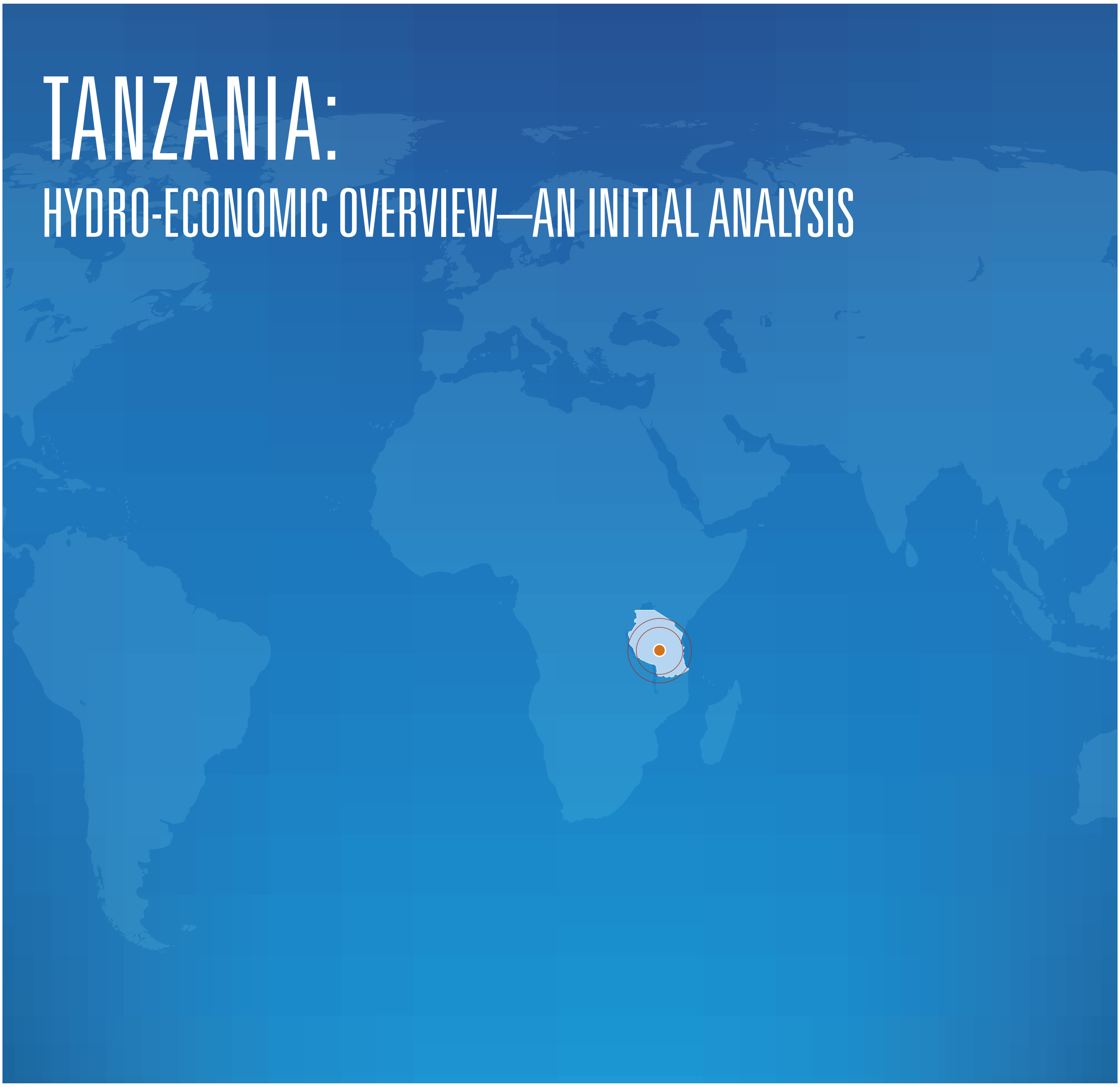
Final Report

June 2014

2030 Water Resources Group

TANZANIA:

HYDRO-ECONOMIC OVERVIEW—AN INITIAL ANALYSIS



Disclaimer

Rights and permissions

About 2030 Water Resources Group

The 2030 Water Resources Group is a unique public-private-civil society partnership that helps governments to accelerate reforms that will ensure sustainable water resource management for the long term development and economic growth of their country. It does so by helping to change the "political economy" for water reform in the country through convening a wide range of actors and providing water resource analysis in ways that are digestible for politicians and business leaders.

Acknowledgments

The 2030 WRG wishes to thank all of the companies, organizations, institutions and individuals that have shared their knowledge on water resources in Tanzania to produce this report.

This report has been prepared by AMEC Environment & Infrastructure UK Limited with the contribution of Dr. Chris Fawcett, Colin Carter, Dr. Graeme Aggett, Harun Makindi, Dr. Nick Hepworth, and Onesmo Sigala. The report takes into account the particular instructions and requirements of our clients. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

FOREWORD

During the 34th Session of Parliament, while discussing the Water Bill in 1958, then Prime Minister Julius K. Nyerere observed that "in a country like ours, where one of our greatest problems is water, we must manage water effectively—unless this is done we can involve ourselves in a great deal of trouble in the future." Half a century later, as the present report points to, the water challenge in Tanzania remains a major issue.

The water challenge is global and touches every country in the world. With its growing population and economy, the world is facing increasing demands for its limited water resources. Competition among different water-dependent sectors—from agriculture, to energy generation and industry—have drastic consequences on water availability and quality. This coupled with the impacts of climate change makes the situation even worse.

In 2009, the 2030 Water Resources Group report "Charting our Water Future" showed that there could be a 40% gap between the required demand and the safe available supply of freshwater by 2030 under business as usual practices.

This alarming figure is also reflected in Tanzania, where this report shows an even more severe gap between water availability and demand by 2030. Furthermore, competing plans and demands for water in the agriculture and energy sectors will require strategic tradeoffs between irrigation and energy production. This clearly illustrates the need for breaking the silos and highlights the need for cross-sector interventions that would encompass the contribution from the public, private sector and civil society.

With the establishment of the 2030 WRG Tanzania Partnership, our first effort was to compile data and information from across sectors to frame the water debate as it relates to Tanzania's economic growth aspirations. We wanted this information to be developed in a clear, compelling and actionable manner, to engage water sector expert and non-expert decision makers, and start a conversation on Tanzania's challenges, and opportunities. The results presented in this report were highlighted at the kick-off workshop of the partnership and helped in bringing a wide range of stakeholders together to discuss the results and the way forward with the bigger aim to catalyze action on water resources reform.

I am pleased to say that the report has indeed met its objective. From an initial discussion based on this report, the 2030 WRG Tanzania Partnership has identified key focus areas for our future work, and is now working to formalize the working groups to take forward the debate and practical action across the following areas: water use efficiency, water source protection and water security and cross-sectoral collaboration. This is, however, only the beginning of a long journey toward water security that will require coordinated and collective action in order to identify and implement solutions that will help to preserve our precious water resources for future generations to come. I hope to see even more stakeholders engage with the 2030 WRG Tanzania Partnership looking forward.

Anders Berntell
Executive Director
2030 Water Resources Group

CONTENTS

TABLES

FIGURES

EXECUTIVE SUMMARY

Purpose of this Report

This report has been prepared under the direction of the 2030 Water Resources Group (2030 WRG) with the Ministry of Water of the Tanzanian Government for the 2030 WRG Tanzania Partnership.

The purpose of the report is to summarize the results of preliminary hydro-economic analyses to support a business case for sustainable water resource management in Tanzania and identify opportunities across the public and private sectors. In particular, it highlights the water resources challenges, identifies the links between economic performance and water availability, and clarifies existing and future constraints which need to be overcome. A range of interventions are discussed and recommendations made for the next steps to address these challenges to improve water resources management, while recognizing the interdependence of both the public and private sectors.

As well as a high level national assessment, the analysis includes a focus on two regions of Tanzania where economic opportunities are of national importance and will be constrained without better water management. The Rufiji basin has large scale potential for development of agriculture, tourism and hydropower while the Wami-Ruvu basin requires balancing demand from existing agriculture upstream and urban pollution downstream to ensure the high industrial growth in the largest city—Dar es Salaam—can continue.

National Assessment

Tanzania has significant annual average renewable water resources of 94,000 MCM per year amounting to some 2,300 CM per capita; well above the Falkenmark indicator[1] for "water sufficiency" of 1,700 CM per capita. Despite the abundant water resources, availability is highly variable in space and time and remains a constraint for Tanzania in meeting overall water demand. Taking into account environmental flow requirements, during dry periods, national demand is 150 percent of accessible water. Under a business as usual scenario and factoring in economic growth projections this increases to 216 percent by 2035. High river flows in the wet season are not all practically available for use due to low water storage capacities. An increase in surface water availability, particularly in the dry season, could be achieved through the increased capture of water in storage reservoirs in the rainy seasons. Tanzania's economy is already suffering directly from lack of water. Recent government analysis estimated that overall GDP growth in 2011 was reduced from 7 percent to 6.4 percent due to drought affecting water and hydropower. A 0.6 percent reduction in GDP corresponds to $142 million in 2011 prices and, based on average GDP per capita figures, is equivalent to contribution to GDP of over a quarter of a million people.

The Rufiji Basin

The Rufiji is the largest of Tanzania's nine water basins and, with 25 percent of national river flow and 33 percent of national rainfall, is the main focus for opportunities for increasing development in agriculture, and hydro-electric power. It is the area for a proposed US$3 billion investment under the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) program, which aims to expand commercial farming by 350,000 hectares including an increase from 16,000 to 120,000 hectares in just one valley—a factor of almost 10. However, irrigation is already causing seriously depleted water flows in some sub-basins and new irrigation schemes planned for the Mpanga and Udagaji catchments in the Kilombero Valley will lead to zero river flow in the dry season unless water management interventions such as increased irrigation efficiency and new reservoirs are implemented. The potential for hydro-electric power in the basin is five to ten times current levels of generation with corresponding increases in revenues from $172 million to $800 million, providing energy output two and a half times the current national electricity use. Currently, considerable irrigation is practiced upstream of hydropower facilities which reduces flows and generation levels. Low irrigation efficiencies and unlicensed abstractions are contributing factors but could be addressed by well chosen water management interventions that mitigate the tradeoffs and choices required between new agricultural development and hydropower, while maintaining environmental quality and supporting tourism.

The Wami-Ruvu Basin

The Wami Ruvu basin includes Dar es Salaam, the largest economic and urban center in Tanzania. Water users in the basin are already consuming all water that can be supplied. By 2035, the volume of water consumed is projected to double due to new agricultural schemes and high industrial growth. Plans for the development of water supplies expect to use the large Kimbiji aquifer and a new dam at Kidunda but the aquifer is at a very early stage of investigation and construction of the dam has not started. Yields from the aquifer are unpredictable and also depend on overcoming difficult technical challenges of retrieving water at a depth of 1,000 meters. Both developments will require substantial investment but are realistic long-term solutions which could address the acute water supply problems already affecting health and economic development in the rapidly growing city. Incremental development of additional storage in the basin would provide benefits from better regulation of seasonal flow supplies and while a number of dam sites have been identified they are currently uncosted. Urban areas supplied from existing surface water resources, like those in the commercial and industrial center of Dar es Salaam, are vulnerable to poor agricultural practices upstream which affects water quality and quantity. In Dar es Salaam, less than half the inhabitants have access to the main water network and instead use private and unlicensed boreholes. Overuse of the shallow aquifer under the city has led to contamination from sea water and health risks resulting from poor disposal of industrial effluents and the reliance on on-site sanitation by 90 percent of the population. The urgent need to tackle these water resource challenges requires new solutions such as water treatment and reuse, industrial water efficiency measures and tackling non-revenue water.

Recommendations

Tanzania requires both strategic national and local solutions and the literature reviewed during this assignment included a wide range of detailed and high-level recommendations at both the national and basin levels.

The 2030 WRG Tanzania Partnership Kick-Off Workshop in November 2013 brought together stakeholders for the first time and began this process by identifying focus areas including **water use efficiency, water security and cross-sectoral coordination**. It identified the need for further in-depth hydro-economic analysis in priority basins such as those with expectations of significant new economic growth.

The recommendations identified and presented below will require **convening groups of stakeholders,** with the **private sector playing an essential role**, to assess opportunities and develop focused proposals. The main recommendations are:

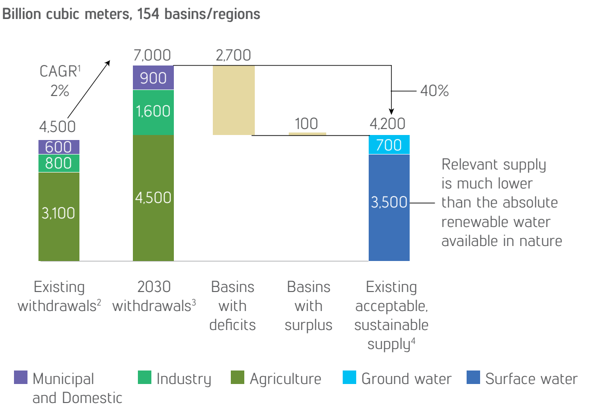
- **Large and Small Scale Water Storage, including Multipurpose Reservoirs**. Lack of water storage in Tanzania limits the possibilities for managing and regulating water supplies in meeting current and future demand. The future investment in storage infrastructure at large and small scales for irrigation purposes is a necessary component for achieving the planned increases in agricultural production. Multipurpose storage schemes would also provide industry with more secure water supplies as well as playing a role in hydropower development. It is proposed that the multipurpose schemes presented in the IWRMDPs as well as new proposals are brought to convening sessions at national or basin level and explored by stakeholder groups for development opportunities including cross-sectoral interactions, collaboration and shared investment.
- The potential for **wastewater treatment and reuse** is very relevant to the urban areas in Tanzania. These are growing rapidly, particularly in Dar es Salaam which is the main commercial and industrial hub. Reuse increases water availability locally and contributes to greater water security for business and domestic consumers. The largest industrial water uses in Dar es Salaam are for cement manufacture, and food, drink and textile production. It is proposed to convene representatives from these groups and the water and sanitation provider, together with potential investors to identify opportunities for partnerships to develop such schemes.
- The same stakeholders should also address the issues of **non-revenue water** and **industrial water use efficiency**. Additional revenues are valuable as an immediate source of funding for improved water infrastructure. Increased water efficiency will reduce water costs and risk to industry. The water savings from both will release additional supplies to other users.
- **Efficiency Improvements in Irrigated Agriculture**. Over 80 percent of irrigated land is farmed using traditional practices for water use with efficiencies as low as 15 percent (compared to modern efficiencies of over 90 percent). Investment in new or rehabilitated irrigation schemes would reduce water use and often leads to increased agricultural productivity. Such developments may, at the same time, benefit existing enterprises, provide infrastructure for smallholders and form hubs for wider added-value initiatives. It is proposed that a selection of irrigation development plans identified from the IWRMDPs are brought to a convening session with potential investors, commercial enterprises and smallholder farmers to assess specific opportunities.
- The **System of Rice Intensification (SRI)** is a strategy that can be adopted by commercial farmers and smallholders to increase productivity and reduce water use. Studies of SRI in Tanzania have shown yield increases of between two and four times while also reducing water requirements significantly. The experience of commercial rice growers already using SRI and other successful agribusinesses using modern water use techniques should be showcased to new and potential investors, smallholders and larger enterprises.

CHAPTER 1. Background and Introduction

1.1 The 2030 Water Resources Group

Since 2006, the World Economic Forum (WEF) and its Members have been bringing to the attention of policy makers the inter-related global risks of crises in water supply and food shortage. In parallel, the International Finance Corporation (IFC) has been working towards its mission of investing US$1 billion each year in water security projects and thereby increasing water supply to 100 million additional people and safe sanitation to 20 million people. In 2006, the WEF's Water Initiative (WI) embarked upon its Water Partnership Project work stream with the objective of creating partnerships between government, development agencies, NGOs, and WEF industry partners in regions of special interest to WEF members. The partnerships seek to develop a body of water-related projects contributing economic benefits while being also attractive to sources of finance in the private sector. In January 2010 WEF published a paper on the principles of partnership using specific case studies: "Innovative Water Partnerships: Experiences, Lessons Learned and Proposed Way Forward."

Figure 1.1 The Global Gap between Existing Accessible, Reliable Supply and 2030 Water Withdrawals Could Reach 40 percent



[1] Compound annual growth rate.

[2] Based on 2010 agricultural production analyses from International Food Policy Research Institute (IFPRI).

[3] Based on GDP, population projections, and agricultural production projections from IFPRI, considers no water productivity gains between 2005 and 2030.

[4] Existing supply that can be provided at 90% reliability, based on historical hydrology and infrastructure investments scheduled through 2030, net of environmental requirements.

Source: 2030 Water Resources Group; global water supply and demand model; agricultural production based on IFPRI IMPACT-WATER base case.

In 2008 a number of multinational businesses (some of them members of WEF) and IFC joined forces and the 2030 Water Resources Group (WRG) was launched. The group sought to develop a new fact base of potential levers and associated costs for addressing water scarcity—with the ultimate objective of providing tools which could be used in the multi-stakeholder settings coming from the WEF partnership work stream.

In November 2009, the 2030 WRG published its ground-breaking report "Charting our Water Future: Economic Frameworks to inform decision-making." The report was something very new in the sense that it put cost benefit economics at the heart of a decision-making framework for prioritizing water interventions. But it also crystallized the global challenge of water scarcity; that we are already withdrawing a volume of blue water which is close to a planetary boundary; that to satisfy the demand for water in 2030 will require us to do things differently.

Against this background, the Water Resources Group Phase 2 was launched in 2010 as a formal alignment of WEF WI and WRG. Phase 2 led to Phase 3 with the establishment of a formal entity known as the 2030 Water Resources Group (2030 WRG) with its secretariat housed in the offices of the IFC in Washington.

The 2030 WRG works as a public-private-civil society partnership, using a three step approach which brings together the Analyze, Convene, and Transform principles developed by WEF and the 2030 WRG.

1.1.1 The 2030 WRG Tanzania Partnership

The Government of Tanzania approached the 2030 Water Resources Group to form a partnership to explore water management options involving stakeholders across the public and private sectors at the World Economic Forum in Davos in January 2013. Government and stakeholder discussions have been ongoing since April 2013 and a Memorandum of Understanding was signed 10th October 2013 to form a partnership following a multi-stakeholder approach with the Minister of Water as Patron and the Permanent Secretary of the Prime Minister's Office as Chair.

The objectives of the resulting 2030 WRG Tanzania Partnership are to support, complement and strengthen the existing efforts of the Government of Tanzania. Specifically the partnership aims to:

- Provide a complete picture of water resources and economic information to help Tanzania make and align policy decisions;
- Create increased awareness, support and momentum from politicians, Ministers and industry water users;
- Provide access to best practice, knowledge, experts and technology from the 2030 WRG global network.

AMEC was appointed to undertake the first assignment for the 2030 WRG Tanzania Partnership relating to the "Analyze" phase of the 2030 WRG's overall approach to hydro-economic analysis.

1.2 Water Resource Challenges in Tanzania

Tanzania represents a microcosm of the difficult water resource challenges facing much of our world. The country must meet and balance the increasing water demands of a growing population of almost 40 million people with water needed for food security, economic growth, and energy production while maintaining some of the most important ecosystems on the planet. This must be done in the context of a variable and changing climate, limited technological choices, constraints on infrastructure and investment; and multiple institutional, political and human resource challenges.

Tanzania is relatively well endowed with water resources, yet many of its largest water bodies are shared with neighboring countries and the subtropical climate results in high temporal variability in rainfall and river flows. Although Tanzania is not currently classified as water stressed, high rainfall variability regularly plunges some regions into severe seasonal drought. Rainfall of over 1,200 mm/yr in the southwest highlands compares to less than 600 mm in the drier Internal Drainage Basin. The economy's susceptibility to flood and drought events is illustrated by a loss of approximately 1 percent of GDP resulting from drought in 2005/6. During this period the agriculture sector experienced an almost 20 percent decline in growth and growth in the electricity and water sectors declined from 5.1 percent to -1.8 percent (URT 2007).

Water demand in the key economic sectors of agriculture, energy and manufacturing is rising sharply alongside rising requirements from population growth for supplying domestic consumption, improving the conditions of the poor and for the environment. Agriculture plays a key role in Tanzania's economy, contributing over a quarter of the country's GDP. Agriculture is a significant water user and 80 percent of the population depends on the sector for their livelihood. Hydropower currently provides 57 percent[2] of the country's power generation and has been heavily affected by drought in recent years. Given Tanzania's ambitious development goals,[3] the need for new investment and coordination around the water-energy-food nexus is acute. Millennium Development Goal targets for water supply, sanitation and hygiene are significantly off track in Tanzania and the proportion of the population with sustainable access to improved water sources actually declined between 1990 and 2008.[4] Water resource use and users are highly disparate with much of the nation's hydropower generation taking place alongside agricultural production in the Rufiji basin while the Wami-Ruvu basin contains the rapidly growing urban and industrial centers of Dar es Salaam and Morogoro.

Climate change is likely to have severe consequences for Tanzania through increased temperatures, changes in rainfall, extreme events and rising sea levels, Climate change is anticipated to cost 2 percent or £270 million per year of Tanzania's GDP by 2030.[5] Embedding resilience through greater water security will make a significant contribution to an effective response to climate change.

In response, the Tanzanian government has recently implemented a revised institutional and policy framework for water resource management. The National Water Policy (2002),[6] National Water Sector Development Strategy (2008)[7] and law of the Water Resources Management Act (2009) developed with assistance from development partners are considerable achievements. However, the Ministry of Water and the nine semi-autonomous Basin Water Offices face multiple practical problems of limited data, resources, human and technical capacity.

"In a country like ours, where one of our greatest problems is water, we must manage water effectively—unless this is done we can involve ourselves in a great deal of trouble in the future."

—Julius K. Nyerere, 34th Session, Water Bill, 17th October 1958, Hansard.

More widely, Tanzania's National Strategy for Growth and Reduction of Poverty (known as MKUKUTA) and Zanzibar's Strategy for Growth and Reduction of Poverty (MKUZA) as well as the more recent Big Results Now (BRN) initiative aim to stimulate poverty reduction, high and shared growth, peace and stability and international competitiveness but have also highlighted the dependency of national objectives on water security. The country's development vision is one of a diversified and semi-industrialized economy, yet the growth sectors targeted require freshwater and produce potentially problematic waste water. The large-scale regional policy of SAGCOT (Southern Agricultural Growth Corridor of Tanzania), covering approximately one-third of the country, aims to modernize agriculture and develop value-added food processing businesses and supporting infrastructure such as transport links. The economic benefits are now recognized as conditional on the cross-cutting issue of water security.

