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Valuing Water in Tanzania: Contribution to Selected Economic Sectors

DELIVERABLE 4: FINAL REPORT - AGRICULTURE, MANUFACTURING, AND MINING

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About GWP

The Global Water Partnership (GWP) vision is for a water secure world. Our mission is to advance governance and management of water resources for sustainable and equitable development. GWP is an international network that was created in 1996 to foster the implementation of integrated water resources management: the coordinated development and management of water, land, and related resources to maximise economic and social welfare without compromising the sustainability of ecosystems and the environment. The GWP Network is open to all organisations which recognise the principles of integrated water resources management endorsed by the GWP Network. It includes states, government institutions (national, regional, and local), intergovernmental organisations, international and national non-governmental organisations, academic and research institutions, private sector companies, and service providers in the public sector. The Network has 13 Regional Water Partnerships, 77 Country Water Partnerships, and more than 3,000 Partners located in 183 countries. The views expressed in this document do not necessarily represent the official views of GWP

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As part of *Value Water Initiative*[2] and the technical assistance given to the Government of Tanzania, the SDG 6 IWRM Support Programme has identified that policy makers and financial decision-makers would be much better equipped to make more informed decisions on how to solve water security issues if they were given a complete picture of the value that water brings to specific economic sectors.

A special mention goes to the Ministry of Water which gave close guidance and advice during the competition of this study, in particular Mrs. Pamella C. Temu, Assistant Director of Water Resources Planning, Monitoring and Assessment, and Dr. Victor Kongo, Director of GWP Tanzania, who provided invaluable support to understand the economics and politics of water in Tanzania.

[1] See www.gwp.org/en/sdg6support/about/the_programme/about/
[2] See https://valuingwaterinitiative.org