Several examples are emerging from Tanzania of unreliable access to water resources imposing severe operational, financial and reputational risks to business. Some enterprises have closed due to water insecurity, reducing much needed employment and export revenue earnings. Competition over water causes regular conflicts and in the worst cases violent clashes have resulted in fatalities.[8]

Improved water resource management is essential to future stability and growth in Tanzania which is outgrowing the methods used to date. The institutional frameworks now in place provide a basis for management of shared risks. The potential for the 2030 WRG to make a transformative contribution on water resource management through generating new analysis, and initiating new partnerships with the private sector is significant.

1.3 Assignment Objectives

The primary objective of this assignment is to raise awareness of the challenges, mobilize stakeholders, and engage 'new actors' from the private sector. Specifically, the assignment was to use the platform of the 2030 WRG Tanzania Partnership to undertake analysis which will develop and build a compelling business case for water resource management in Tanzania, recognizing the interdependency of the public and private sectors both in overcoming bottlenecks and in identifying opportunities.

The outputs provide a catalyst for the Tanzanian Government's establishment of a group of champions and actors representing key water using stakeholders. It is hoped that this group will take a leading role in implementing best practice and undertaking sustainable water management in Tanzania and engage in potential joint funding in identified partnership projects.

The assignment aimed to draw on existing information and data to provide:

- A national overview of the magnitude and urgency of the water resources challenge to meet national growth and development targets based on a business-as-usual scenario;
- Specific focus on the Wami-Ruvu basin where the largest urban and economic center of Dar es Salaam is located; and
- Specific focus on the Rufiji basin, a key agricultural area and the location of the government's SAGCOT program with investment blueprints already established that depend on overcoming water challenges.

It was recognized that the refinement and scope of subsequent analysis undertaken by 2030 WRG (or others) depends on stakeholder views expressed at the kick-off workshop.

1.4 Assignment Delivery Approach

The terms of reference of a preliminary assignment of Hydro-Economic Analysis were published for tender in September 2013 to kick start the multi-sector platform partnership and a contract awarded to AMEC Environment and Infrastructure UK Ltd in October 2013.

The AMEC project team was on the ground in Tanzania over a five week duration and comprised International experts: Dr. Graeme Aggett, Team lead and Hydrologist; Dr. Chris Fawcett, Agricultural Water Resources lead; Colin Carter, Water Economist lead; and Onesmo Zakaria Sigala (Mo Resources, Tanzania); and was assisted by Dr. Nick Hepworth, Tanzanian water expert (Common Futures) based in the UK.

Rapid assimilation of information was undertaken during this five week period involving meeting with stakeholders and reviewing the literature from both an economic and water resources standpoint. A wide range of stakeholders were consulted during the assignment which reinforced the importance of water resources to a range of key sectors with considerable growth potential within the Tanzanian economy. Further information on the stakeholder consultation can be found in Appendix A.

The main sources of information used in this assignment are reports associated with the Integrated Water Resource Management Development Plans (IWRMDP) which are currently being developed for each of the nine basins in Tanzania, a program of work led by the Ministry of Water with support from different donors. These plans have substantially improved the understanding of water resources in Tanzania. As this is a new program, the consultants developing the IWRMDPs have used a variety of methodologies aligned to the basins they investigated, and which are likely to be refined as the plans are developed and revised. From these reports and other literature, data relating to current and future water availability and sectoral water requirements were identified and used to assess the water gap. Information on the specific programs of interventions to deal with the water challenges nationally and in each basin was highlighted.

The outputs of the analysis were presented to multi-sector stakeholders at the Kick-off meeting of the 2030 WRG Tanzania Partnership held in November 2013. Further information can be found in Appendix B.

1.5 Report Structure

An overview of the report structure is provided below.

The technical outputs are summarized in Chapters 2—8 and in linked appendices:

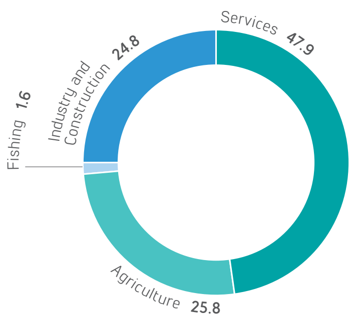
- Chapter 2: An overview of the Tanzanian economy, links to water availability and economic opportunities;
- Chapter 3: A national overview of Tanzania's water resources with a specific assessment and comparison of the current and future water demand and availability given business as usual growth and the resulting challenges;
- Chapters 4 and 5: Two case studies which have a specific focus on the integrations and challenges between water resources and economic growth and potential measures that could be adopted to deal with these challenges:
  - The Wami-Ruvu basin where the largest urban and economic center of Dar es Salaam is located; and
  - The Rufiji basin, a key agricultural area and the location of the government's Southern Agricultural Growth Corridor of Tanzania (SAGCOT) program;
- Chapter 6: A summary of evidence from the assignment;
- Chapter 7: A review of potential water management interventions that could be implemented to tackle the water resources challenges; and
- Chapter 8: Recommendations.

CHAPTER 2. Overview of Tanzanian Economy

2.1 National Trends

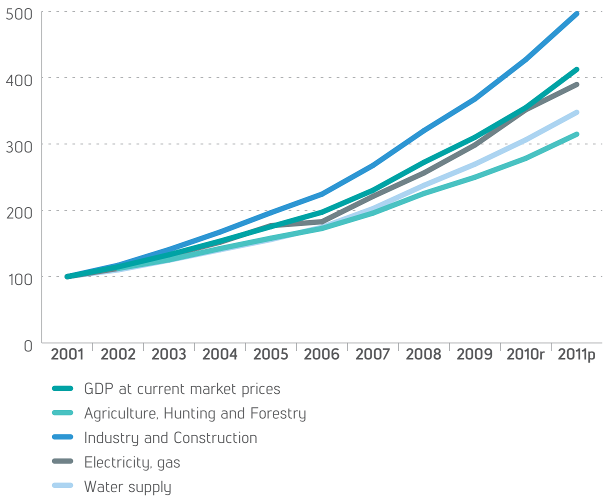
Tanzania has a relatively small economy in world terms with a gross domestic product (GDP) of US$23 billion (in 2011),[9] approximately 30 percent of the combined GDP of the East African Community[10], 20 percent greater than Zambia to the south and 24 percent less than Kenya to the north. It is one of the few countries in Sub-Saharan Africa to have recorded sound macroeconomic management and rapid economic growth, which averaged 6 percent per year since 2000.[11] Tanzania is particularly resistant to sectarian economic upheaval due to government policies implemented soon after independence which integrated people from different areas of the country.

Figure 2.1 Share of GDP between the Main Economic Sectors, 2011



Source: National Accounts of Tanzania Mainland.

Figure 2.2 Increase in GDP for Major Economic Sector (2001=100)



Source: National Accounts of Tanzania Mainland.

However, the results of day to day economic decision making for the average Tanzanian is not well represented in a national GDP figure. Tanzania has a large subsistence agriculture sector where smallholders' cultivation is for their individual and family's benefit and such activities will not be fully represented in national accounts. Agriculture is nonetheless a large proportion of the traded monetary economy and accounts for major proportion of export earnings. Overall, 75 percent of the workforce are in agriculture and produce 97 percent of the nation's food and 26 percent of GDP (Figure 2.1).[12]

Tanzania's overall economic growth has been stable with growth averaging 6.8 percent per year over the more recent period from 2005 to 2010[13] with the structure of the economy undergoing a gradual and steady transformation characterized by stronger growth in industry and construction and slower growth in the more traditional agricultural sectors (Figure 2.2). The gradual change masks a rebalancing of the economy with industry and construction recently coming to contribute the same to GDP as agriculture, fishing and forestry. This change is also accompanied by urbanisation with the urban population (23%) now generating 51 percent of national GDP. Communication services also allow new patterns of economic activity and growth in this sector has averaged close to 20 percent for the last 10 years.[14]

The principal exports are minerals, particularly gold, and agricultural commodities (Table 2.1).

Table 2.1 Major Exports from Tanzania (TShs. billions)

Commodity	2010	2011	2012
Gold	1,336.7	3,463.8	3,410.7
Tobacco	178.7	437.9	348.1
Coffee	162.3	225.7	292.8
Cashew nuts	173.2	189.6	222.0
Cotton	133.1	103.9	
Cloves	68.1	73.5	87.4
Diamonds	11.3	48.4	58.3
Sisal	11.1	17.0	41.0
TOTAL	2,088.7	4,559.8	4,460.3

Source: National Accounts of Tanzania Mainland.

As a result of this mix, Tanzania export earnings are particularly dependent on prices of products with a history of volatility. In 2011, the price of cloves increased by over 200 percent due to a failure in the Indonesian harvest. For 2011, the Economic Survey notes that:

"The value of traditional exports increased by 16.8 percent to US$668.7 million from US$572.3 million in 2010. This was due to the increase in the volume of goods exported particularly tobacco and coffee, as well as increase in the average price of coffee, cloves and cashew nuts in the world market."[14]

Although the overall value of goods and services exported increased by 17.1 percent in 2011, the value of goods and services imported increased by 33 percent, largely driven by increase in oil imports.[14] Long-standing government policy to achieve self-sufficiency in national food production mitigates the financial impacts of trade imbalances in agricultural commodities and is a reason for supporting improvements in agriculture.

2.2 Economic Performance and Water Availability

World Bank briefing notes recognize that "Overall, water-intensive sectors—including agriculture, industry and mining, and renewable natural resource-based activities such as forestry, tourism and fisheries—account for most of GDP."[15]

The specific structural factors underlying the dependency of Tanzania's economy on water are:

- The high proportion of agriculture using traditional methods which have a relatively high water demand compared to more modern methods using additional infrastructure;
- Agricultural practices which are vulnerable to climatic variation and surface water availability which can vary by a factor of several times year on year;
- Agricultural products are an important component of exports and so variability directly affects foreign currency earnings;
- Hydropower is a major contributor to national electricity production and is affected by seasonal factors such as drought as well as chronic problems such as upstream farming practices;
- The main industrial center in Dar es Salaam suffers from both water and power supply constraints; and
- Labor productivity is affected by unavailability of water and inefficiency in water supply.

Overall, the impact of water availability can be seen in macro-economic reporting and in micro-economic behaviors. At the macro level, drought leads to the need for imports of basic foodstuffs as well as oil for electricity generation to substitute for lost hydropower. It also leads to lower export earnings from agricultural exports. Both are likely to occur together with effects that are therefore more pronounced. Changes in balance of payments may also affect exchange rates and so returns in other sectors such as tourism. At the micro level, firms will need to manage unavailability of water and energy and families may need to plan for the requirement to carry water.

Evidence of the dependency of the economy on the availability of water is provided by in-depth research and ongoing statistical publications.

The first paragraphs in the most recent Economic Survey (2011) (produced biannually by the President's office of Tanzania) highlights the importance of water availability to the country and its direct impact on GDP:

"In 2011, real Gross Domestic Product (GDP) grew by 6.4 percent compared to 7.0 percent in 2010. The slowdown in growth was a result of drought in different parts of the country, which affected agricultural sector and power supply which eventually affected industrial production and other sectors that depends on electricity." [14]

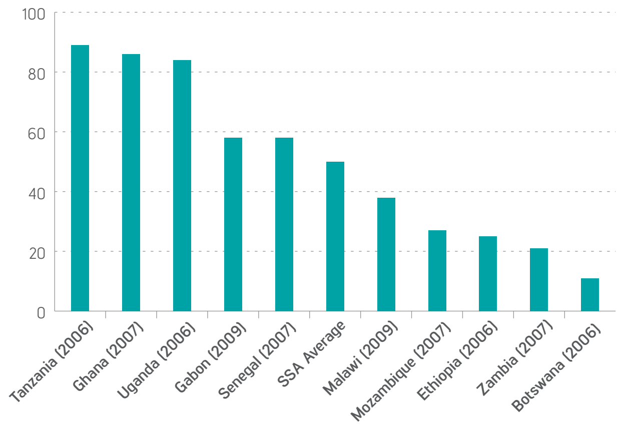
"The growth rate of crops sub activity decreased to 3.5 percent in 2011 from 4.4 percent in 2010 as a result of decrease in production caused by unfavourable weather." [14]

As well as drought, Tanzania is vulnerable to climatic variability in the form of extreme weather, due to the lack of investment in drainage systems:

"[In December 2011] Two consecutive days of heavy rains flooded Dar es Salaam, causing loss of life and assets." [12]

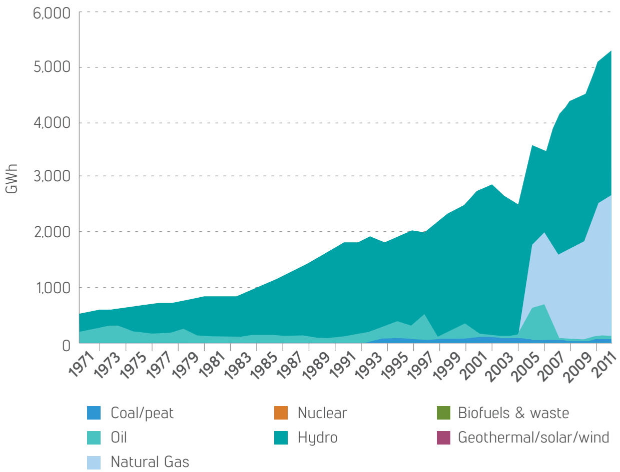
Energy is identified as a key constraint to growth in "The Tanzania Growth Diagnostic-Partnership for Growth (2011), a joint analysis for the Governments of the United Republic of Tanzania and the USA".[13]

Figure 2.3 Percentage of Firms Identifying Electricity as a Major Constraint



Source: Data taken from The Tanzania Growth Diagnostic—Partnership for Growth (2011).

Figure 2.4 Electricity Generation by Fuel as reported by IEA



Source: International Energy Agency, http://www.ea.org/statistics

Figure 2.5 Tourist Trade in the Ruaha National Park

Source: Ruaha National Park (RUNAPA).

Tanzanian firms are most likely of those in 11 competitor countries in Sub-Saharan Africa (Botswana, Ethiopia, Ghana, Gabon, Kenya, Malawi, Mozambique, Senegal, Uganda, and Zambia) to quote electricity availability as a major constraint (see Figure 2.3), as well as having the highest percentage of electricity (16%) obtained from private generators due to the paucity of on-grid supply.

The Tanzania Growth Diagnostic notes that:

> *"Regional droughts in 2003 and 2006 reduced electricity production at Tanzania's hydropower facility. While direct causality is difficult to prove, 2003 and 2006 were the only two years since 2000 in which GDP growth slowed from the previous year."*[13]

Hydropower was formerly the major source of electricity and still remains critically important compared to other fuel sources (see Figure 2.4). The overall energy generation in the figure also indicates the economic growth more generally and provides a broad indication of the corresponding degree of pressure on related resource requirements. Despite this pressing demand for electricity, recent evidence (from the Tanzania Economic Survey), notes that:

> *"The growth rate of electricity and gas sub activities decreased drastically to 1.5 percent in 2011 compared to 10.2 percent in 2010. The decrease was due to shortage of rain which led to decline in water levels in the main hydropower dams of Kihansi and Mtera; increase in human economic activities that are detrimental to the sources of water in the power generation dams;"*[14]

The requirement for energy has also led to the recent operation of dams below their design minimums which has further impacts such as limitations on using the dams for regulating river flows.

The impact on the new growing industrial sector in export markets was particularly pronounced:

> *"The value of exports of manufactured goods decreased from USD 964.0 million in 2010 to USD 861.5 million in 2011, equivalent to a decrease of 10.6 percent. The decrease was caused by the power rationing that led to low production of manufactured goods particularly paper products, plastic products and cotton fibres."*

The growth in other sectors that also require water is also pronounced. Figure 2.5 shows the growth in tourism in the Ruaha national park which is within the Rufiji basin (described in the case study below), where flows have been reducing due to human activities. Environmental impacts may result from reaching a tipping point, from which such unique habitats may never recover.

2.3 Economic Opportunities

The climate and geo-physical features of Tanzania provide a stock of natural resources which are sufficient to resolve many of these challenges if used appropriately. Furthermore, the economic value of the water resources has not been clearly delineated to date as in many cases they were abundant and taken for granted. A particular impact with relevance to all sectors is that, with no economic penalty for inefficient practices, there can be overuse of a natural resource such as water. Furthermore, as catchments are large, users can be widely separated and only manage water within a small locality, such as a village, leaving problems at the scale of the catchment unresolved.

The current patterns of water use show negative impacts which are seen quantitatively at the sectoral level and in macroeconomic statistics. However, in many future planning contexts the mindset and history of water use has led to assumptions of continued availability. In addition, planning within sectors has been conducted independently by relying on high level assumptions, such as that hydropower is only a non-consumptive use, when in fact details, such as seasonal irrigation water release schedules, may be important for users in other sectors.

The degree of economic opportunity has been assessed in a number of government plans. In particular, for agriculture the Agriculture Sector Development Programme (ASDP)[16] and the National Irrigation Master Plan (NIMP).[17] The BRN and SAGCOT initiatives are the most recent planning documents.

Concerns with the overlap between these plans have been recently raised with the recognition that individual sectoral objectives may be constrained by water availability and that overlap between plans also needs to be considered. The solutions fall into two complementary categories, investment in facilities to increase water availability, and in development of plans which are responsive to the available resource and to the requirements of other sectors.

The economic activity related to agriculture has an inherent potential to support a money-based system which includes transactions which complement existing work on smallholdings (for example by providing decision support via outreach workers) and thereby generate financial flows which more easily support infrastructure development such as improved water management facilities. The development of more efficient agriculture provides the potential for increased private sector earnings at all scales from existing large commercial farms to cooperatives and smallholders based on the vision embodied in incentives such as SAGCOT.

Tanzania cultivates some 5.1 million hectares annually, of which 85 percent is under food crops, however less than 10 percent of this is irrigated.[14, 18] The NIMP plans for irrigation developed in 2002 are extensive and based on a technical rather than social assessment, and provide an upper limit of 2.3 million hectares of high potential land for irrigation.

The Economic Survey notes a 14.8 percent increase in irrigated land from 365,744 hectares in 2010 to 419,744 hectares in 2011. Furthermore the number of households benefiting from improved irrigation infrastructures increased to 440,892 from 351,720 households in 2010, equivalent to 25.4 percent increase.[14] However, these increases are relatively small compared to the potential and may have proceeded based on local knowledge rather than integrated water resource assessments.

There is substantial potential for energy development for both hydropower and from gas reserves as identified in the Growth Diagnostic:

> *"The country has estimated hydropower potential of 4,700 MW compared to a current installed capacity of 561 MW. Tanzania also has 4,636 billion cubic feet of proven natural gas reserves, which represents 24 years of reserves at current levels of production (more than 100 years if probable reserves are included)."*[13]

As a result, Tanzania has the potential to be a substantial power exporter to the East African Community in the long term.

Economic growth in industry and construction is currently constrained by both energy and water shortages with the former highlighted in most macro-economic analyses. From a national perspective, resolving water issues including maximizing sustainable use of hydropower would benefit industry's requirements for both energy and water. Without them, the evidence is that the industry and construction sectors, which currently has the greatest growth of the major sectors, will be the most constrained.

CHAPTER 3. Water Resources Overview

In this chapter the current and future (2012–2035) water resource availability and demand are quantified respectively using data that has been taken from existing published sources. No primary data generation has been undertaken. A comparison of the water demand with water availability is then made using the data gathered.

3.1 Overview

Tanzania has numerous and diverse water resources in the form of rivers, lakes, wetlands and aquifers. The country is divided into nine river basins which are the Pangani, Wami-Ruvu, Rufiji, Ruvuma, Lake Nyasa, Internal Drainage, Lakes Rukwa, Lake Tanganyika and Lake Victoria. The country shares eleven international lakes and rivers with other nations including the three East African Great Lakes of Victoria, Tanganyika and Nyasa.

There is considerable variability and complexity in hydrological conditions across the country and within each of the basins. Each has unique characteristics with varying climate, typography, soils and land cover. The seasonal pattern of rainfall across the country depends mainly on the migration of the Inter-Tropical Convergence Zone. There are two distinct seasonal wet periods in the north and east of the country—the "short" rains in October to December and the "long" rains in March to May—while in the southern, western and central parts of the country there is one wet season from October through to April or May. These seasonal rainfall patterns result in considerable variability of runoff throughout the year. There are both perennial and ephemeral rivers and streams with internal drainage systems. Surface waters flow into lakes, to the sea and in some basins exhibit extensive endorheic conditions where major losses of water occur through evaporation.

Despite its numerous water bodies, Tanzania faces water shortages in many areas: the distribution of water availability and population is uneven across the country and presents considerable water resource management challenges. The general trend is that river flows and lake levels are declining. This is reported to be caused by a range of both natural and manmade factors such as declining rainfalls, unsustainable water uses such as operational rules at hydropower plants, over abstraction of rivers and unsustainable agricultural expansion.

Aquastat[19] reports that Tanzania has an average volume of renewable water resources of 2,290m^3 per capita per year which is classified as "non water scarce" according to the Falkenmark Water Stress Indicator (FWSI).

3.2 Water Resource Management Policy Framework

The Tanzanian government has developed an institutional and policy framework for water resource management. The National Water Policy (NAWAPO)[20] forms the basis of water sector policy and provides a comprehensive framework for the sustainable development and management of the nation's water resources and highlights that this management should be participatory, multi-sectoral, inter-disciplinary and be based on lake and river basins.

Based on this policy, the Ministry of Water is implementing the National Water Sector Development Strategy (NWSDS)[21] and launched the Water Sector Development Programme (WSDP)[22] in order to realize this strategy and policy with the main focus on strengthening sector institutions for integrated water resource management and improving access to water supply and sanitation services to meet the Millennium Development Goals and targets of the National Strategy for Growth and Poverty.

The Water Resources Management Act (2009)[23] provided the institutional and legal framework for the management and development of water resources, and finally passed into law the principles of the NAWAPO.

The overall objectives of the Water Resource Management and Development (WRMD) of the WSDP are to:

- Develop a sound WRMD framework for all nine water basins for optimizing the utilization of the water resources in a sustainable manner for various competing uses;
- Promote good governance of water resources through empowering water users, encouraging participatory and transparent decision-making, devolving ownership to user level, and granting secure water rights with responsibilities to water users, community groups, local government and Basin Boards; and
- Strengthen the capacity of basin offices to address trans-boundary and lake basin issues.

The development and implementation of the Integrated Water Resource Management and Development Plans (IWRMDPs) are a key component of these objectives.

3.2.1 Integrated Water Resource Management and Development Plans

The development of the Integrated Water Resource Management and Development Plans (IWRMDPs) for each of the nine basins is a crucial step which draws together qualitative and quantitative evidence on the basin characteristics, an assessment of the current water resources in each basin, and current water use and demand. The IWRMDPs also have the goal of assessing the implications of climate change for future water resource availability and take into consideration the future social and economic scenarios driving changes in water demand. Future water availability and demand can then be assessed, different interventions evaluated and plans for priority actions made.

Data and information from reports associated with the development of the IWRMDPs were an extremely valuable source of inputs to the analysis undertaken as part of this assignment. A number of consultants are responsible for compiling each of the IWRMDPs, and each are at different stages of development and follow different formats and approach while following the same generic framework.

As a result, different levels of detail are available within each of the IWRMDPs reflecting the consultants' approach as well as existing levels of data for each basin.

Hydrological Monitoring Data

Robust records of historical weather and stream flow are essential for hydrological assessments and project planning and development. Several of the consultants involved with developing the IWRMDPs reported that there are gaps in historical datasets, and that there are many gauging stations which are not operational (due to breakdown of equipment, vandalism and poor maintenance). Where data collection systems are operating, the frequency of data collection is often impacted by available resources, thereby reducing the quality of data. Rehabilitation of programs for water resource monitoring systems is critical. IWRMDPs state that this is a key area for future development and often provide plans for this, but clearly such improvements need to be adequately funded and be consistent across all basins in Tanzania.

3.3 Current and Future Water Resource Availability

Current Water Availability

Surface waters are the major source of water across Tanzania. There is considerable variation in the extent and robustness of hydrological records across the country: all Basin Water Boards have reported inadequacy in spatial and temporal cover and age of monitoring stations; the recording of hydrometric data ceased to be produced during years of recent economic hardship. Surface water availability figures for each basin have been compiled based on the long-term average river flows in each sub-basin. This has meant that the consultants developing the IWRMDPs have had to use simulated records derived from the output of calibrated rainfall—runoff models where robust long-term gauging records are not available. In many cases, the flow data has been "'naturalized", where the influence of artificial water abstractions have been removed.

Groundwater is an important source of water, supplying more than 25 percent of the domestic water consumption[17] and used for livestock, agriculture and sustaining the ecosystems of the country (e.g., when contributing to base flows in rivers). Groundwater development is mainly through shallow wells for domestic purposes over a wide part of country but mainly rural areas.[24] Groundwater is also commonly used within the urban fringes where there is no distribution network or where the network is unreliable. Nationally, groundwater has not been extensively used for irrigation.[24]

However, the hydrogeology of Tanzania has not been thoroughly studied and the levels of available data, understanding and resulting knowledge are not well developed[24] and vary between basins. The latest assessments made in the IWRMDPs use different recharge assumptions according to the judgements of the respective consultants but are a key step forward in the understanding of groundwater characteristics and development potential.

Two different estimates of potential groundwater availability data have been used in the assignment and the nomenclature used for their reference hereafter is: a "Higher Groundwater Estimate" (HGW) based on data from the IWRMDPs and a "Lower Groundwater Estimate" (LGW) based on data from JICA (2002).[17]

The HGW data used in this assessment are estimates of the total potential sustainable groundwater availability, where these are available. Different methods and assumptions have been adopted by each of the consultants developing the IWRMDPs to derive these estimates, which provides uncertainty of an aggregated national estimate. For example, in the Lake Tanganyika basin 50 percent of the annual recharge figure is used,[25] in the Lake Nyasa basin a figure of 10 percent of annual recharge is adopted[26] and in the Ruvuma and Southern Coast basin 40 percent is used.[27] In the Wami-Ruvu a more complex approach is used based on comparing a ceiling amount of the development potential and an abstraction amount that will not cause an adverse impact on social and environmental conditions.[28] In the remaining basins, estimates have been simply based on annual average recharge.

The LWG data is taken from JICA (2002)[17] estimates of groundwater recharge for each of nine basins. There is great variability in the recharge estimates across the country which is a function of the methods of used in their calculation.[24] The estimated annual basin recharge is 3,725 million cubic meters (MCM) and is a low and conservative estimate of groundwater development potential.

At a national level, two estimates of the annual renewable water resources have been made (Figure 3.1), based on HGW and LGW estimates and aggregated from basin level values and expressed in million cubic meters (MCM), and are 110,000 MCM and 94,000 MCM respectively. These estimates compare closely to the latest figures published by Aquastat[19] of 96,000 MCM. The split between surface and groundwater resources and by basin is highlighted for both LGW and HGW estimates. Tanzania's water resources are dominated by surface waters but in the HGW estimate, groundwater contributes 19 percent of the total resource. There is considerable variability of annual renewable water resource availability across the different basins. By area, the Lake Nyasa catchment has the highest water resource availability. The Rufiji basin has between 20–24 percent of the total national water resources and over 50 percent of the water resources are within the Rufiji, Ruvuma and Lake Victoria basins combined.

Climate Change and Future Water Availability

The impact of climate change on water resources is an important consideration for water management planning in terms of how it affects river flows, the occurrence of floods and droughts, impacts on groundwater recharge and water quality. Tanzania has already seen the impact of a changing climate. For example, the population has suffered from hunger due to the occurrence of floods and droughts coupled with poor harvests. The ice cap on Mt. Kilimanjaro indicates substantial evidence for increasing temperatures by global warming.[29]

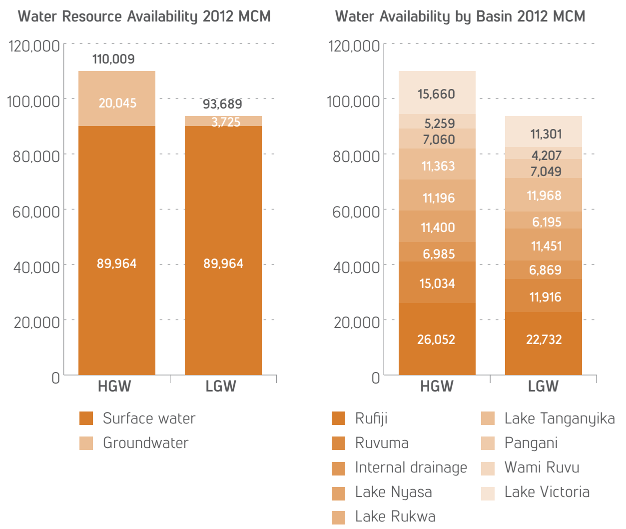
Through increased temperatures, changes in rainfall, extreme events and rising sea levels, human induced climate change is likely to have severe consequences for Tanzania. Average annual temperature is expected to rise by between 0.7°C and 1.5°C by the 2020s and between 1.8°C and 4.3°C by the 2080s, rates unprecedented in recent history. There is uncertainty about how rainfall patterns will be affected, though most models suggest that annual rainfall will increase with more intense rainfall during the wet season. Changes in the magnitude and frequency of extreme events—floods, droughts and storms—are also uncertain, though some models project increases in these events.

Occurrence of more extreme events poses a significant challenge for water planning and management processes. The severe water scarcity during drought periods has resulted in significant loss of productivity and led to an escalation of conflicts between competing water users. For example in the Great Ruaha sub-basin, serious water use conflicts arise during the dry season when excessive upstream irrigation withdrawals cause the river to dry up for several weeks, with critical environmental, ecological, and hydropower consequences. These conflicts are likely to get worse as climate change exacerbates the severity and frequency of future droughts and floods, which destroy property and human life and damage crops and rural infrastructure, along with general disruption of socio-economic activities.

Five out of the nine basins (Ruvuma, Internal Drainage, Lake Nyasa, Lake Tanganyika, Pangani) have quantified estimates of the impacts of climate change on surface water resource availability at the basin level within the IWRMDPs. The general approach used by the consultants was to take projections of climate variables generated by global circulation models (GCM) under different scenarios of greenhouse gas emissions over different time horizons. The climate projections were then used as inputs into pre-calibrated rainfall flow models to provide predictions of future runoff. For basins where no quantified projections of future annual renewable surface waters were available for 2015, 2025 and 2035, these have been interpolated based on the average overall changes predicted for the five basins where projections exist. Ground water availability estimates have been left constant over the 2015–2035 unless data was otherwise available. It should be noted that although the effects of climate change on annual renewable water resources have been predicted, there is a high degree of uncertainty with the values. Further details on climate change and water availability can be found in Appendix C.

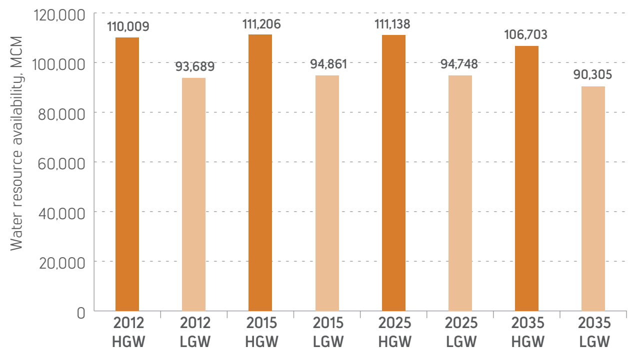
It has been estimated that annual renewable water resources will decrease slightly across Tanzania as a result of climate change as is shown in Figure 3.2 with total water resource availability decreasing to 106,703 MCM and 90,305 MCM respectively for HGW and LGW estimates respectively. However, these figures are limited as the impact of climate change on groundwater has not been fully assessed and reflected in the figures.

Figure 3.1 National Estimate of Annual Renewable Water Resources for 2012 shown by Basin and by Surface and Ground Waters, for High Groundwater Estimates (HGW) and Low Groundwater Estimates (LGW)



Source: Ministry of Water—Tanzania's Integrated Water Resources Management and Development Plans and JICA (2002).

Figure 3.2 Forecast of Changing Annual Renewable Water Resources as a Result of Climate Change from 2012–2035



Source: Ministry of Water—Tanzania's Integrated Water Resources Management and Development Plans and JICA (2002).

3.4 Overview of Current and Future Water Demand

This section presents an assessment of the current and future water use by the major sectors in Tanzania. The objective of the assessment is to provide a national and basin level overview of the current commitment of water resources, with a focus on the consumptive sectors, and then to provide estimates of future water demand within a planning window to 2035.

There is limited data on actual water abstractions for each of the major consuming sectors highlighted below. For example, the abstraction of surface waters for irrigation is not well regulated and where water permits do exist, the volume of water allowed to be abstracted is often not recorded and not followed. For this reason a bottom up approach has been taken by the consultants where the theoretical water demand has been estimated using the approaches and resulting data reported in each of the basin IWRMDPs.

Water is a fundamental natural resource for socio-economic development. The availability of usable water will continue to define where and to what extent future socio-economic development can occur. Water must be sufficiently available in each basin for the socio-economic activities in each basin to develop and therefore each basin cannot continue to develop if the demand exceeds availability. The sectors with the most significant water requirements in Tanzania are:

- Agriculture for irrigation of crops and for livestock use;
- Domestic use in urban and rural areas;
- Industry and commerce; and
- Environmental requirements.

A brief summary of each of these sectors is presented below.

3.4.1 Agriculture

Agriculture is the leading sector in the Tanzanian economy and contributes 26 percent of GDP annually and about 30 percent of the foreign exchange earnings. It is estimated that 75 percent of the population live and work in the agricultural sector, producing 97 percent of the food consumed within the country.[12] The agricultural sector also is the major source of raw materials for local and overseas industries.

The most dominant farming practice in Tanzania is small-scale subsistence farming with farmers largely depending on hoes as the main cultivating tool, although a small percentage use tractors and draft animals. While livestock farming plays an important role (contributing 30 percent of the agricultural GDP), arable faming is the most prevalent, Since rain-fed practices dominate, with high variability in seasonal rainfall, the crop yields are invariably low. There is also a greater susceptibility to the effects of climate change, which necessitates a means of increasing sustainable prodcutivity. The main food crops are maize, cassava, sweet potatoes, legumes, bananas, sorghum and rice. Key crop exports are cotton, coffee and tobacco each with a value of $100 million.[30] The area of paddy rice production has increased from less than 0.4 million hectares (ha) to more than 0.5 million ha within the past few years. The importance of rice in the national diet is also increasing in urban areas.

Increasing agricultural productivity will improve food security, contribute to reducing poverty and increase GDP through exports. Irrigation provides an effective way of helping to increase productivity and the Tanzanian Government has placed great importance on improving existing irrigation infrastructure and practices (National Irrigation Development Plan (NIDP); URT, 1994) and increasing the overall irrigated area.

Of Tanzania's 94.5 million ha of land, 44 million ha are classified as suitable for agriculture but only 5.2 million ha are being culitivated.[19] There is, therefore, significant agricultural development potential.

The new initiative of SAGCOT, covering approximately one-third of mainland Tanzania, is designed as an agricultural partnership. SAGCOT's aim is to improve agricultural productivity, food security and livelihoods in Tanzania and has an objective of adding an additional 350,000 ha of commercial farming to the existing 110,000 ha[31] over a 20 year period. This initiative is helping to highlight the importance of water security for the nation's development.

3.4.2 Irrigation

Irrigation practices in Tanzania have occurred for several thousand years, originating in the north of the country at the foot of the Rift Valley Escarpment.[32] Irrigated agriculture in Tanzania is mostly undertaken by smallholder farmers whose overall crop productivity and irrigation efficiency is low.[33] The existing irrigation infrastructure across the country is generally poor with inappropriate methods used which result in very low levels of water use efficiency with an average of 15-20 percent due to losses during distribution, conveyance, and in the field amounting to 80-85 percent.[34] In most basins, because of lack of storage, most irrigation occurs in the long rainy season when water can be diverted from the rivers. Cultivation drops to a small fraction during the dry season which limits the number of potential crops grown per year.

The Tanzanian Government has a policy to increase irrigation to enhance agricultural output. The NIMP[17] identifies 29.4 million ha as suitable for irrigation out of the 44 million ha suitable for agriculture: 2.3 million ha are classified as high potential; 4.8 million ha as medium potential; and 22.3 million ha as low potential.

It is estimated that the current area under irrigation is 381,000 ha,[35] of which 80 percent is using traditional irrigation schemes with low water efficiencies and the remaining 20 percent is under private or public ownership and has enhanced levels of efficiency.

Overall, the current levels of irrigation development in the country are still very low at just over 1 percent of the potential land area. This marginal use of the available potential for irrigation development is due to a variety of reasons including inadequate financial capital and human resources. This is in spite of the priority that the Government has placed on development in this area.

The National Irrigation Policy (2010)[36] highlights the main type of irrigation systems in operation, which are summarized in Appendix D.

Irrigation Water Demand

Estimates of the current and future irrigation water demand for each of the nine basins were obtained from the IWRBMPs. The exact method used for calculating current and future irrigation demands in each of the nine basins varied, but the following framework provides a general indication:

- **Cropped area under irrigation:** Actual and planned areas of irrigation were typically obtained from the NIMP[17] and from Zonal Irrigation units and projections of irrigation area estimated from this by each of the consultants.
- **Cropping pattern:** Estimated percentage areas for irrigable areas under different crops for each sub-basin were obtained from either the 2002 National Irrigation Master Plan[17] or from Zonal Irrigation units.
- **Scheme efficiency:** Different values for scheme efficiencies were used depending upon the typical irrigation schemes in operation within the basins and sub-basins and any projections for improvements.
- **Crop water requirements:** These were generally estimated using the FAO CROPWAT[37] model which adopts the Penmen Montieth equation for calculating crop evapotransipration. Gross irrigation requirement for each crop was then calculated by dividing the crop water requirement by the scheme efficiency.

3.4.3 Livestock

The raising of livestock is an important livelihood in Tanzania and is therefore an important activity of the agricultural sector, and nationwide contributes about 4.1 percent of the national GDP. Livestock are important for both crop production as draft animals and as a source of manure. In addition, meat production is an important industry and most meat consumed in the country is locally produced. The key livestock species used for meat production are cattle, goat, sheep, pigs and poultry and 90 percent of the animals are indigenous. Land use conflicts are common between farmers and pastoralists as has been witnessed recently in November 2013 in the Morogoro district.

Livestock Water Demand

Estimates of the current and future livestock water demand for each of the nine basins were obtained from the IWRBMPs. Livestock population figures at the sub-basin level were calculated from a variety of sources including the national census of livestock (2007/2008), statistics provided by the Ministry of Livestock and Fisheries, from the Districts directly or from field visits. Standard livestock water consumption rates were obtained from a variety of sources including from the Ministry Design Manual[38] and IUCN (2009). Different projections of livestock populations were used including the official growth calculated from the 2007/2008 survey.

3.4.4 Domestic

Despite recent investments, the public water supply and sanitation coverage across Tanzania is varied within and across basins but is generally low and remains well behind the targets committed to by the Tanzanian Government within the National Strategy for Growth and Reduction of Poverty (MKUKUTA).[39]

Across the country, the rapid growth in urban areas is placing a higher demand on the existing and often insufficient networked supplies and systems. Dar es Salaam is one of the fastest growing cities in Africa and the population is expected to double by 2030 to 7.5 million.[28]

In the Rufiji, rural coverage is about 55 percent and urban coverage 41 percent (compared to 2010 national target of 90%).[31] In the Rukwa basin, average coverage is 45 percent and 50 percent in rural and urban areas[40] and in the Lake Nyasa basin, the average rural coverage is 52 percent and urban coverage ranges from 56 percent to 92 percent.[41] These figures are well behind the 2010 national target of 65 percent and 90 percent for rural and urban areas respectively and even more significantly behind the 2015 targets of 79 percent and 95 percent.

These low figures are a result of the investment in new water supply infrastructure and sanitation systems not keeping pace with population growth and distribution, as well as inadequate maintenance of existing infrastructure. In addition, the varied performances achieved reflect the technical difficulties of maintaining infrastructure and the different levels of investment made across the country over previous years.

The poor water supply situation is further exacerbated because of high levels of non-revenue water (NRW): that which is delivered into the supply network and lost through leakage or illegal connections. NRW levels in urban areas are generally high across Tanzania with an average at 37 percent in 2012/2013 and in Dar es Salaam 49 percent.[42]

Domestic Water Demand

The approach for calculating domestic water demand in rural and urban areas follows a consistent framework in each of the IWRMDP documents. The two main parameters used to estimate domestic water demand are population served and per capita consumption.

Population statistics and growth rates for both urban and rural areas for each sub-basin are available from the population census which is conducted every 10 years (last undertaken in 2002) by the National Bureau of Statistics (NBS). The NBS also provide projections of population growth for all rural and urban areas.

The Design Manual for Water Supply and Waste Water Disposal provides guidance on estimates to use for per capita consumption. The basic value is 25 litres per person per day if water is drawn from a public kiosk in rural and urban areas. For urban areas, the per capita consumption value varies depending on the service level. For example: 70 litres per capita per day is used if there is a water connection in the backyard; and between 120-150 litres per capita per day if there is supply into the house.

Most of the IWRMDPs used different per capita rates as described above but the Rufiji,[31] for example, used 25 litres per capita consumption per day for both urban and rural areas. Water losses, as a result of NRW, were incorporated into the domestic water use calculations in most IWRMDPs but in a number of cases expressed within scenario analysis. Institutional water demand (public, private, or religious institutions, schools, health centers, office blocks) estimates have been included as part of the domestic figures.

3.4.5 Industry

The industry sector includes manufacturing, mining, quarrying, and construction subsectors. Industrial activities in Tanzania are steadily supporting the economic growth of the country and the construction and industry sector now contributes approximately 25 percent of GDP, contributing nearly as much as the agricultural sector. Many industries rely on water for use either as a key input (e.g., food and drink, construction) or within processing (e.g., mining) and as such, the future availability of water resources can present a key limitation and challenge for continued industrial growth. Some "dry" industries only use water for drinking and sanitation purposes for its staff. In addition, industry can place a high impact on the water environment though discharge of effluent back into watercourses.

Across Tanzania, industry is mainly focused in and around Dar es Salaam (Wami-Ruvu) and a small number of other urban centers e.g., Arusha, Kilimanjaro (Pangani), Mwanza and Kagera (Lake Victoria), Singida (Internal Drainage) and Iringa (Rufiji), Morogoro (Wami-Ruvu), and Mbeya (Lake Rukwa).

Most industries have developed their own water sources, so the quantity of water abstracted and volumes discharged into receiving water bodies is not known and not readily disclosed. Where water permits have been issued (e.g., in the Pangani) tariffs paid are not necessarily in line with their usage[43] since they may not actually record abstraction amounts. It is argued that one reason industries do not connect to the water supply networks is that the volumes required are considerably higher than the limited capacities of the networks.

Industrial Water Demand

Lack of recorded data can make estimating the water demand for industry problematic. The approaches taken in the IWRMDPs are three-fold. Firstly, water use has been estimated as a function of productivity, applying a unit rate per amount per production; secondly, by permit; and thirdly as a percentage of domestic supply or use per capita.

In the Wami-Ruvu,[44] industrial water use is estimated based on the production rates of mining activities and manufacturing industries and for commerce based on a percentage of the domestic consumption. In the Pangani basin, water consumption requirements for the industrial sector were estimated to be 10 percent based on the net domestic demand in 2012 and 13 percent in 2015, 2025 and 2035.[43] Lake Nyasa took a similar approach. The consultants of the IWRMDPs used future projections of water use based on industrial growth figures which have been adopted here.

3.4.6 Environmental Flows

Environmental flows can be defined as the amount of water required in a watercourse to maintain healthy ecosystems. The term environmental flow (EF) is usually applied in the context of regulated rivers where the system has been dammed to mitigate downstream floods and to optimize use of water for domestic purposes, economic activities such as irrigation agriculture, and hydropower generation. The establishment of an EF is critical to ensure that the environmental services historically provided by the river are directly maintained by flow or indirectly via ecosystem functions. Services might include flushing of sediments, salinity control, fish production via provision of aquatic habitat and supply of nutrients, and floodplain soils for food production and soil moisture for crops (Hirji and Davis, 2009).[45]

Recognizing the importance to river health and function, Tanzania has adopted the principle of environmental flows in its National Water Policy (2002).[20] However, quantifying how much water can be abstracted without damaging fisheries and other ecological systems is in reality a major and costly challenge (EF assessment of the Pangani basin cost about US$500,000 (Dickens, 2011)[46]). Another challenge is that available methods for developing environmental flows are often inconsistent with one another, and therefore results may not be comparable across species or across basins. Currently, few methods are built around a holistic approach that enables environmental flows to be developed for an entire system, or even for several species within a system. Most typically, case-specific (single species and single issue) predictive wildlife models are used, based on a relationship between species habitat and flow discharge which is used to develop a suitability index curve describing the habitat upon which the species of interest is dependent.

A risk with this approach is that species-specific environmental flows may then be used more broadly without consideration for other species or ecosystem components, and thus fail to capture system processes and biological community interactions that are important for creating and sustaining the habitat and well-being of the system overall. More holistic methodologies include frameworks that incorporate hydrologic, hydraulic and habitat simulation models. Interactive EF assessments may also be used to establish the relationship between river flow and one or more attributes of the river-system. This relationship may then be used to describe environmental/ecosystem implications (and resulting social/economic implications) of various flow scenarios. Interactive methodologies thus facilitate the exploration of tradeoffs of several water allocation options.

To date a variety of EF methods have been applied in Tanzania. For example, the Great Ruaha River Environmental Flow Assessment (GRR-EFA) used the holistic Building Block Methodology (BBM) to develop an assessment of river and wetland environmental flows necessary to maintain the ecological ecosystems of Ruaha National Park, with a view to reinstatement of dry season flow (which ceased in 1993) (URT, 2012).[47] The BBM method was selected for its flexibility and robustness, especially where data is limited and where the specialist team is relatively inexperienced (Dickens, 2011).[46] Recommended flows for each component of the study were obtained through a combination of desk and field studies, as well as a series of consultative workshops involving basin stakeholders. The EFA was implemented with a river field study at two sites in the Ruaha National Park in 2008. Given the situation then of zero Great Ruaha River inflows into Ihefu wetland in the dry season, the assessment determined a requirement for $7m^3/s$ to come from the Ndembera River (URT, 2009).[48] Such a dependable flow could only be realized through construction of a reservoir, a result that highlights the importance of planning based on environmental flows, and the need to conduct the environmental flow analysis rigorously so that major planning decisions can be made with the best possible information.

Various initiatives are attempting to improve the quality of environmental flow information in Tanzania. For example, the Wami River Environmental Flows Initiative (part of the larger Tanzania Water and Development Alliance (WADA) program, financed by The Coca-Cola Company and the U.S. Agency for International Development (USAID)) has provided the Wami-Ruvu Basin Water Office with information and tools necessary for managing the flow of the Wami River. In a multi-step process, an interdisciplinary team of experts analyzed historical flow records and examined the importance of natural flow variability to the ecology and geomorphology of the Wami River sub-basin, as well as quantifying the dependence of riparian human communities on aquatic ecosystems. In 2011, an important report critically reviewed work done in the previous decade to assess and implement environmental flows in four Tanzanian basins, the Pangani, Great Ruaha, Wami and Mara (shared with Kenya) (Dickens, 2011[46]). The report provides many examples of lessons learned from these EF assessments, highlights possible criteria for more synchronized EF assessments in Tanzania, and discusses how to operationalize EF assessments to achieve sustainable management of flows.

Our analysis of current and future water demand in Tanzania (below) highlights the importance and role of EF assessment for effective water resources management planning. Currently just a handful of basins in Tanzania have developed quantitative estimates of EF requirements, and each of these have used different methodologies, making them difficult to compare reliably. With further study and a more accurate assessment of local stream flow needs, it may be possible to reduce these large environmental flow requirements while still maintaining stream health. More widespread EF studies will also facilitate assessment of how other sector impacts (such as excessive upstream water abstraction for irrigation), or flow variability as a result of climate change, can affect fisheries productivity or ecosystem health in critical sections of river systems (wetlands, reservoirs, and delta).

Current and Future Water Demand

Current and future water demand data for each of the sectors described in the previous section was synthesized from the IWRMDP reports for each of the nine basins. A summary by sector for 2012, and for the projected years of 2015, 2025 and 2035 is shown in Figure 3.3 and a breakdown by basin in Figure 3.4. In 2012, the estimate of total demand across Tanzania is 37,000 MCM rising to 45,000 MCM in 2035.

In 2012 the highest demand for water is for environmental flow, irrigation, domestic, livestock and industrial purposes respectively, but it is clear that environmental flows dominate water requirements. By 2035 the projected growth by industry sees this sector overtake livestock water use requirements.

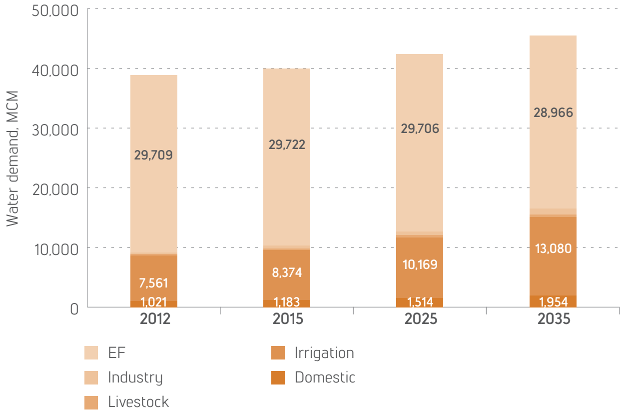
Excluding environmental flows the total demand in 2012 is 9,175 MCM with irrigation consuming the largest share with 7,561 MCM (82%), while the domestic sector uses 1,021 MCM (11.1%), the livestock sector 261 MCM (2.8%), and industry 322 MCM (3.6%). These compare to the latest figures published by Aquastat[19] for 2002 which give a total water withdrawal of 5,142 MCM and broken down for irrigation, domestic, livestock, and industry use as 4,417 MCM (85.3%), 493 MCM (10.2%), 207 MCM (4.0%) and 25 MCM (0.5%) respectively.

Environmental flows place the greatest demand for water in each basin ranging from 43–96 percent of total demand. Only three of the basins provided quantitative estimates of EF requirements and each of these used different methodologies. For the remaining basins, environmental flows have been estimated.

Depending on the estimation method used and the projection of available surface water, EF requirements range from 12–74 percent of available surface water with the overall average requirement for all of Tanzania at 33 percent of available surface water. With further study and a more accurate assessment of local stream flow needs, it may be possible to reduce these EF requirements while maintaining stream health.

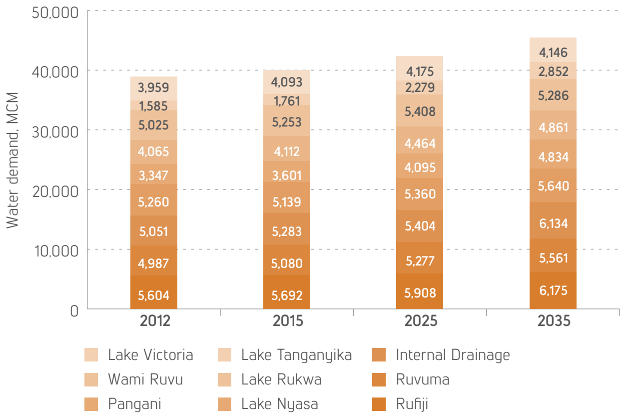
Approximately 75 percent of Tanzania's 40 million inhabitants are reliant on subsistence agriculture and over 80 percent of irrigated land is farmed using traditional water use practices with efficiency as low as 15 percent (compared to modern efficiencies of

Figure 3.3 Current and Future Projections of Water Demand by Key Water Consuming Sectors



Source: Ministry of Water—Tanzania's Integrated Water Resources Management and Development Plans.

Figure 3.4 Current and Future Projections of Water Demand by Basin



Source: Ministry of Water—Tanzania's Integrated Water Resources Management and Development Plans.

over 90%). In 2012, irrigation accounts for 82 percent of the total national water demand excluding environmental flows. With the planned expansion of irrigated agriculture, water consumption by irrigation is due to double by 2035 but will decrease to 80 percent of the national demand. The highest irrigation demand is found in the Pangani, Lake Rukwa and Rufiji basins but in proportion to area, the greatest demand is found in the Pangani. Irrigation demand in 2035 is set to increase by over 400 percent in Lake Tanganyika, Lake Nyasa, Ruvuma and the Internal Drainage basins from 2012 levels as a reflection of the government's policy to increase agricultural production.

The coverage of domestic water supply remains well below the national targets across the country. For example, in the Rufiji, rural coverage is about 55 percent (compared to a target of 65%) and urban coverage 41 percent (compared to 90%). Infrastructure networks are poorly maintained and vulnerable with high levels of leaks and illegal abstraction.

Tanzania's population is projected more than double by 2035 and increased domestic water use is set to rise by over 180 percent with particularly high growth projected in the Lake Tanganyika basin at over 350 percent. Rapid growth in urban areas is placing increasing demand on already insufficient supplies and inadequate sanitation systems leading to the abstraction of groundwater at unknown rates from unregulated boreholes.

At a national level, the water requirements from industry are set to increase by over 300 percent with specific growth focused within the Wami-Ruvu basin, where water consumption by industry is projected to increase by over 600 percent.

3.5 Comparison of Water Availability and Demand

An overview of annual renewable water resources and water demand for each of the nine basins was made in Sections 3.3 and 3.4 and in this section a comparative assessment is made. Firstly, in Section 3.5.1 a comparison is made using aggregated annual data for annual renewable water resources versus demand made at a national and basin level. Secondly, in Section 3.5.2, a comparison is made of estimates of accessible renewable water resources versus demand under two different Scenarios A and B. And lastly, in Section 3.5.3, for basins where data exists, a seasonal comparison is made.

3.5.1 Annual Comparison of Water Availability and Demand

The annual renewable water resources exceed the total water demand (including environmental flows) in 2012 and 2035 for each of the nine basins as shown in Table 3.1, where data for the low groundwater estimate (LGW) is used. Demand in the Pangani and Internal Drainage basins are both high at over 70 percent of the annual renewable water resources in 2012 increasing to over 80 percent and 90 percent respectively by 2035.

Table 3.1 Basin Comparison of Total Renewable Water Resources and Demand in 2012 and 2035 using LGW Estimate

Basin	Annual Renewable Water Resources MCM		Total Water Demand MCM		Demand as % of Availability	
	2012	2035	2012	2035	2012	2035
Rufiji	22,732	21,897	5,604	6,175	25%	28%
Ruvuma	11,916	12,116	4,987	5,561	42%	46%
Internal Drainage	6,869	6,572	5,051	6,134	74%	93%
Lake Nyasa	11,451	10,748	5,260	5,640	46%	52%
Lake Rukwa	6,195	5,982	3,347	4,834	54%	81%
Lake Tanganyika	11,968	11,638	4,065	4,861	34%	42%
Pangani	7,049	6,402	5,025	5,286	71%	83%
Wami Ruvu	4,207	4,057	1,585	2,852	38%	70%
Lake Victoria	11,301	10,894	3,959	4,146	35%	38%
TOTAL/AVERAGE	93,689	90,305	38,884	45,489	46%	59%

Source: Ministry of Water—Tanzania's Integrated Water Resources Management and Development Plans.

The annual renewable water resource estimates summarized in Section 3.3 and shown above in Table 3.1 are based on the total water resources that are potentially available but do not necessarily represent the water resources that are reliably accessible for use currently. For example, from the surface water perspective a large proportion of the annual total discharge is observed during the wet season. Without adequate capture and appropriately sited storage, this water is potentially lost without effective utilization.

3.5.2 Annual Comparison of Accessible Water Availability and Demand

Estimating the reliably accessible proportion of annual renewable water resources can be very difficult and prone to a high level of uncertainty without robust and representative flow records and groundwater yield data. Undertaking this analysis and detailed assessment for each of the basins is outside the scope of this project. However, for the purposes of this assignment we have taken information from the IWRMDP reports where it exists and used this to develop a number of scenario estimates of the accessible annual renewable water resource for each basin assuming no changes to basin storage or transfer of water are made.

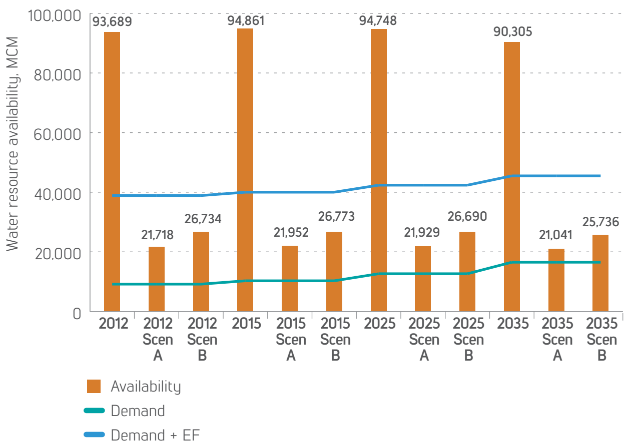
Scenario A

JICA (2013) reported that in the Wami-Ruvu, the 97 percentile flow in a drought year equates to 15-25 percent of the annual total discharge. This represents a precautionary estimate of the reliable surface water resources that can be used without water storage. Based on this analysis, in this scenario 20 percent of the annual average flow for each basin was added to the respective groundwater (HGW and LGW as above) figures to provide an estimate of the accessible annual renewable water resources. We acknowledge the high levels of uncertainty in this estimation process but this does provide an indicative value for comparative purposes.

Scenario B

As is discussed in further detail in the seasonal comparison section below, SMEC (2013) derived flow duration curves for each of the sub-basins in the Pangani and Lake Nyasa basin. In Scenario B, the 95 percentile flows from the flow duration curves were applied for the Pangani and Lake Nyasa basin to

Figure 3.5 National Estimates of Annual Renewable Water Resources, Accessible Renewable Water Resources under Scenarios A and B and Water Demand using the LGW Estimate



Source: Ministry of Water—Tanzania's Integrated Water Resources Management and Development Plans and AMEC.

Figure 3.6 Basins where Demand + Environmental Flows Exceeds Annual Accessible Renewable Water Resources under Scenarios A and B, using High Groundwater (HGW) and Low Groundwater (LGW) Estimates

	2012 Scenario A	2012 Scenario B	2035 Scenario A	2035 Scenario B
Low Groundwater	Ruvuma Internal Drainage Lake Nyasa Lake Rukwa Lake Tanganyika Pangani Wami Ruvu Lake Victoria Rufiji	Ruvuma Internal Drainage Lake Rukwa Lake Tanganyika Pangani Wami Ruvu Lake Victoria Rufiji	Ruvuma Internal Drainage Lake Nyasa Lake Rukwa Lake Tanganyika Pangani Wami Ruvu Lake Victoria Rufiji	Ruvuma Internal Drainage Lake Rukwa Lake Tanganyika Pangani Wami Ruvu Lake Victoria Rufiji
High Groundwater	Internal Drainage Lake Nyasa Lake Tanganyika Pangani	Internal Drainage Lake Tanganyika Pangani	Internal Drainage Lake Nyasa Lake Tanganyika Pangani Wami Ruvu	Internal Drainage Lake Tanganyika Pangani Wami Ruvu

Source: Ministry of Water—Tanzania's Integrated Water Resources Management and Development Plans and AMEC.

provide accessible surface water flow estimates and added to the groundwater figures. For the remaining seven basins, the same approach as Scenario A was used.

Using the LGW estimate, taking into account the necessary environmental flow requirements to maintain natural river ecosystems, at a national level in dry periods Tanzania is using water unsustainably with current demand 179 percent and 145 percent of the accessible water in Scenarios A and B respectively (see Figure 3.5). There is not sufficient water to maintain environmental flows and other demand requirements in periods of low flows. Under business as usual and factoring in economic growth projections, this increases to 216 percent and 177 percent by 2035 due to population growth in Tanzania which is expected to double, and to meet national agricultural targets for irrigation.

Using the HGW estimate, at a national level at dry periods there is enough accessible water to meet the demands in 2012 under both Scenario A and Scenario B. However, by 2035 demand outstrips supply in both Scenarios.

At a basin level the picture is slightly different. All nine basins have a demand that exceeds the accessible annual renewable water resource in dry periods in Scenario A in both 2012 and 2035 using the low groundwater estimate and under Scenario B this decreases to eight (Figure 3.6). By 2035, using the high groundwater estimate, five and four basins out of the nine fail to meet the anticipated demand requirements under Scenario A and B respectively.

In the above analysis it was assumed that all potential groundwater is accessible which is not currently the case, so the reported gaps would in reality be greater. In addition, this could also change the position where demand is currently being met.

3.5.3 Seasonal Comparison of Water Availability and Demand

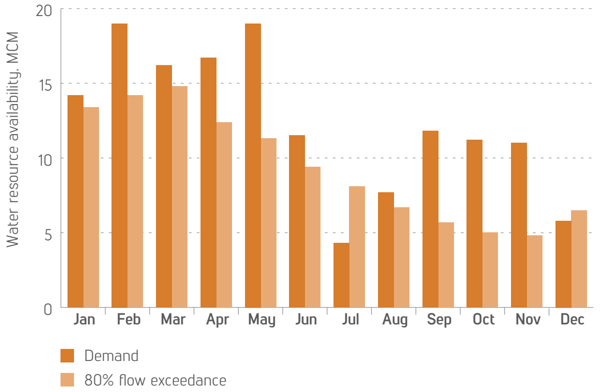
The important seasonal variation of water availability and demand is not revealed in the national estimates outlined above, which is particularly important given the low levels of storage infrastructure and other water resource management strategies (e.g. inter basin transfers, reuse of treated waste water) currently developed in the country.

In reports for three of the IWRMDPs (Pangani,[43] Lake Nyasa[41] and Wami-Ruvu[28]) an assessment of demand against surface water resource was made over a monthly basis. Within these assessments flow duration curves were quantified at a sub-basin level and for Lake Nyasa and the Pangani, monthly flow probabilities were calculated. This information was then used to derive different scenarios of accessible monthly surface water resources and compared against monthly demand to see where shortages exist.

A summary of the results of this analysis shows that:

- In the Wami-Ruvu, a water gap exists now and grows more exaggerated by 2035 within specific sub-basins when you look at the water balance based on monthly demand and the monthly average discharge in a drought year with a 10 year return period. Even when a measure of the environmental flow requirements is considered, a gap is observed in all but one sub-basin by 2035, assuming no storage; and
- In Lake Nyasa, shortages are observed now and expected to increase further in the Mchuchuma sub-basin by 2035 when the 80 percentile exceeded flows are compared against total demand including environmental flows (Figure 3.7). In the Mbaka sub-basin, shortages are expected in 2035. In the remaining sub-basins no deficit is expected.
- A very detailed water resource assessment was carried out in the Pangani basin, including the use of groundwater resources, which showed that a water gap exists now in one sub-basin and could exist in all sub-basins during the dry season. Based on monthly average flows and disregarding environmental flows, the Pangani River sub-basin shows a deficit by 2035 while the Zigi-Mkulumuzi, Umba and Msangazi show a surplus. However, when you take into account environmental flows and consider flow exceedance at different probabilities, each of the sub-basins may not provide the required seasonal runoff to meet the demand in the dry season, particularly by 2035. Overall, improved management of most rivers in the basin is required to meet dry season demands.

Figure 3.7 Total Demand (including environmental flows) compared to the 80 Percentile Flows in the Mchuchuma Sub-basin of Lake Nyasa taken from SMEC (2013)[41]



Source: Ministry of Water—Tanzania's Integrated Water Resources Management and Development Plans.

Water Storage

Tanzania has significant annual renewable water resources. However, the climate has high seasonal variability in rainfall and even higher variability in river flows. With relatively few dams and reservoirs, storage of water following high seasonal flows in the wet season is not possible. By building new storage infrastructure an increase in usable surface water could be achieved through the careful management and regulation of seasonal storage of water in the rainy season. New reservoirs would allow improved water availability in dry years, and water storage could be developed at a range of scales corresponding to the demands in a particular location. In many cases this storage could have a multi-purpose function for irrigation, flood protection and hydropower. Increasing storage infrastructure, as one of a series of measures, would provide an effective means to reduce water availability gaps.

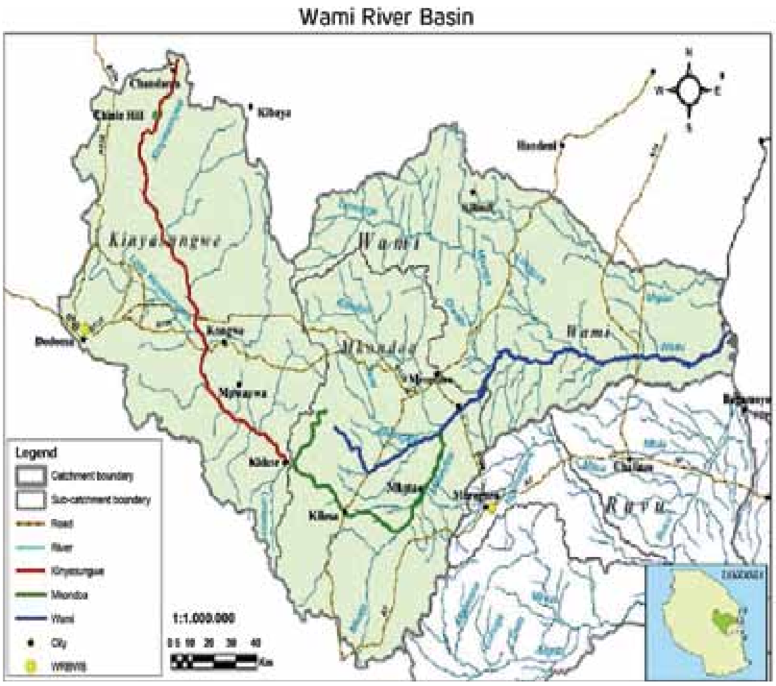
3.5.4 Summary of Water Availability and Demand

- Tanzania has a **significant level of annual average renewable water resources of 94,000 MCM per year** amounting to some 2,300 CM per capita; well above the Falkenmark indicator for "water sufficiency" of 1,700 CM per capita;
- **Environmental flow** (EF) needs for basins and sub-basins have received varying degrees of study and implementation but **on a national scale are estimated to be some 29,000 MCM per year;** and
- After taking into account EF needs, **the annual average water availability is 65,000 MCM** per year; while
- Blue **water demand is 9,900 MCM per year** and is forecast **to rise to some 17,200 MCM by 2035**; but
- **Water availability is highly variable in space** (Rufiji river basin has 24% and Wami Ruvu 4% of the annual average total); and
- **Water availability is highly variable in time** (Wami Ruvu Q97 is as low as 15% of annual average); leading to
- In some catchments in dry periods, demand takes *all* the flow of the watercourse, **leaving no environmental flow to maintain the river ecosystem**, and
- In **dry periods national demand is some 150 percent of accessible water** after taking into account EF needs;
- With particular concern in Wami-Ruvu, Lake Tanganyika, Pangani and Internal Drainage basins.

CHAPTER 4. Case Study: Wami-Ruvu Basin

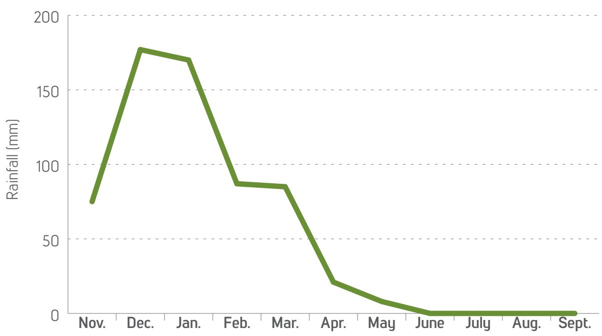
The Wami-Ruvu basin is centrally located within Tanzania, draining into the Indian Ocean. The Wami basin area is 43,742 km^2 and the river length is approximately 637 km while the shorter Ruvu has a basin area of 11,789 km^2 and river length of 316 km (Figure 4.1).

Figure 4.1 The Extent of the Wami-Ruvu Basins



Source: Figure taken from Ministry of Water—Wami Ruvu Integrated Water Resources Management and Development Plan.[28]

Figure 4.2 Monthly Average Rainfall for the Wami Sub-basin



Source: Figure taken from Ministry of Water—Wami Ruvu Integrated Water Resources Management and Development Plan.[28]

Tanzania's climate is consistent with its location within the Inter-tropical Convergence Zone (ITCZ) and the wind direction is predominantly easterly. In the Wami-Ruvu region, the rainfall is 1,100 mm at the coast and 600 mm inland, though the mountains receive over 2,500 mm. The dry season lasts from June to September and the middle of the rainy season is in December. For areas which are not inland, an additional rainy season occurs in April.

In the upper parts, the two sub-basins increasingly experience the same water stresses related to smallholder agriculture of the much studied Pangani basin to the north, which has a similar elevation and geography, while the much flatter lower sections are the main source of piped water for Dar es Salaam, the largest city in Tanzania.

The population in the basin is estimated to grow from the 7.28 million estimated in 2011 to 12.6 million by 2035 with an increase in the urban proportion from 55 percent to 59 percent over the period. As the majority of the urban population is in Dar es Salaam, the catchment can be thought of in simple terms as an upstream rural population and downstream urban population. Dar es Salaam also uses shallow groundwater sources in part due to the limited supplies of surface water.[49]

The Wami-Ruvu basin also illustrates the interactions between economic sectors as a result of their use of water within the same catchment. Upstream the impacts on water resources result from agriculture, much of it based on traditional methods, as well as from the use of wood as a fuel which leads to deforestation. Downstream, the industry and commercial activity of Dar es Salaam makes it the economically dominant region in the Wami-Ruvu basin, as well as in Tanzania.

Of the 21 regions in the country, the six located in the Wami-Ruvu basin contribute 34.7 percent to the national economy (2010) with Dar es Salaam alone responsible for 16.8 percent of national GDP (see Figure 4.3). Dar es Salaam also has the highest GDP per capita which without evidence to the contrary would also imply a higher per capita water consumption (Figure 4.4).

The Wami-Ruvu basin presents a contrast between well established traditional farming practices and more developed urban livelihoods based on industry and with their higher demand for water.

In common with the rest of Tanzania, agriculture upstream is the predominant activity in rural areas with irrigation practiced in elevated areas such as Kilosa and Movomero in the Morogoro region. Traditional irrigation is practiced in the Ruvu basin particularly in the Ulugulu highlands of the Mgeta area. There are also irrigation schemes, some no longer in operation, in the lowlands of the basin.

Substantial quantities of livestock (over 1 million head) are reared in the catchment and conflicts over water use between small holders and pastoralists have been recently recorded.[28]

The Ruvu sub-basin contains the majority of the industry which is located on the coastal plain. It includes the production of textiles, sisal, beverages, beer, cigarettes, and pharmaceutical products including soaps. These industries result in industrial effluents which cause significant pollution.[24] In the Wami sub-basin, the only industry is a salt production facility which has contributed to deforestation through use of wood fuel.[28]

The majority of industry is in Dar es Salaam which is a center for high growth industry with corresponding water demand. The table below (Table 4.1) shows current and expected water consumption for the main industrial sectors. Cement manufacture makes up almost half the industrial demand for water, reflecting the strong growth in construction activity. Vegetable oils and beer manufacture make up the next two.

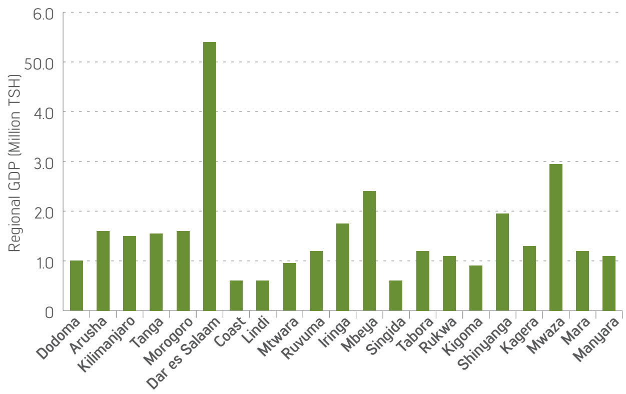
For the basin as a whole, irrigation accounts for the greatest proportionate use of water, 60 percent of the total in 2011. Although industry currently accounts for approximately 5 percent, projected growth takes this to 16 percent of the total by 2025.

Table 4.1 Main Industries in Wami-Ruvu Catchment and their Respective Water Demand

Commodity	Water intensity m³/tonne	2011 m³/year	2035 m³/year	Percent
Cement	3.8	18,124,000	133,000,000	37
Vegetable Oils	6.4	4,490,000	85,482,000	24
Beer	7.7	4,550,000	24,972,000	7
Knitted Fabrics	100	2,721,000	29,406,233	8
Other		14,266,00	82,310,000	23
TOTAL		44,151,000	355,170,233	100

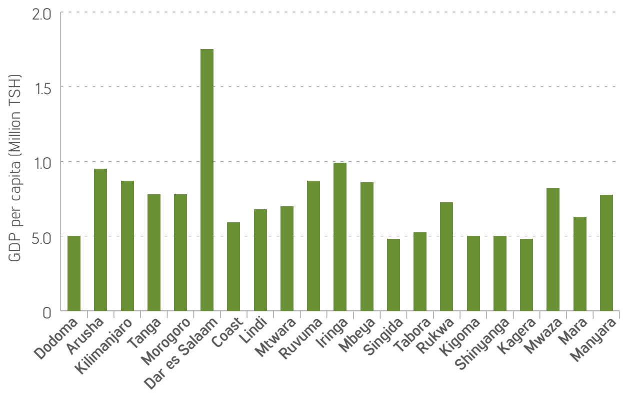
Source: Data taken from Ministry of Water—Wami Ruvu Integrated Water Resources Management and Development Plan.[28] [Note that the standardised water intensity figures used by the consultants help compare water use in different sectors, but are known to differ from individual companies' own estimates]

Figure 4.3 Regional Tanzania GDP showing the Importance of Dar es Salaam



Source: Figure taken from Ministry of Water—Wami Ruvu Integrated Water Resources Management and Development Plan.[28] referencing URT, National Accounts of Tanzanian Mainland (NBS), 2011.

Figure 4.4 Regional Tanzanian GDP per Capita (Tsh) showing the Importance of Dar es Salaam



Source: Figure taken from Ministry of Water—Wami Ruvu Integrated Water Resources Management and Development Plan.[28] referencing URT, National Accounts of Tanzanian Mainland (NBS), 2011.

4.1 Status of Water Management

Surface water availability varies markedly between years and also seasonally following the patterns of seasonal rainfall. While long-term hydrological records are far from complete within the basin, the annual flows show an overall declining trend.

Such year on year variation provide management challenges for water users. One method adopted by farmers is to extend farming to less favorable land in years when there is greater water availability and so obtain greater harvests. However, without storage facilities, water availability is limited to that naturally available in years of lower flow. In addition, water management measures to maximize the available water in both low and high flow years, such as increasing irrigation water use efficiency, or adopting alternative cultivation techniques such as the System of Rice Intensification (SRI), should be considered.

Current practices identified in the IWRMDP that affect surface water availability are as follows:

- Permitted abstraction already exceeds development potential of surface water in two sub-catchments;
- Sediment washed downstream impedes natural flood control function by wetlands and widens rivers also increasing losses from evaporation (likely to be higher in hotter years of low flow);
- Lack of data on permits issued, missing specifications (e.g., size of intakes) and unlicensed abstractions discredits abstraction management authorities and affects transparency of decision-making;
- Maintenance of river structures is not systematically conducted at present; and
- There is no enforcement of measures to address pollution from industrial effluents.

For groundwater, current practices identified in the IWRMDP that affect water availability are as follows:

- The permit system for groundwater is largely not applied, with results such as no consideration of extractable yield and no backfilling of unsuccessful or abandoned boreholes allowing potential pollution; and
- Low understanding of water permitting regime by users and potential users.

From an institutional perspective, 11 Water Users Associations (WUAs) specified in the Water Resources Management Act (2009)[23] have been formed in Wami-Ruvu basin, but are lacking the skills necessary to carry out their function of coordinating water use and facilitating conflict resolution between compteting users of water resources in the same river catchment. The intermediate organizations that link WUAs to the Basin Water Boards (BWB) do have not clear legal status or sources of funding specified in the Act.

In addition, data collection and management systems are not well established.

4.2 Current Plans for Water Supply

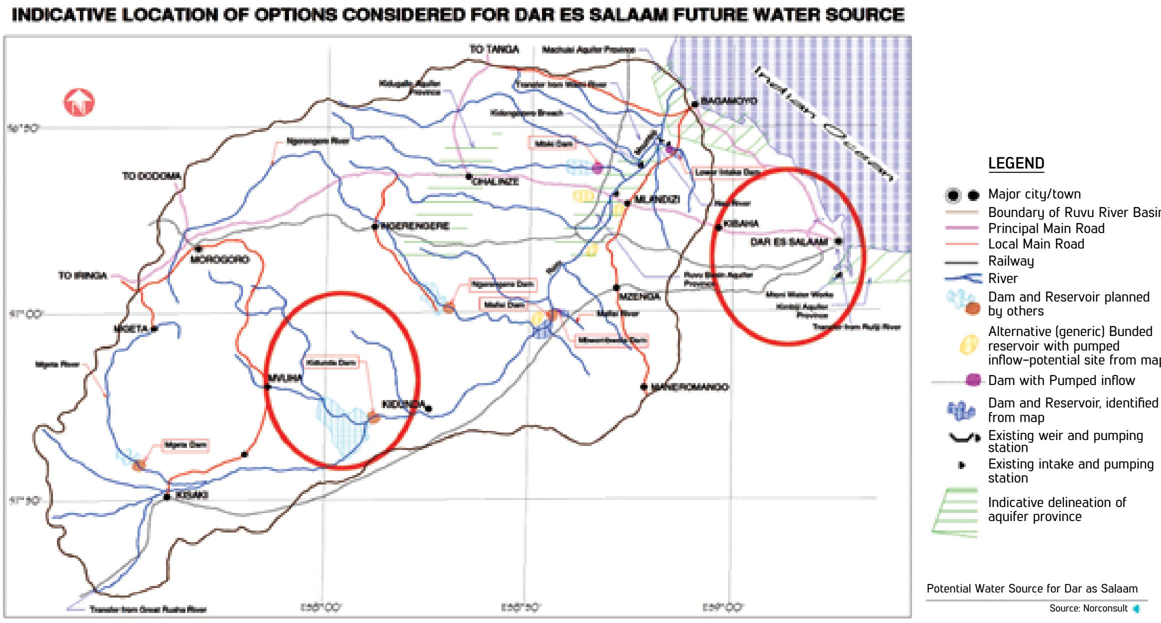
The strategic plan for water supply prepared by the Ministry of Water relies on development of the Kimbiji aquifer and Kindunda dam.

The Kindunda dam, in the middle of the basin, (ringed in the centre of Figure 4.5) will provide a regulating capacity storing 7 percent of annual flow. The Kimbiji is a deep aquifer to the South of Dar es Salaam (ringed on the right of Figure 4.5).

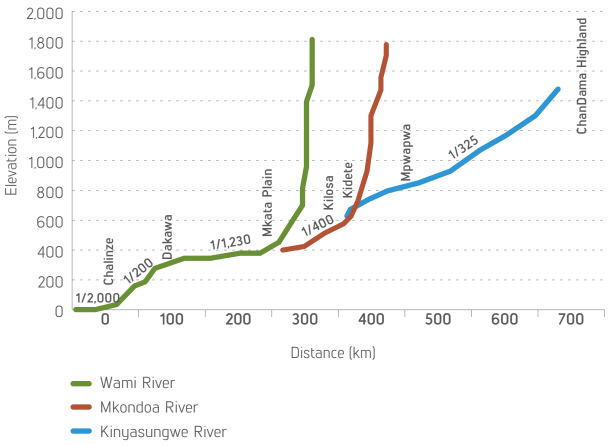
Future groundwater from the Kimbiji is a sustainable source in principle, however, there are technical challenges which include deep boreholes (up to 1,000 m), which may need lining and have higher pumping costs and unpredictable yields, and hence a high average cost per usable borehole. There is also an associated requirement for a new network to distribute the water, if it is to be part of a complete solution to the lack of mains water in Dar es Salaam.

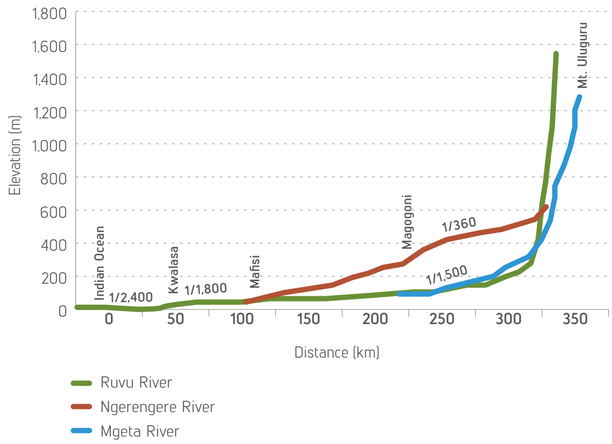
The value of the Kindunda dam, which will be impacted by the behavior of upstream users, is compromised by sediment

Figure 4.5 Key Components in Future Water Supply in the Wami-Ruvu Catchment



Source: Development of a Future Water Source for Dar es Salaam Water Source Development Master Plan, Dar es Salaam Water and Sewerage Authority (DAWASA), 2007[28]





Source: Figure taken from Ministry of Water—Wami Ruvu Integrated Water Resources Management and Development Plan [28]

transport. The two rivers are particularly prone to sedimentation impacts as they have steep mountain sections immediately upstream of the dam (see Figure 4.6). Without behavioral changes in agriculture and forestry practices, the dam will in effect become more costly as its volume decreases from sedimentation for the same capital expenditure. Existing dams in Tanzania have such problems.

4.3 Water Demand and Supply Balance in Wami-Ruvu basin

The Wami-Ruvu basin has negligible spare water compared to demand and is forecast to be greatly deficit by 2035.

Table 4.2 Water Supply and Demand in Wami-Ruvu Catchment

MCM	2011	2025	2035
Supply	990	1,080	1,170
Demand	900	1,600	2,170
Gap	90	-520	-1,000
If Industry growth + 2%		-561	-1,200
If Irrigation efficiency and less 20% less area		-320	-480

Source: Data taken from Ministry of Water—Wami Ruvu Integrated Water Resources Management and Development Plan.[28]

Most of the surface water available from the Wami-Ruvu abstraction point is used in Dar es Salaam with water distributed by private road tanker as well as by mains network. There is substantial un-served demand, particularly for good quality water. Substantial numbers of private and unlicensed boreholes access groundwater from the shallow aquifer under the city and the extent of overall abstraction is unknown. However the lack of control risks over abstraction and pollution. Saline intrusion has been observed developing at sites near the coast while poor sanitation and disposal of industrial effluents are endemic in parts of the city.

Using the current situation as a basis, the relative impact of lack of water can be understood by showing the change in demand from the current situation as a baseline for discussion as per Table 4.2.

- The gap in 2035 is as large as current consumption (-1,000 MCM);
- Improving irrigation efficiency will substantially reduce the gap (-480 MCM instead of -1,000 MCM); and
- Additional industrial growth would add to the deficit (-1,200 MCM instead of -1,000 MCM).

The range of options is relatively large with measures such as agricultural efficiency in fact providing substantial benefits for the urban population in terms of saved investment in alternative measures. Equally, a successful and rapidly growing industrial sector will require additional water resources which will increase investment costs.

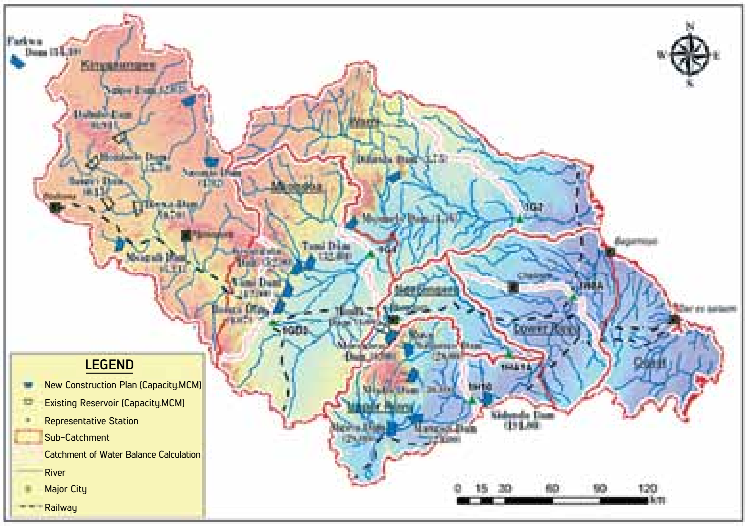
This analysis is based on the current situation where water demand is substantially greater than supply. The level of un-served demand is difficult to estimate as the size of the population is also uncertain and the degree to which water would be affordable for this population is unknown. However it is probable that demand is underestimated and the lack of water is greater than calculated here.

Investment in future water resources is compromised by the level of non-collection of water charges known as "non-revenue water."

4.4 Scenario for Long Term Development

The IWRMDP for Wami-Ruvu includes an illustrative scenario with an extensive series of dams. These storage options have not been costed but would allow a greater and more predictable water supply which in the local climate would provide the conditions for a variety of agriculture, while the increased certainty in water supply would reduce the risk of growing higher value crops. The plans, shown in Figure 4.7, show a total storage volume of ~446 MCM which compares with the planned Kindunda dam of 191 MCM.

Figure 4.7 Location of Proposed Reservoirs



Source: Figure taken from Ministry of Water—Wami Ruvu Integrated Water Resources Management and Development Plan.[28]

4.5 Summary of Evidence from the Wami-Ruvu Basin

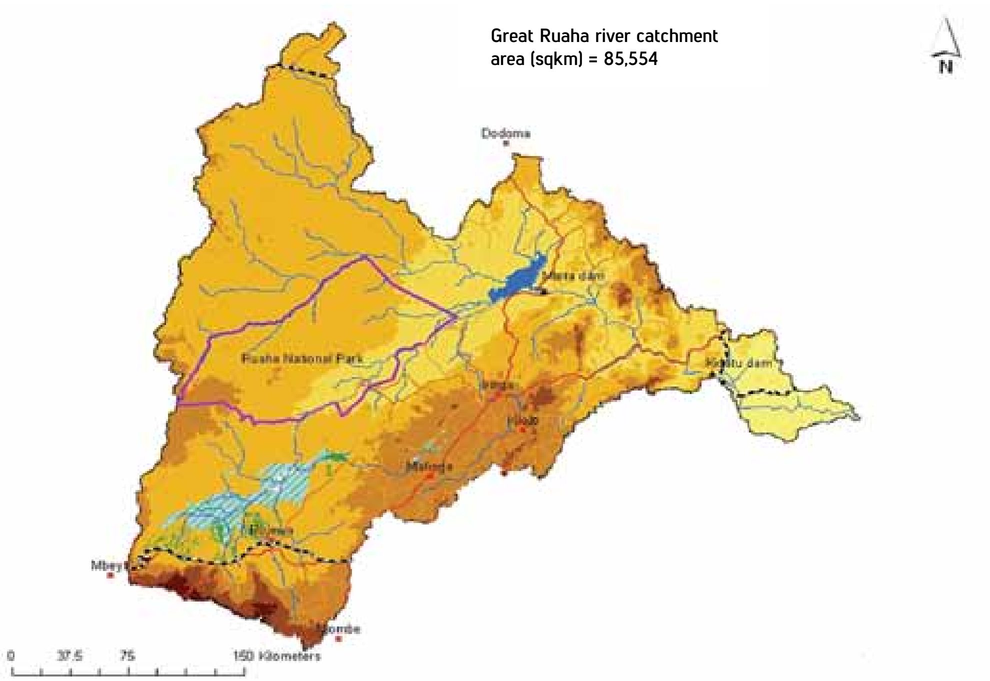
- The population in the Wami-Ruvu basin has good options for water resource development and will need to manage complex legacy issues arising from traditional agricultural practices upstream and transitional issues related to financing new storage assets, boreholes and networks;
- Wami-Ruvu is already at its limit—current demand already consumes all available water even without considering environmental flows;
- In 2035, Wami-Ruvu will need to double its water availability to meet the projected demand from high growth industry and planned agriculture;
- Access to new ground and surface water sources may be possible, but this is uncertain and could have wide variation;
- Access to groundwater and surface water options means Dar es Salaam has long term water resilience with a diversified portfolio of water assets and the potential to make a step change in water supply to residents; and
- Due to the concentration of industry and population, efficiency measures by individuals and companies can have a large collective impact.

CHAPTER 5 Case Study: Rufiji Basin

5.1 Overview

The Rufiji basin is Tanzania's largest and has significant economic importance and competing demands for water from agriculture, hydropower and its unique habitats as well as from other sectors with land uses including mining, forestry, livestock, fishing and inhabited areas. The basin has four National Parks, large game reserves, more than 80 forest reserves and significant biodiversity. Comprised of the Great Ruaha, Kilombero, Luwegu, and Rufiji River systems, the Rufiji basin covers approximately one-fifth of Tanzania's land area and drains into the Indian Ocean via the Rufiji River, the lowest river in the system. Rainfall in the Rufiji basin ranges from 400–1,600 mm/yr, which translates to nearly a third of national rainfall and a quarter of national river flows (WREM, 2012).[31] The altitude of the basin rises from sea level at the Indian Ocean to nearly 3,000 meters above mean sea level in the highlands. The mean annual outflow of the Rufiji River at the Indian Ocean is 900 m^3/s but this flow rate covers a dramatic range of low-high flow variations between dry and wet seasons, and between drought and wet years. The Rufiji basin has a low population density overall and it is unevenly distributed across the basin (URT, 2012).[47]

Figure 5.1 Map of the Rufiji Basin



The Kilombero River contributes the greatest flow (60%) to the Rufiji River, and contains internationally important protected wetlands (Ramsar listed). These wetlands contribute sources of food, water and energy, as well as ecosystem services that sustain wildlife and livestock.

The largest sub-basin in the Rufiji contains the Great Ruaha River. It rises in the highlands of the Usangu sub-catchment which is located in the Rift valley in the south-west of Tanzania. Water drains from these highlands into the Ruaha National Park through the Usangu Plains, into the Usangu Wetland, empties into the Middle Great Ruaha River and then to reservoirs and hydropower plants at Mtera and Kidatu, before joining the Kilombero and Ruwegu to form the Rufiji River and emptying into the Indian Ocean. The Usangu plains account for over one-tenth of the entire Rufiji basin and are a critical area for irrigated agriculture (mainly rice production) and for livestock.

5.2 Agriculture in the Rufiji Basin—Challenges and Potential Opportunities

Agriculture is the leading economic sector in the Rufiji with some 85 percent of the total population pursuing agriculturally-based livelihoods. A wide variety of crops are grown for local consumption and sale using a variety of farming systems. The main food crops include maize, paddy rice, sorghum, and sweet potatoes, supplemented by fish and pulses for protein. Major cash crops include sunflower, cotton, tobacco, coffee, tea, and sugarcane. Food production records in the Rufiji indicate increasing agricultural output and an increase in the area under food crops.

Most farms in the Rufiji basin are small-scale/household-level farms and the level of modernization in agriculture varies across the basin. Some districts have a number of medium- to large-scale commercial farms/plantations using irrigation to grow paddy rice, tea, pyrethrum, sugarcane and other crops and are some of the most modern and efficient farms in Tanzania. Many are in the Kilombero valley.

There have been a number of efforts to promote irrigation farming in the Rufiji in the past, and many of these have focused on large-scale irrigation schemes. In several cases these have been too mechanized and expensive for many farmers but some projects have failed due to inadequate management and related problems such as sedimentation and salinization.

However, although the Rufiji is endowed with high irrigation potential, currently only 37,000 ha of a possible 4 million ha are irrigated, mostly within the Great Ruaha and Kilombero sub-basins and the majority of farmers still use inefficient traditional irrigation methods. There are plans for extensive areas of irrigated agriculture in both of these sub-basins. The table below highlights the potential, including up to 330,000 ha of irrigable land in the Kilombero (Table 5.1).

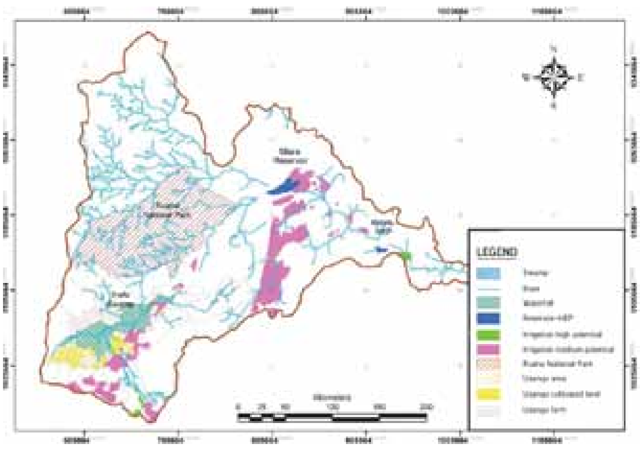
A significant part of the Great Ruaha River basin falls within national protected areas and therefore cannot be used for farming (85% of the Upper Great Ruaha River catchment is within two Game Reserves and the Ruaha National Park). Agriculture in the Great Ruaha River basin is both rain fed and irrigated, with valley bottom cultivation being widely practiced during the dry season. Figure 5.2 shows the irrigation areas in the sub-basin.

Table 5.1 Irrigable Land in the Rufiji Basin

Valley	Potential (ha)	Percentage (%) of Total
Usangu	208,000	33
Little Ruaha	4,800	1
Kilombero	329,600	53
Lower Rufiji	80,000	13
BASIN TOTAL	622,400	100

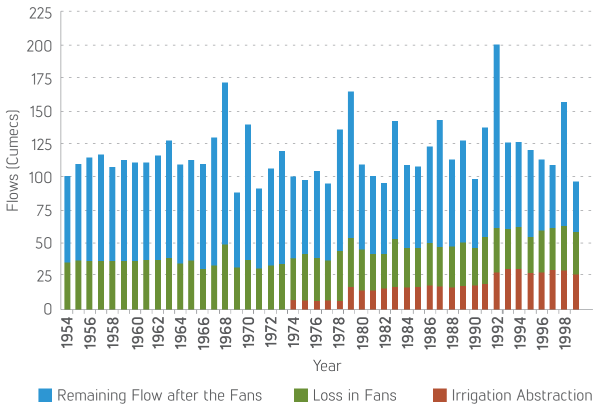
Source: Rufiji Basin Development Authority (RuBADA, 2011) and WREM (2012).[31]

Figure 5.2 Potential Irrigation Areas in the Great Ruaha Sub-basin



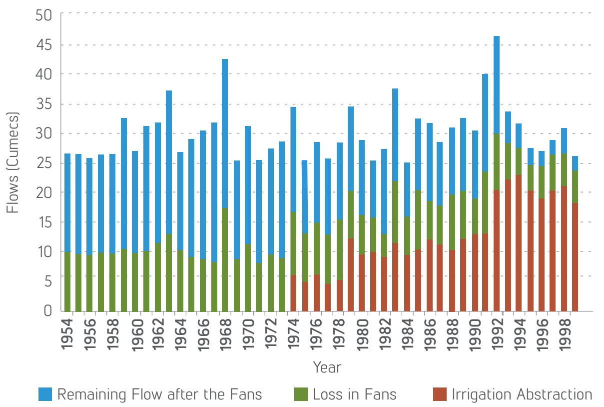
Source: Figure taken from Ministry of Water—Rufiji Integrated Water Resources Management and Development Plan.[31]

Figure 5.3 Annual Losses from High Catchment Flows



Source: Figure taken from Ministry of Water—Rufiji Integrated Water Resources Management and Development Plan.[31]

Figure 5.4 Losses from High Catchment Flows during Dry Seasons (1st June–30th November)



Source: Figure taken from Ministry of Water—Rufiji Integrated Water Resources Management and Development Plan.[31]

Figure 5.5 Great Ruaha River in Ruaha National Park in 2006

Source: Wikipedia http://en.wikipedia.org/wiki/Great_Ruaha_River photographer Paul Shaffner

Farming is mainly subsistence but there are several private large-scale paddy irrigation farms (originally developed under government ownership) on the southern part of the Usangu fans, making up some 60 percent of the area under irrigation. Small-scale often opportunistic enterprises make up the remainder of rice paddy production on the fans, these being dependent on the availability of water.

Even before implementation of new plans, existing operations in the Great Ruaha are already causing dangerously depleted water flows. In dry years irrigation takes the majority of the flow in the Great Ruaha, which was illustrated in a study (Yawson, 2003)[50] that provided a detailed analysis of water abstractions in the Usangu plains (yellow area on the map in Figure 5.2).

Water available in the high catchment before abstraction for irrigation in the Usangu plains and losses in the fans (including irrigation abstractions in the plains) were monitored for a long period. Findings included a time series of estimated water abstractions from the river system (Figures 5.3 and 5.4). The red lines indicate irrigation abstractions and the full line is the estimated total sum of high catchment flow. Irrigation abstractions taken in the dry season of June to November start from around 1974 and increase gradually to a high in 1994.

The study identified that the amount of water abstracted for irrigation on an annual basis (Figure 5.3) was not a problem, but during the dry season (Figure 5.4) it became serious. The study (Yawson, 2003)[50] found that about 25 percent and 22 percent of the yearly and dry season flows from the catchment respectively were lost due to the fans in the post-1985 period, while 19 percent and 53 percent of the annual and dry season flows, respectively, were abstracted for irrigation activities. The impact of dry season irrigation has therefore been extreme. In 1993 the river dried up (for two weeks) for the first time in living memory, and since then the period of flow through each consecutive year has shrunk. Since 1999 the river has been consistently dry for over 100 days, with wet season flows now under threat (Figure 5.5). This situation has directly threatened wildlife in Ruaha National Park, while flows to the Mtera and Kidatu Hydropower stations (that currently provide over half the nation's power supply) have also been compromised.[39]

5.2.1 Southern Agricultural Growth Corridor of Tanzania

The Southern Agricultural Growth Corridor of Tanzania (SAGCOT) program is a new public-private partnership initiative aiming to improve agricultural productivity, food security and livelihoods of small holder farmers in Tanzania. This will be achieved by linking them to internationally competitive supply chains and accelerating commercial agricultural development.[51]

The SAGCOT program will cover approximately one-third of mainland Tanzania falling almost entirely within the Rufiji basin. It has an objective of adding an additional 350,000 ha of commercial farming to the existing 110,000 ha over a 20 year period to increase farming revenues by US$1.2 billion and lift 450,000 households out of poverty.[51]

This initiative is helping to highlight the importance of water security for the nation's development. The availability of water to irrigate crops during the dry season is important for agricultural growth and the impacts of its use is a concern raised within the Strategic Regional Environment and Social Assessment (SRESA) of the program.[51] Stakeholders consulted were concerned that irrigation development in the Kilombero Valley could repeat the disastrous experience in the Usangu. Analysis of potential sites in the Kilombero Valley, within the SRESA, identified that while the total volume of water required for irrigation is not high, "even without considering the environmental flow requirements **dry season water availability is likely to be a significant constraint at almost all of the proposed irrigation sites**, unless storage dams are built."[51]

5.3 Hydropower in the Rufiji Basin

Hydropower remains the major source of electricity in Tanzania, a country that has been struggling with one of the lowest electrification rates in sub-Saharan Africa. On average less than 15 percent of the population has access to electricity. The Rufiji basin is vital with regard to power generation in Tanzania. At present, if working as designed, the facilities have the capacity of 460 MW at three hydropower sites: Kidatu (200 MW), Kihansi (180 MW), and Mtera (80 MW). However, drought and other constraints lead to much lower capacity being available in practice. The installed capacity in these three power plants represents 80 percent of the total national hydropower capacity and half of the total national hydro-thermal power capacity. During the construction phase of the Kihansi hydropower plant, the ecological quality and importance of the gorge below the dam was compromised. Since then, extensive measures have been taken to protect the gorge, but the damage, which included the loss of habitat of a rare toad species (Kihansi spray toad), appears to be irreversible (TANESCO, 2006).

The social, economic and environmental benefits of hydroelectric power still make this a likely contributor to the present and future energy mix for Tanzania. There are potential large-scale hydropower resources that could increase output by between five and ten times if fully harnessed. However, future development of hydropower will require a fully integrated approach if this resource is to be tapped in a sustainable manner, considering the entire basin and in terms of development tradeoffs, and considering not just the incremental benefits from individual hydropower development projects but also the combined benefits from various project configurations, including marginal value (gain or loss) of irrigation agriculture with respect to hydropower in the basin, and irrigation versus hydropower tradeoffs for each sub-basin and the basin as a whole.

The topography and geology of the Rufiji basin is conducive for greater development of hydropower. Aside from the Mtera, Kidatu, and Kihansi plants, several other sites have been identified as having significant hydropower development potential (Table 5.2). For example, an additional 2,400 MW of hydropower capacity could be developed in the basin at Stiegler's Gorge.

Table 5.2 Operational and Planned Hydropower Stations in the Rufiji

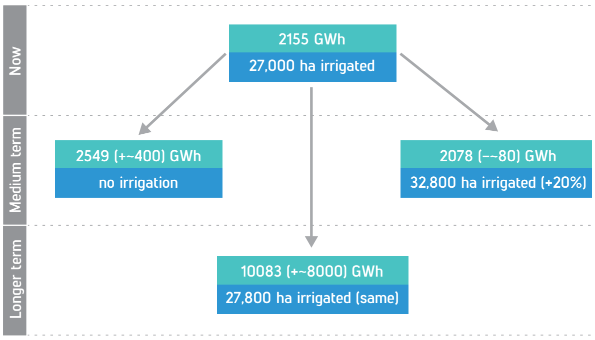
Operational Hydropower Plants	Capacity (MW)	Potential Hydropower Plants	Capacity (MW)
1. Kidatu	200	1. Stiegler's Gorge	2,100
2. Mtera	80	2. Ruhudji	500
3. Kihansi	180	3. Mpanga	160
		4. Mnyera	485
		5. Lukuse	130
		6. Iringa	87
		7. Shughali Falls	464
		8. Ikondo	340
		9. Kingenena	Not determined
TOTAL	460	TOTAL	4,266

Source: Figure taken from Ministry of Water—Rufiji Integrated Water Resources Management [31]

5.4 Tradeoffs and the Need for Cross-Sector Integration

Most water related development projects in the Rufiji have been implemented based on either sectoral, regional or district interests with little consideration of other sectors and associated future impacts. Recent water policies have identified the need for integrated planning to avoid this issue and seek to address cross-sectoral interests in integrated water resource management, however, integrated assessments and institutional coordination is in its infancy and would also benefit from improved legal frameworks to enforce the policy (e.g., Sokile et al., 2003; URT, 2004).

Figure 5.6 Hydropower and Irrigation are Possible Alternatives



Reduction in generation due to current irrigation = average output from Mtera (383GWh)

The competition for water among sectors may be aggravated by planning focused only on an individual sector. In the Rufiji basin the major water uses are rainfed agriculture and domestic supply in the upper catchments of Great Ruaha river sub-catchments; paddy irrigation and livestock rearing in the Usangu plains, riverine wetlands, Ruaha National Park, and the Mtera-Kidatu hydropower system. The level of irrigation upstream has resulted in the hydropower plants downstream running considerably below capacity. While irrigated agriculture is critical for supporting the livelihoods of rural populations and reducing poverty, hydropower provides the energy essential for economic development, especially in urban areas.

The expansion in irrigated land averaging 10 percent per year has resulted in part from the need to feed an increased population. However water demand for irrigation in Usangu was substantiated as a prime cause of the drying up of the Great Ruaha River from September-January 1994. During that period Tanzania experienced an energy crisis in cities and towns, and power has been rationed several times since. While irrigation expansion undoubtedly affected downstream flows, especially during the dry season, there was also evidence of mismanagement of the hydropower reservoirs by unnecessary spills at Mtera dam between 1991 and 1992 to cater to power generation at Kidatu station (Yawson et al., 2003).[50] Irrigation upstream of hydropower is thus not the only cause of reduced water levels in the dams, as other factors such as drought and poor operations management clearly also had a role.

Development of both hydropower and better irrigation systems are possible. Figure 5.6 indicates the results of a high-level analysis of the tradeoff between hydropower and irrigated agriculture. Currently, 27,000 ha are irrigated, and (under normal climatic conditions) annual electricity generation is 2,155 GWh. If the irrigated area was increased to 32,800 ha, then electricity production would need to fall to 2,078 GWh. As an alternative, irrigated agriculture could be stopped, in which case 2,549 GWh could be produced. In a longer term scenario, if no further irrigation was planned, 10,083 GWh could be produced. However, current plans are for greatly increased irrigation which would preclude this level of electricity generation. A rough calculation suggests that rice would need to be produced at more than double the yield currently achieved by subsistence farming for it to match the revenues from electricity production. This level is achievable but would almost certainly require improved farming practices.

Transformations in the use of water across multiple sectors in the Rufiji basin have been significant throughout the past half-century. A growing human population and increasing water demands in the basin have been associated with institutional conflicts, management ineffectiveness, gaps in management imperatives and duplication of efforts. Due to these rapid changes and the large scale of the basin itself, activities within the Rufiji basin have a history of being conducted independently.[31] While significant management transformations are underway, specifically the implementation of integrated water resources management planning at the basin level, sustainable water resources management in the Rufiji still requires, among other things, significant strengthening of institutional arrangements, clearer assignment of responsibilities, increased stakeholder participation, and more effective transfer of technical capabilities from state level to local basin managers and water user associations.

5.5 Summary of Evidence from the Rufiji Basin

- Rufiji is a key water basin for Tanzania—one of largest and most important economically;
- Economic agents are widely separated geographically but closely linked hydrologically;
- Current water use from irrigation is already depleting water flows and significant additional irrigation is planned;
- Hydropower in the basin has significant potential but even now is being impeded by other water users; and
- At current irrigation efficiencies, tradeoffs and choices between agriculture and hydropower are required at the national and local levels.

CHAPTER 6. Summary of Evidence

This chapter provides a summary of the evidence identified during the assignment which can be used to inform recommendations for future work in the context of the ACT principles developed by the 2030 WRG.

- Tanzania has **significant annual average renewable water resources of 94,000 MCM per year** amounting to some 2,300 CM per capita; well above the Falkenmark indicator for "water sufficiency" of 1,700 CM per capita;
- **Environmental flow** (EF) needs for basins and sub-basins have received varying degrees of study and implementation but **on a national scale are estimated to be some 29,000 MCM per year;** and
- After taking into account EF needs, **the annual average water availability is 65,000 MCM** per year; while
- Blue **water demand is 9,900 MCM per year** and is forecast **to rise to some 17,200 MCM by 2035**; but
- **Water availability is highly variable in space** (Rufiji River basin has 24 percent and Wami-Ruvu 5 percent of the annual average total); and
- **Water availability is highly variable in time** (Wami Ruvu Q97 is as low as 15% of annual average); leading to
- In some catchments in dry periods, demand takes *all* the flow of the watercourse, **leaving no environmental flow to maintain the river ecosystem**, and
- In **dry periods national demand is some 150 percent of accessible water** after taking into account EF needs;
- With **particular concern in Wami-Ruvu, Lake Tanganyika, Pangani and Internal Drainage basins**.
- The need to maintain **environmental flows has been recognized as a major priority and they are greater than all other demands in each basin**, but their overall assessment is uncertain.
- **Irrigation is currently responsible for over 82 percent of the water abstracted for human** uses and is expected to double by 2035 as a result of the government's policy to increase agricultural production.
- **The coverage of domestic water supply remains well below the national targets** across the country. Infrastructure networks are poorly maintained and vulnerable with high levels of leaks and illegal abstraction.
- **Tanzania's population is projected to double by 2035 and increased domestic water use is set to rise by over 180 percent.** Rapid growth in urban areas is placing increasing demand on already insufficient supplies and inadequate sanitation systems leading to the abstraction of groundwater at unknown rates from unregulated boreholes.
- At a national level, the water requirements from industry are set to increase by over 300 percent with specific growth focused within the Wami-Ruvu basin.
- The Rufiji is Tanzania's largest basin and has significant economic importance. There are considerable and competing demands for water from agriculture and hydropower. Current water use from irrigation is already depleting water flows in some sub-basins and significant additional irrigation is planned. Hydropower in the basin has significant potential but even now is being impeded and producing well below capacity. Tradeoffs and choices between agriculture and hydropower are required at the national and local levels.
- Wami-Ruvu is already at its limit—current demand already consumes all available water even without considering environmental flows and by 2035 will need to double its water availability to meet the projected demand from high growth industry and planned agriculture. However, the basin has good options for water resource development and will need to manage complex legacy issues arising from traditional agricultural practices upstream and transitional issues related to financing new storage assets, boreholes and network.

CHAPTER 7. Potential Water Management Interventions

Water management interventions in Tanzania have great potential, especially those focused on agricultural water. The main goal of these interventions is to contribute to relieving constraints on agricultural and industrial production and on productivity, and to strengthen policies and institutional capabilities for water management at all levels, ultimately reducing poverty and improving livelihoods. During the review of the literature, water management interventions were identified that are being implemented to some degree in Tanzania and show potential to be developed. In addition, there are new interventions that have not yet been implemented. Some of these interventions are discussed in various parts of the report as part of the context. The review below organizes key existing and suggested potential interventions by Institutional/Policy-related, Water Supply, and Water Demand. Within this assignment and summary no prioritization or detailed assessment has been made and further robust hydro-economic analysis is required before any investment decisions are made. There is considerable opportunity for interventions within the context of public-private partnerships.

7.1 Summary of Key Existing and Suggested Potential Interventions

7.1.1 Institutional/Policy-Related Interventions

Low and unreliable investments in infrastructure for water-using sectors. Tanzania has the highest level of natural water storage capacity per capita in Africa, and yet the country depends on rainfed agriculture. Fourteen of the twenty-one dams constructed for irrigation supply are no longer operational. Irrigation uses about 97 percent of the total consumptive use of water and is the most inefficient user of water. Investment in irrigation cannot be fully realized because of weak management of water allocations. In order to address these needs, substantial investments are needed in sustainable water resources infrastructure including single and multi-purpose dams, inter-basin transfers, and conveyance systems.

Increasing institutional capacity. The National Water Sector Development Strategy (NWSDS) (2006) and the Water Resources Management Act (2009) established a new institutional framework for water resources, based on autonomous basin level organizations. The Ministry of Water has the overarching role of water resource coordination, policy and guideline formulation, and regulation with delegated responsibilities passed down to the institutions of the National Water Board and Basin Water Boards (BWB), and further down to Catchment Water Committees, Sub-Catchment Water Committees and Water User Associations. While this is a robust framework, detailed in the IWRMDPs, it is undermined by a significant shortfall in resources both in terms of staffing levels and wider operating expenditure to fulfill its responsibilities. The BWBs are largely funded by water user fees and it is therefore essential that fees are collected. Support to increase the skills and capacity of staff to develop strategies to increase the collection ratio of water user fees, and mechanisms to enforce noncompliance, are necessary.

Establishment and strengthening of Water Use Associations (WUAs). WUAs have an important role in regulating traditional water abstraction, and they reduce the number of water right holders for better coordination of water use. They also provide an important conflict resolution role, WUAs are generally recognized as being a long awaited solution to intersectoral water management, but do not always meet the expectations of the poorest of the poor in the villages (they are normally formed by the high and mid-class villagers that can both express themselves and win the support of the equally rigid water right acquisition procedures).

7.1.2 Water Supply Interventions

Large and small scale water storage. Tanzania has put the highest priority on the development of the agricultural sector as a means to meet Millennium Development Goals (URT, 2009). Tanzania is endowed with an abundance of water resources such as rivers, lakes and groundwater. However, the distribution of water resources is disparate both geographically and temporally. Despite water resource availability, due to inadequate infrastructures (e.g., storage), water supplies cannot be managed and regulated efficiently (storing water in times of high flow periods for use in times of low rainfall) which is significantly restricting agricultural growth and security of supplies to other water users.

Water storage for use in the dry season could unlock tremendous agricultural productivity. For example if newly constructed dams stored 7 percent of annual flows across the country, it could provide over 6,000 MCM, provide irrigation for ~40,000 ha at a per hectare cost of between $7,500–$37,000.

Within this context, efforts have been made over several decades to construct small, medium and large scale dams including the hydropower dams at Kihansi, Ruhudji, and Mpanga in the Rufiji. Other basins have yet to build significant storage dams, for example the Wami sub-basin which is relatively undeveloped compared to the neighboring Ruvu sub-basin, with fewer abstractions and no major dams or hydroelectric plants. In other locations large storage projects have been planned but are on hold, partly due to significant concerns regarding their environmental impact (e.g., the proposed Stiegler's Gorge dam on the Rufiji River) (World Bank, 2013).

In many cases there is not the economic justification to construct large dams. Small earthen dams can contribute significant storage in a region when many are installed. They can have storage capacities up to 10,000 cubic meters and can be built manually for relatively low cost using animal draught or a farm tractor. Aside from enabling farmers to plant more crops and to have some storage available during dry periods, water storage using a small dam can provide many benefits. It allows for watering livestock near villages (saving time and reducing erosion caused by cattle), and can allow the raising of fowl and fish farming for food and income. Dams may also reduce water-borne diseases by providing improved water supply for domestic use while saving peoples' time by reducing walking distances to fetch water. Added benefits include reduced impact of floods by storing initial floodwaters and raising the water table downstream of ponds and dams which benefit well levels for hand dug wells as well as tree root systems. Ultimately the dam may also increase the value of nearby land because of all the above benefits.

Specifically the draft IWRMDPs for the Internal Drainage basin (IDB) and Wami-Ruvu have provided detailed consideration of water storage options at different scales, which could be developed to regulate and manage water to meet the water supply challenges and provide opportunity for continued economic growth.

Multipurpose reservoirs are large scale water storage structures which serve more than one use category. Typical conjunctive use examples are hydro-electricity generation with public water supply, irrigation with public water supply and flood control with hydro-electricity generation. One of the best known examples in the world is the Lesotho Highlands project, a multipurpose undertaking that transfers 780 MCM of water per year and generates 72 MW of hydropower. However, successful projects of a more modest scale can be envisioned such as that proposed at Engarasero in the IDB which would generate 1 MW of electricity (enough to serve 50,000 people), and supply 1.5 MCM of water for drinking and irrigation. The challenges facing such projects are institutional and technical. Institutional, because they serve uses which typically fall to different public and private entities, and technical, because their operational rules must recognize an equitable allocation of costs and benefits. However, there are many examples of successful projects of this type and they are very suitable for private sector and community participation. Business cases for such projects depend on many factors, not the least of which are hydrology, topography and water affordability.

Small-scale rainwater harvesting is a cheap, simple, and often the most effective solution to provide greater access to water, allowing women to dedicate more time to income-earning tasks, and to decrease the risk of disease from contaminated water. Rooftop water systems involve three primary components: catchment, conveyance, and a collection device. The catchment device is the roof surface that captures the rainwater. Rainwater drains down the slanted roof top to the conveyance gutters, at the base of the roof. These gutters transport the water from the rooftop to the collection device, typically a large ferrocement cistern. The rainwater is then stored in the collection device until its use.

Wastewater Treatment and Reuse

Population and urban growth is one of the major challenges facing Tanzania. Rapid urbanization poses major infrastructure, economic, environmental and social problems. Total water supply and sanitation coverage is currently low, and even in Dar es Salaam is to a large extent informal. Untreated urban wastewater is polluting water sources throughout major cities, changing freshwater irrigation into wastewater irrigation in and around most cities. Because of its contribution to urban food supply and poverty alleviation, this informal irrigation sector has positive effects but constitutes at the same time a public health and environmental threat. The low levels of water sanitation and waste water treatment observed in urban centers provides an opportunity for investment.

Water reuse provides an alternative option to secure water supplies from traditional water supply schemes, e.g., new reservoirs, new groundwater and surface water abstractions. The treatment and reuse of municipal wastewater for industrial, agricultural and domestic purposes is attracting attention globally and the technological basis for reuse schemes is well established with proven efficacy. Countries with extensive and successful reuse sectors have mature and reuse-specific regulatory and governance environments. The greatest opportunity for the development of water reuse schemes are likely to be in Dar es Salaam where industrial water requirements are the highest. Cement manufacture makes up half the industrial demand for water with current demand of 18 MCM set to increase to 133 MCM by 2035 and could be a priority target for private sector participation in a water reuse scheme, freeing up the resource for other users.

Inter-basin transfers are a means of balancing out variations in spatial availability of available water resources. There are many large-scale examples from around the world, but one of the best known is the system of canals which transfers water from wet northern California to dry southern California through what is known as the State Water Project and which supplies water to 25 million people and irrigates 300,000 ha of agricultural land. However, much more modest projects are possible, for example the project which transfers 29 MCM of drinking water from Lake Victoria to Shinyanga in IDB, enough for 400,000 people. In a paper "Managing Trans-regional Water Transfer in Dry African Countries to Mitigate Shortages" the economics of transferring water from Tanzanian river basins to IDB was modelled. Most of these transfers would involve pumping but there may be potential gravity transfer projects from Lake Rukwa or Lake Nyasa basins to IDB or Rufiji basins. Business cases for inter-basin transfers require the raising and repayment of relatively large capital investments for what are usually tunnelled transfer systems through the higher ground between basins. They are suitable projects for private sector participation though the cost of capital may be so high (if geological conditions pose high construction risks) that they cannot be viable without sovereign guarantee funding structures.

7.1.3 Water Demand Interventions

Widespread adoption of the system of rice intensification (SRI) in Tanzania. Irrigation provides the greatest human demand for water at over 82 percent of all water abstracted and is contributing to considerable challenges and conflicts with other users of the available water. The demand for more food to feed the growing population is also increasing, calling for new technologies and farming practices that ensure more food production while minimizing water uses. Most rice producers in Tanzania are subsistence farmers and carry out continuous flooding, an inefficient technique that requires much water. In addition, the conventional practice of growing paddy rice using a transplanting process where 3-4 seedlings are transplanted in one hole results in low yields, as well as low water productivity and water use efficiency (Katambara, 2013). The system of rice intensification (SRI) is a promising new practice of growing paddy rice that has proven to be very effective in saving water and increasing rice yields in many parts of the world. Irrigated and rainfed rice has a yield of 1-2t/ha. SRI rice can have a yield of 4t/ha. SRI practice is spreading fast and it has been adopted in many countries.

The SRI practice was introduced in Tanzania in 2009 by Kilombero Plantations Limited, a company in Morogoro, in an effort to increase the country's food security. As of 2013, SRI is being practiced in Mkindo and Dakawa in Morogoro region, and in the Mwanza and Kilimanjaro. A project to introduce climate smart agriculture in Kiroka village in Morogoro Region, initiated by FAO and Sokoine University in 2011, has resulted in **tripling some farmers' yields with SRI**. The SRI practice consists of applied principles ranging from seed sorting, sowing, transplanting younger seedlings, weeding, and water management.

Uptake by smallholder farmers has been slow due to a lack of technical transfer (via education and extension) and knowledge is still evolving. However, in areas of Tanzania where the practice has been introduced, SRI has been quite well accepted by subsistence rice growers and has shown positive results. SRI's contribution towards resource use efficiency is not yet well reported, and more work in this area could help support more rapid uptake of the technology if results continue to be positive.

Advantages for the adoption of SRI: results from latest research

Research in the Mkindo area indicated the grain yield from SRI was 6.3 tons/ha, which was higher than conventional practice (recorded yields of 3.83 tons/ha). Above ground biomass obtained was 10.7 tons/ha for SRI compared to 8.9 tons/ha in conventional practice.

Water use under SRI practice was found to be 1.01 m^3/m^2 versus 2.9 m^3/m^2 in conventional practice. This suggests that SRI can save up to 65 percent of water in application.

It is also likely that the surface runoff generated from the fields under SRI will be lower than runoff generated in conventional approaches, thus soil erosion will be reduced.

SRI is able to provide higher yields on limited land, increasing food self-sufficiency in the community, and with overall financial savings achieved from less seed and water use.

Source: Katambara, Z. (2013).

Example Challenges and Implications of Implementing SRI in Tanzania

- SRI requires less water, but the assurance of availability of water is still high since it is required when soil moisture in the field is low and delays will impact rice yields;
- Although SRI can easily be integrated into existing infrastructure, there is a need for a policy framework to support its implementation (e.g., issue of when to irrigate and how to control seepage from neighboring non-SRI practicing farms that interfere with the drying of the fields);
- Given the nature and varying expectations of subsistence farmers, an appropriate approach towards wider introduction of SRI in Tanzania is required through the work of experienced researchers and agricultural experts;
- The design and production of easily readable training materials to be used during the adoption process is critical;
- Practicing farmers will need to have exchange visits to realize what other farmers are experiencing with regard to the implementation of SRI practices;
- All of the above will require private sector, donor or government investments to be made available during the early adoption process;

It has been estimated that if only 20 percent of all currently un-irrigated rice was switched to SRI cultivation, all of the remaining irrigated lands in Tanzania could be replaced, releasing vast amounts of water for other uses.

Improving irrigation efficiencies of existing, small water delivery systems. Irrigation development has been an important strategy for achieving self-sufficiency and food security and most planning has focused on capital-intensive schemes while paying little attention to the advantages of traditional and lower-tech irrigation schemes which can be far more efficient. In the 90s the Ministry of Agriculture, with assistance from FAO and UNDP, reviewed the government's experience with irrigation. They concluded that new emphasis should be on rehabilitation and improvement of existing smallholder schemes, including canal lining to reduce water losses which are a significant inefficiency in Tanzania; the rehabilitation or upgrading of existing traditional irrigation schemes in all regions where this type of irrigation is significant; and the use of traditional water harvesting technology in regions where more intensive irrigation is not feasible.

Most of the traditional schemes are operating with a low water efficiency of between 15–20 percent as a result of poor irrigation systems and management.[32] The ASDP (2006) reports that

Reducing business risk through municipal leakage reduction–South Africa

Emfuleni Local Municipality (ELM) is located in a catchment that experiences 44 percent annual mean water losses. The intervention involves an innovative public-private collaboration between industry, local government and funding agencies to reduce network leakage, domestic leakage and pressure management. The project reduced Sasol New Energy water risk while reducing the municipality's costs and increasing its water supply security.

Significant water savings are estimated to be achieved by 2014 reaching 12,000,000 m^3/year which reduces water risks for all water users in the catchment, and increases availability to others. Financial savings of $10 million are expected.

Metering of non-revenue water–South Africa

Ekurhuleni Metropolitan Municipality (EMM) supplies over 314,000,000 m^3/year to 800,000 customers and non-revenue water is estimated to be over 50 percent of the water being used.

There was increased awareness that large quantities of water were being supplied to industry which was not being billed and as a result a project was undertaken to replace and consolidate meters, identify illegal connections and identify and repair leakage.

With a project cost of $2.5-million the key outcomes included a decrease in non-revenue water estimated at 5,800,000 m^3/year and increase in revenue for EMM by $5.4 million/year.

Source: 2030 WRG (2013) Managing Water User in Scarce Environments.

Water use reduction strategy for the food sector–South Africa

A drought in 2010 in the Western Cape region of South Africa threatened the operation of a Nestle powdered milk factory due to a significant reduction in water availability. The objective of the project was to implement a strategy to reduce water use in the factory and involved actions of active water use monitoring, retrofit of low flow plumbing fixtures, employee engagement and engineering solutions to enable water reuse.

The driver for the investment was not the financial benefits from reduced water use, but to reduce the impact on the operation of the plant due to low water availability. Reduced water usage in the factory has resulted in greater water availability to other water users in the region.

Source: 2030 WRG (20130 Managing Water User in Scarce Environments

improved irrigation management of traditional schemes increased overall water use efficiencies from 15 percent to 30 percent (with up to 86% conveyance efficiency) and in the case of paddy rice increased production from 1.8t/ha to 5.0t/ha. The FAO has reported[52] the total cost of irrigation in Tanzania per hectare was US$38 for paddies under traditional gravity systems and US$69 under improved gravity systems. These figures indicate a 2.8 improvement in yield for a 1.8 increase in cost.

There is large opportunity to reduce water demand through the implementation of water efficiency measures in urban areas. In the **Water Industry**, a number of intervention strategies can be implemented, including recovery of non-revenue water; tariff design, and water metering. **Non-revenue water** levels in urban areas are high in Tanzania with an average of 37 percent in 2012/13 and in Dar es Salaam of 49 percent.[42] There is a particular opportunity to reduce this water loss in Dar es Salaam, making more water available for domestic and industrial purposes, reducing the dependence on private groundwater use (which is unregulated) and so help alleviate the risks of saline intrusion into the groundwater from over pumping.

Water metering has been in existence in Tanzania for some time, but has been limited to the urban areas. Initial development of water metering was primarily for estimating consumer demand, analysis of water loss, and detection of illegal connections in the Dar es Salaam water distribution system, but was found to be a constant source of revenue loss through poor management of meter operation and maintenance. Water meters should perform efficiently if the expected results of metering are to be obtained, and metering needs to be extended to more rural areas as well.

In **Industry,** improvements in best practice in water use efficiency, water treatment and effluent reuse, and rainwater harvesting can all have significant impacts. Industrial water demand in the Wami-Ruvu basin is particularly high for the manufacture of cement and producers of food, beverages and textiles products. Convening discussions with these businesses should be a priority to develop a business case for the implementation of water saving measures which would help free up water for other users in the basin.

In the **Domestic Water Use** domain, uptake of water-efficient fixtures and appliances, and behavioral changes (shorter shower times, switching off taps, etc.) can have significant and positive cumulative impacts on water conservation. Investment requirements and higher prices are needed to provide incentives to economize.

CHAPTER 8. Recommendations

The literature reviewed during this assignment included a wide range of recommendations for future action at both detailed and higher levels nationally and for individual basins. Given the variety of these recommendations, convening groups of relevant stakeholders is likely to be essential for developing focused proposals.

The 2030 WRG Tanzania Partnership Kick-Off Workshop in November 2013 brought together a number of stakeholders for the first time and provides the start of such a process. Following the presentation of analysis reported here, a discussion between stakeholders highlighted the following main points. (for more information on the discussion, see Appendix B):

- In-depth hydro-economic analysis should be conducted in specific regions. The Wami-Ruvu, Rufiji and Pangani basins were suggested, but it was also suggested that other basins with expectations of significant new economic growth should also be considered. A review of the IWRMDPs was suggested as the means of identifying basins.
- Water scarcity challenges could be addressed by focusing on the areas of water use efficiency, water security and cross-sectoral coordination.

Overall, there is a need to gain an **improved and consistent understanding of the available surface and groundwater water resources** in all Tanzanian basins. The completion of the IWRMDPs will provide a body of information that is substantially more advanced than was previously available. Subsequent work should include processes to highlight and resolve differences in methodologies.

1 Large and Small Scale Water Storage, including Multipurpose Reservoirs

Despite the abundance of water resources in Tanzania, water availability is disparate geographically and temporally. Inadequate infrastructure, particularly lack of water storage, is limiting the possibilities for managing and regulating water supplies to meet current and future demand. The future investment in storage infrastructure at large and small scales for irrigation purposes is a necessary component for achieving the planned increases in agricultural production. Multipurpose schemes would bring benefits to other sectors such as industry and hydropower. The outputs of the IWRMDPs are identifying interventions to meet the water challenges in each basin. Specific new storage schemes have been identified as key options to consider as is seen within the Wami-Ruvu and Internal Drainage draft reports. It is proposed that the schemes presented in the IWRMDPs, as well as any new proposals, are brought to convening sessions at national or basin level and explored by stakeholder groups for development opportunities including cross-sectoral interactions, collaboration and shared investment. These sessions would bring together investors and water users such as commercial and subsistence farmers, industry representatives, hydropower and energy sector developers and managers in the water sector. Within this forum potential inter-basin transfer schemes identified in the IWRMDPs could also be assessed against overarching criteria for scheme selection.

2 Wastewater Treatment and Reuse

The potential for **wastewater treatment and reuse** is very relevant to the urban areas in Tanzania. These are growing rapidly, particularly in Dar es Salaam which is the main commercial and industrial hub. Reuse increases water availability locally, contributes to greater water security for business and domestic consumers and would help reduce overall levels of water pollution. The largest industrial water uses in Dar es Salaam are for cement manufacture, and food, drink and textile production. It is proposed to convene sessions with representatives from these groups and the water and sanitation provider DAWASCO, together with potential investors to identify opportunities for partnerships to develop such treatment and reuse schemes.

3 Non-Revenue Water and Industrial Water Use Efficiency

The same stakeholders could also address the issues of **non-revenue water** and **industrial water use efficiency**. The business case and return on investment is well proven (see examples highlighted earlier in the report). Additional revenues are valuable as an immediate source of funding for improved water infrastructure and increased water efficiency will reduce water costs and risk to industry. The water savings from both will release additional supplies to other users.

4 Efficiency Improvements in Irrigated Agriculture

Irrigation is responsible for over 82 percent of the water abstracted for human uses in Tanzania and the demand is expected to double by 2035. Over 80 percent of irrigated land is farmed using traditional practices for water use with efficiencies as low as 15 percent (compared to modern efficiencies of over 90%). Investment in new or rehabilitated irrigation schemes would reduce water use and may lead to increased agricultural productivity. Such developments may, at the same time, benefit existing enterprises, provide infrastructure for smallholders and form hubs for wider added value initiatives. It is proposed that a selection of irrigation development plans identified from the IWRMDPs are brought to a convening session with potential investors, commercial enterprises and smallholder farmers who could assess specific opportunities.

Such interventions could be combined within a wider water resources scheme such as the construction of reservoirs for water storage and potential hydropower.

5 Increasing Agricultural Productivity and Reducing Water Consumption

The increased demand for rice associated with higher standards of living provides market opportunities for Tanzanian growers. The **System of Rice Intensification (SRI)** is a strategy that can be adopted by commercial farmers and smallholders to increase productivity and reduce water use. Studies of SRI in Tanzania have shown yield increases of between two and four times while also reducing water requirements significantly. The experience of commercial rice growers already using SRI and other successful agri-businesses using modern water use techniques can be showcased to new and potential investors, smallholders and larger enterprises. For example, the model adopted by Agro EcoEnergy Tanzania Limited, growers of sugar cane, incorporates a comprehensive out-grower and community development program with a rapid build up of production capacity by the out-growers over a four year period. This model could be adopted more widely by agri-businesses for rice production. In addition, private investment in commercial rice growing would be greatly enhanced with government support. Recently, tariff reductions for imported rice have created financial challenges for investors attempting to launch SRI-based agribusiness in Tanzania.

Processes for **education and knowledge transfer** of a currently disparate body of data and experience affecting water use, such as best irrigation techniques and SRI, would be beneficial using simple knowledge transfer and extension services.

6 Cross-Sectoral Integrated Planning

Cross-sectoral integrated planning is essential in order to achieve efficient, equitable and sustainable use of water resources and resolve sectoral plans which have largely been developed independently with no account taken of competition for water resources. All existing major sector programs should be reviewed in combination with the current information available from the IWRMDPs. Working groups comprised of government departments (e.g., Ministry of Water, Ministry of Agriculture, Food and Cooperatives, Ministry of Energy and Minerals, and Ministry of Finance) and industry representatives should be convened to identify hotspots in relation to competing planned sector water resource use and the actions necessary to resolve issues identified and implemented.

APPENDIX A. Stakeholder Consultations

The 2030 WRG is a unique multi-stakeholder partnership that helps government accelerate reforms that will ensure sustainable water resource management, for the long term development and economic growth of their country, while respecting social access and the environment.

Figure A.1 Stakeholders Consulted during the Delivery of the Assignment

Table A.1 Stakeholders Consulted during the Delivery of the Assignment and Who Attended the Kick Off Meeting

Stakeholders consulted during the assignment		
Ministry of Water	Barrick Gold	Wami Ruvu Basin Water Board
Ministry of Agriculture, Food and Cooperatives	Tanzania Breweries Ltd	Internal Drainage Basin Water Board
Ministry of Finance	Nestle	Water & Environmental Sanitation Project—WEPMO
Prime Minister's Office	Agrica	Global Water for Sustainability
Ministry of Energy and Minerals	Kilombero Plantations Ltd	The Nature Conservancy
UK Department for International Development	SAGCOT	SAB Miller
GIZ	Global Water Partnership	University of Dar es Salaam
USAID	Lake Nyasa Basin Water Board	Tanzania Investment Centre
The World Bank	Lake Ruvuma Basin Water Board	International Union for Conservation of Nature
DAWASCO	Lake Tanganyika Basin Water Board	Lake Victoria Environmental Management Project
DAWASA	Pangani Basin Water Board	Jain Irrigation System Ltd.
WWF—Tanzania	Rufiji Basin Water Board	Agro EcoEnergy Tanzania Limited
Water Aid	Ruvuma River & Southern Coast Basin Board	
FAO	Lake Victoria Basin Water Board	

Central to its approach, the 2030 WRG is able to leverage its unique public-private-expert-civil society network through powerful convening platforms to help government water officials and water professionals work with existing key users and bring new actors into the national water debate.

This assignment forms the initial working activity of the 2030 WRG Tanzania Partnership. It was therefore essential to engage with a wide range of stakeholders throughout the assignment for the following reasons:

- To provide overall awareness of the 2030 WRG Tanzania Partnership and highlight that this assignment is the first phase of an ongoing long term commitment to tackle sustainable water resource management for economic growth;
- To make it clear that the 2030 WRG Tanzania Partnership objectives are to complement and bolster existing activity that stakeholders may be undertaking and are not designed to replicate or compete with their initiatives;
- To gain awareness of the initiatives/schemes that they are engaged in, in relation to water security and water resource management, which would be useful for this assignment;
- To gain referrals to key reports and documentation, and other relevant organizations with whom the project team and the 2030 WRG should make contact during the first assignment; and
- To ask specific questions from the project team.

As a multi-stakeholder partnership it was important to engage with existing and new actors within Government departments, NGO's, IFI's, utilities and the private sector. The private sector are particularly important to the 2030 WRG as they often represent the most important water user as they depend on water resources either directly, as a manufacturing or producing industry and/or indirectly as a producer or purchaser of agricultural products. The private sector also have the ability to act swiftly, can have knowledge to share at a national and international level and represent different and sometimes often competing interests to other stakeholders and are therefore very important in the discussion of trade-offs. In addition, as water is often a prerequisite for private sector growth and the private sector is important for overall economic growth of the country, politicians are willing to engage with them to help trigger action.

The project delivery team agreed on an initial target list of stakeholders with the 2030 WRG Project Officer at project inception and the list was updated as new information became available during the course of the assignment. Face to face meetings were arranged wherever possible throughout the five week period in country or by telephone conference when this was not practical.

The Ministry of Water, as the key 2030 WRG partner, was a central stakeholder and source of key information. Figure A.1 highlights the different stakeholders who were consulted during the assignment. These stakeholders, together with others that attended the first 2030 WRG Tanzania Partnership Kick-Off workshop are highlighted in Table A.1

APPENDIX B. The 2030 WRG Tanzania Partnership Kick-Off Workshop

The Kick-off Workshop of the 2030 Water Resources Group Partnership in Tanzania was held on 27th November 2013 at the Hyatt Regency, Dar es Salaam.

A key goal of the Workshop was to emphasize the point that the 2030 WRG Tanzania Partnership was to be "owned" by stakeholders in Tanzania and that the stakeholders should agree on the focus of future work areas. The specific objectives and expected outcomes of the workshop were as follows:

- Convene stakeholders of the 2030 Water Resources Group Tanzania Partnership together for the first time;
- Raise awareness of the partnership to a wider audience; and
- Identify and agree on the key focus areas for the partnership to address.

The delegates invited to the workshop ensured there was multi-sector representation which included the following: Government ministries (including: Water, Finance, Prime Minister's Office, Agriculture Food Security and Cooperatives), basin water boards; the private sector (including: Nestle, Tanzania Breweries, Coca Cola, PepsiCo), IFIs (including: GIZ, USAID, DIFID) and NGO's (including SAGCOT, Water Aid, iWASH, WWF and the Nature Conservancy).

In the first morning session, welcoming remarks were given by Mr. Obey Assery, Director of Sector Coordination within the Prime Minister's Office; by Anders Berntell, Executive Director of the 2030 WRG; and by Deputy Permanent Secretary of the Prime Minister's office, Ms. Reginal Kikuli, who represented the Minister for Water. Following an overview of the goals and objectives of the workshop provided by the workshop moderator Mr. Meraji Msuya, Anders Berntell gave a presentation on the objectives of the 2030 WRG, and specifically on how hydro-economic analysis can help countries prioritize actions to achieve sustainable water resource management for long-term economic growth. The final morning session was a presentation by AMEC on the summary of Tanzanian hydro-economic analysis undertaken as part of the preliminary phase of the partnership. Following this presentation a discussion was held among all delegates to query and validate the outputs of the analysis undertaken.

The afternoon's session focused on taking the key outputs of the hydro-economic analysis provided by AMEC and agreeing on the next steps. Specifically, the delegates were split into eight separate groups, with each group comprising of a mix of representative sectors, and were tasked with the following questions to discuss and report back:

1. Based on the overview the consultants provided, what are key geographic areas with competing water demands that would benefit from further in-depth hydro-economic analysis?

2. For a multi-stakeholder platform on water in Tanzania, what would be the most important focus areas to address the existing and future water scarcity challenges, etc.? (e.g., improving water use efficiency, achieving water security).

The key conclusions from the break-out session were as follows:

1. Key geographic areas benefiting from further in-depth hydro-economic analysis:
   - While many different basins were mentioned by each of the groups, three basins were most frequently identified as able to benefit from additional and more detailed hydro-economic analysis: Wami-Ruvu, Rufiji and the Pangani;
   - In addition, it was suggested that basins which were on the cusp of significant economic growth could also be analyzed;
   - It was proposed that the consultant could review each IWRMDP and prioritize a list of geographic areas with competing current and projected demand issues; and
   - It was proposed that the consultant could review all water basins and assess how to optimize water resource for various water uses;

Key focus area to address the existing and future water scarcity challenges:

- Water use efficiency;
- Water security;
- Inter-sectoral coordination;
- Water source protection; and
- Enhanced environmental conservation.

Figure B.1 Delegates at the Kick-off Meeting of the 2030 WRG Tanzania Partnership

APPENDIX C. Climate Change and Water Availability

One of the most widespread and potentially overwhelming impacts of climate change in Tanzania is likely to be changes in the frequency, intensity, and predictability of rainfall. Projections of climate change propose that by 2050 Tanzania will experience warmer temperatures with 5–10 percent less rainfall June–August and 5–20 percent more rainfall December–February (Hulme et al., 2001[53]; IPCC, 2001[54]). These adjustments in regional precipitation will likely vary and come with increased intensities of both flood and erosion events. It is expected that there will be less precipitation in Tanzania during the already dry season, which may cause more frequent and severe droughts increased desertification in the region, significantly impacting water availability. Research suggests that warming sea surface temperatures in addition to inter-annual climate variability (i.e., El Niño/Southern Oscillation (ENSO)) plays a key role in East African rainfall and may be linked to the change in rainfall across some parts of equatorial–subtropical East Africa (Rowe, 2001[55]). Warm sea surface temperatures are thought to be responsible for the recent droughts in equatorial and subtropical Eastern Africa during the 1980s to the 2000s (Funk et al., 2005).[56] While not yet impacting Tanzania in the same manner as countries such as Ethiopia, drought diminished water supplies reduce crop productivity and have resulted in widespread famine in East Africa (WWF, 2006[57]).

In addition to declining soil moisture required for agriculture, water availability for human consumption is a major concern. High temperatures and reduced rainfall during already dry months in Tanzanian river catchments could affect the annual flow of rivers such as the Pangani and Ruvu by 6–10 percent (VPO-URT, 2003[58]). The Pangani basin is fed by the Kilimanjaro glaciers, a resource that has been melting fast and is estimated to disappear completely by 2020 (Thompson et al., 2002[59]). The population living around the base of Kilimanjaro uses this meltwater for drinking, irrigation, and hydropower. The Pangani basin is one of Tanzania's most agriculturally productive areas and is an important hydropower production region. Because of this, climate change threatens the productivity and sustainability of the region's resources, which currently support 3.7 million people. Across Tanzania reduced flow due to declining regional rainfall has had ecological and economic impacts such as water shortages, lowered agricultural production, increased fungal and insect infestations, decreased biodiversity and variable hydropower production (WWF, 2006; Orindi and Murray, 2005[60]).

Occurrence of more extreme events poses a significant challenge for water planning and management processes. The severe water scarcity during drought periods has resulted in significant loss of productivity and led to an escalation of conflicts between competing water users. For example in the Great Ruaha sub-basin, serious water use conflicts arise during the dry season when excessive upstream irrigation withdrawals cause the river to dry up for several weeks, with critical environmental, ecological, and hydropower consequences. These conflicts are likely to get worse as climate change exacerbates the severity and frequency of future droughts and floods which destroy properties and human life and damage crops and rural infrastructure, along with general disruption of socio-economic activities.

There is therefore a need to plan now for mitigation of these more extreme events in the future, including measures such as construction of flood control and storage infrastructure to capture flood waters for use during dry periods; development of comprehensive water resources management and development plans that take into account the impacts of simultaneous demands and climate change and variability; and development of modern flood and drought forecasting and early warning systems to enable timely implementation of mitigation and evacuation contingency measures, and climate change forecasting.

Climate change forecasting will involve retrieval of IPCC (Inter-Governmental Panel for Climate Change) precipitation and temperature scenarios for the Tanzania region, and downscaling of the precipitation and temperature fields onto a scale compatible with the size of the key basins of interest. The downscaled precipitation and temperature sequences will be used together with future demand scenarios as input to the water balance models to assess future water stress conditions and mitigation measures. Demand change forecasting will be undertaken for target dates (e.g., 2025, 2050) for each major water sector and other environmental/ecological water uses. Updates to these climate change forecasts will be made as new IPCC models and projections data comes on-line.

APPENDIX D. Main Irrigation Systems

The National Irrigation Policy (2010) summarizes the main type of irrigation systems in operation as:

Traditional irrigation schemes (Informal): Traditional irrigation is constructed and managed by local farmers using their own skills and local materials. Diversion weirs or temporary canal intakes are often destroyed by flood and reconstructed by farmers. Canals are earthen and usually of inadequate capacity to supply water to the entire community. These poor infrastructure schemes are characterized by poor water management, low water use efficiencies and low crop yields.

Rainwater harvesting schemes (Informal): These schemes collect runoff from a large area or collect water from seasonal and ephemeral streams and use it to irrigate a smaller targeted area. The objective is simply to capture as much water as possible and store it within bunds in the soil profile or in a small storage reservoir. Information is not available on the extent of this type of scheme. These poor infrastructure schemes are characterized by poor water management, low water use efficiencies and low crop yields.

Improved traditional irrigation schemes (Formal): Improved versions of the traditional schemes may have concrete diversion weirs, gated canal intakes, better layout of canals and water diversion boxes, among other modifications. The schemes have usually been developed through government or aid funds. These schemes typically result in enhanced water use efficiency and crop yield.

Large scale commercial irrigation schemes: A few commercial farmers are using conventional pressurized sprinkler irrigation abstracting water by pump from either ground or surface waters. Drip irrigation is also used in limited circumstances mainly for the production of high value crops such as flowers, vegetables, coffee and tea. These schemes are well maintained and have higher water use efficiencies.

ENDNOTES

1 Falkenmark, M., 1989. The massive water scarcity threatening Africa–why isn't it being addressed. *Ambio* 18, no. 2 : 112–118.

2 http://www.tanesco.co.tz/index.php?option=com_content&view=article&id=70&Itemid=158

3 As set out in MKUKUTA and the Big Results Now initiative.

4 Most recent figures available. UNICEF/WHO JMP 2010.

5 Hepworth, N. D., 2010. Vulnerability to climate change in Tanzania, An assessment to support DFID Tanzania's Strategic Programme Review, Department of International Development–Tanzania.

6 http://www.egov.go.tz/egov_uploads/documents/Water_Policy_en.pdf

7 Water P-Notes (January 2009). Improving Water Security for Sustaining Livelihoods and Growth in Tanzania. World Bank.

8 Madulu 2002, Mbonile 2005, Burgess et al. 2005, Nkini, E., pers. comm., 15 January 2006.

9 World Bank Statistics on GDP taken from http://data.worldbank.org/indicator/NY.GDP.MKTP.CD, accessed 4th January 2014.

10 East African Community: Burundi, Kenya, Rwanda, Tanzania, and Uganda.

11 World Bank, 2008. Sustaining and Sharing Economic Growth in Tanzania. Ed R Utz.

12 National Bureau of Statistics, 2011. National Accounts of Tanzania Mainland (NBS).

13 The Tanzania Growth Diagnostic—Partnership for Growth (2011), a joint analysis for the Governments of the United Republic of Tanzania and the USA.

14 United Republic of Tanzania, 2011. The Economic Survey 2011. President's Office, Planning Commission.

15 Big Results Now and Tomorrow: Managing Water to Meet Tanzania's Development Targets; World Bank, Draft Discussion Brief, October 2013.

16 United Republic of Tanzania. Agricultural Sector Development Programme.

17 JICA. 2002. The Study on the National Irrigation Master Plan in the United Republic of Tanzania. Vol I (Main report). Ministry of Agriculture and Food Security.

18 Agricultural Water Management National Situation Analysis Brief, Agwater Solutions, November 2011.

19 http://www.fao.org/nr/water/aquastat/countries_regions/tanzania/index.stm.

20 Ministry of Water and Livestock Development, 2002. National Water Policy. The United Republic of Tanzania.

21 Ministry of Water and Livestock Development, 2006. National Water Sector Development Strategy. The United Republic of Tanzania.

22 Ministry of Water, 2006. Water Sector Development Programme (2005–2025). The United Republic of Tanzania.

23 http://www.maji.go.tz/modules/documents/index.php?action=downloadfile&filename=THE%20WATER%20RESOURCES%20MANAGEMENT%20ACT.pdf&directory=Water%20Legislation&

24 Kashaigili, J.K., 2010. Assessment of the groundwater availability and its current and potential use and impacts in Tanzania.

25 SMEC, 2013. Preparation of an integrated water resources management and development plan for the Lake Tanganyika Basin. Groundwater resources assessment report.

26 SMEC, 2013. Preparation of an integrated water resources management and development plan for the Lake Nyasa Basin. Groundwater report.

27 Atkins, 2013. Preparation of an Integrated Water Resources Management and Development Plan for the Ruvuma River and Southern Coast Basin. Component 1: Review and Inventory of Water Use and Demand and Water Resources Assessment. Volume 2: Groundwater Resource Assessment.

28 JICA, 2013. The study on water resources management and development in the Wami/Ruvu in the United Republic of Tanzania. Draft Final Report.

29 SMEC, 2013. Preparation of an integrated water resources management and development plan for the Pangani Basin. Interim Report 2, Climate Change Assessment.

30 ERM, 2013. Southern Agricultural Growth Corridor of Tanzania (SAGCOT) Strategic Regional Environmental and Social Assessment. Revised Draft Final Report. Government of Tanzania.

31 WREM, 2012. Rufiji Integrated Water Resources Management and Development Plan, Interim Report, Volume III. Current Water Use and Infrastructure Assessment.

32 A guide to wetland friendly investments: Sustainable irrigation management in wetlands (2012). The United Republic of Tanzania Ministry of Natural Resources and Tourism Wildlife Division.

33 Why developing countries need dramatic increase of water resources productivity. (2008) Ministry of Water and Irrigation United Republic of Tanzania.

34 National Irrigation Master Plan, 2002. Ministry of Agriculture, Food Security and Cooperatives.

35 International Commission on Irrigation and Drainage: http://www.icid.org/v_tanzania.pdf (accessed on 12th December 2013).

36 Ministry of Water and Irrigation, 2010. National Irrigation Policy. The United Republic of Tanzania

37 http://www.fao.org/nr/water/infores_databases_cropwat.html (accessed 4th January 2014).

38 Ministry of Water, 2009. Ministry Design Manual for Water Supply and Waste Water, 3rd Edition.

39 Ministry of Water, 2013. Water Sector Development Plan Review

40 WREM, 2012, Lake Rukwa Basin IWRMD Plan: Draft Interim Report I, Volume III: Current Water Demand and Use Assessment.

41 SMEC, 2013. Preparation of an integrated water resources management and development plan for Lake Nyasa Basin, Surface Water Resources Assessment Report.

42 Ministry of Water, 2013. Water sector development programme, Water Sector Status Report.

43 SMEC, 2013. Preparation of an integrated water resources management and development plan for the Pangani Basin. Water Resources Assessment Report.

44 JICA, 2013. The study on water resources management and development in the Wami/Ruvu in the United Republic of Tanzania. Draft Final Report.

45 Hirji, R. and R. Davis, 2009. Environmental Flows in Water Resources Policies, Plans, and Projects—Case Studies. Natural Resource Management Series. The World Bank Environment Department.

46 Dickens, C. 2011. Critical analysis of environmental flow assessments of selected rivers in Tanzania and Kenya. Nairobi, Kenya: IUCN ESARO office and Scottsville, South Africa: INR. Viii+104pp

47 URT, 2012. Sustainable Wetlands Management Program – A Guide to Wetland Friendly Investments: Sustainable Irrigation management in Wetlands.

48 URT, 2009. Environmental Flow Assessment Final Report.

49 Groundwater also provides water in parts of Dar es Salaam where there is no distribution network.

50 Yawson, D.K., J.J. Kashaigili, R.K. Kachroo, and F.W. Mtalo, 2003. Modelling the Mtera-Kidatu Reservoir System to improve Integrated Water Resources Management. International Conference on Hydropower (Hydro Africa 2003), 17th-19th Nov. 2003, Arusha, Tanzania.

51 ERM, 2013. Southern Agricultural Growth Corridor of Tanzania (SAGCOT) Strategic Regional Environmental and Social Assessment. Interim report. Government of Tanzania.

52 http://www.fao.org/docrep/w7314e/w7314e0h.htm . (accessed 1st May 2014).

53 Hulme, M., R. Doherty, T. Ngara, M. New, D. Lister. 2001. African climate change: 1900—2100. *Climate Research* 17: 145-168.

54 Intergovernmental Panel on Climate Change. 2001. Climate Change 2001. Synthesis report. Cambridge University Press. Cambridge.

55 Rowe, D.P. 2001. Teleconnections between the tropical Pacific and the Sahel. *Quarterly Journal of the Royal Meteorological Society* 127: 1683-1706.

56 Funk, C., G. Senay, A. Asfaw, J. Verdin, J. Rowland, J. Michaelson, G. Eilerts, D. Korecha and R. Choularton. 2005. Recent drought tendencies in Ethiopia and equatorial-subtropical eastern Africa. Washington DC, FEWS-NET.

57 Case, M. 2006. Climate Change Impacts on East Africa: A Review of the Scientific Literature. WWF-World Wide Fund For Nature.

58 Vice President Office, United Republic of Tanzania, 2003. Initial National Communication Under the United Nations Framework Convention on Climate Change (UNFCCC).

59 Thompson, L.G., E. Mosley-Thompson, M.E. Davis, K.A. Henderson, H.H. Brecher, V.S. Zagorodnov, T.A. Mashiotta, P-N. Lin, V.N. Mikhalenko, D.R. Hardy and J. Beer. 2002. Kilimanjaro ice core records: evidence of Holocene climate change in tropical Africa. *Science* 298: 589—593.

60 Orindi, V. A., and L.A. Murray. 2005. Adapting to climate change in East Africa: a strategic approach. Gatekeeper Series 117: International Institute for Environment and Development.

REFERENCES (PARTIAL LIST)

Atkins. 2013. Preparation of an Integrated Water Resources Management and Development Plan for the Ruvuma River and Southern Coast Basin. Component 1: Review and Inventory of Water Use and Demand and Water Resources Assessment. Volume 2: Groundwater Råesource Assessment.

Case, M. 2006. Climate Change Impacts on East Africa: A Review of the Scientific Literature. World Wide Fund for Nature (WWF).

Dickens, C . 2011. Critical analysis of environmental flow assessments of selected rivers in Tanzania and Kenya. IUCN ESARO: Nairobi, Kenya ; and INR: Scottsville, South Africa.

ERM. 2013 Southern Agricultural Growth Corridor of Tanzania (SAGCOT) Strategic Regional Environmental and Social Assessment. Revised Final Draft Report. Government of Tanzania.

ERM. 2013. SAGCOT Strategic Regional Environmental and Social Assessment. Interim Report. Government of Tanzania.

Falkenmark, M. 1989. The Massive Water Scarcity Threatening Africa—why isn't it being addressed. *Ambio* 18, no. 2: 112–118.

FAO. Economics of irrigation at http://www.fao.org/docrep/w7314e/w7314e0h.htm, (accessed May 1, 2014).

FAO. Cropwat database at http://www.fao.org/nr/water/infores_databases_cropwat.htm, (accessed January 4, 2014).

Funk, C. et al. 2005. Recent drought tendencies in Ethiopia and equatorial-subtropical eastern Africa. FEWS-NET: Washington, DC.

Government of Tanzania. 2009. Water Resources Management Act.

Government of Tanzania. 2008. National Water Sector Development Strategy.

Government of Tanzania. 2002. The National Water Policy.

Hirji, R., and Davis, R . 2009. Environmental Flows in Water Resources Policies, Plans, and Projects—Case Studies. Natural Resource Management Series. The World Bank Environment Department.

Hulme, et al. 2001 M., R. Doherty, T. Ngara, M. New, D. Lister. 2001. African climate change: 1900—2100. *Climate Research* 17: 145–168.

IPCC. 2001. *Climate Change 2001.* Synthesis Report. Cambridge University Press: Cambridge.

JICA. 2013. The study on water resources management and development in the Wami/Ruvu in the United Republic of Tanzania. Draft Final Report.

Katambara, Z. 2013 Zacharia Katambara1, Frederick C. Kahimba, Winfred B. Mbungu, Paul Reuben, Muyenjwa. Maugo, Fikiri D. Mhenga, and Henry F. Mahoo. 2013. Optimizing System of Rice Intensification Parameters Using Aquacrop Model for Increasing Water Productivity and Water Use Efficiency on Rice Production in Tanzania. Journal of Agriculture and Sustainability, Volume 4, Number 2, 235–244.

Nyerere, Julius K. 1958. Comments addressing the 34th Palimentary Session on the Water Bill. Hansard.

Orindi and Murray. 2005. Orindi, V. A., and L.A. Murray. 2005. Adapting to climate change in East Africa: a strategic approach. Gatekeeper Series 117: International Institute for Environment and Development.

Sokile, C.S., Kashaigili, J.J., and Kadigi, R.M.J., 2003, Towards an integrated water resource management in Tanzania: the role of appropriate institutional frameworks in Rufiji Basin. Physics and Chemistry of the Earth 28: 1015–1024.

SMEC. 2013. Preparation of an integrated water resources management and development plan for the Lake Nyasa Basin. Groundwater report. SMEC, 2013. Preparation of an integrated water resources management and development plan for the Pangani Basin. Interim Report 2, Climate Change Assessment.

KFW-ENTWICKLUNGSBAN (2006) Tanzania: Lower Kihansi Hydropower Station Ex Post Evaluation.

URT 2007. Lower Kihansi Environmental Management Project. Lower Kihansi Environmental Management Project (Lkemp): Issues Paper For The Proposed Population And Habitat Viability Assessment (Phva) Workshop For The Preparation Of Recovery Plan For The Kihansi Spray Toad (Nectophrynoides Asperginis)

URT. 2012. URT, 2012. Sustainable Wetlands Management Program – A Guide to Wetland Friendly Investments: Sustainable Irrigation management in Wetlands.

URT. 2009. Environmental Flow Assessment. Final Report.

URT 2007. National Adaptation Programme Of Action (NAPA). Vice Presidents Office. Division of Environment.

URT. 1994. National Irrigation Development Plan (NIDP). Agriculture and Irrigation Department.

Vice President Office, United Republic of Tanzania, 2003. Initial National Communication Under the United Nations Framework Convention on Climate Change (UNFCCC).

World Bank. 2013. Big Results Now and Tomorrow: Managing Water to Meet ...

WREM. 2012. Lake Rukwa Basin IWRMD Plan: Draft Interim Report I, Volume III: Current Water Demand and Use Assessment.

WWF. 2006. Rufiji Integrated Water Resources Management and Development Plan, Interim Report, Volume III. Current Water Use and Infrastructure Assessment.

Yawson, 2003. Yawson, D.K., J.J. Kashaigili, R.K. Kachroo, and F.W. Mtalo, 2003. Modelling the Mtera-Kidatu Reservoir System to improve Integrated Water Resources Management. International Conference on Hydropower (Hydro Africa 2003), 17th-19th Nov. 2003, Arusha, Tanzania

ACRONYMS

AMEC	AMEC Environment and Infrastructure UK Ltd
BBM	Building Block Methodology
ASDP	Agricultural Sector Development Programme
BWB	Basin Water Boards
BRN	Big Results Now initiative
EF	environmental flow
ENSO	El Nino/Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
FWSI	Falkenmark Water Stress Indicator
GCM	global circulation model
GDP	gross domestic product
HGW	Higher Groundwater estimate
IDB	Internal Drainage basin
IEA	International Energy Agency
IFC	International Finance Corporation
IPCC	Inter-Governmental Panel on Climate Change
ITCZ	Inter-tropical Convergence Zone
IWRMDP	Integrated Water Resource Management Development Plan
JICA	Japan International Cooperation Agency
LGW	Lower Groundwater estimate
MKUKUTA	Tanzania's National Strategy for Growth and Reduction of Poverty
MKUZA	Zanibar's Strategy for Growth and Reduction of Poverty
MCM	million cubic meters
NAWAPO	Tanzania's National Water Policy
NBS	National Bureau of Statistics
NIDP	National Irrigation Development Plan
NIMP	National Irrigation Master Plan
NRW	non-revenue water
NWSDS	National Water Sector Development Strategy
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SMEC	
SRI	System of Rice Intensification
WUA	Water Users Association
WEF	World Economic Forum
WEF WI	WEF Water Initiative
WRMD	Water Resource Management and Development
WSDP	Water Sector Development Programme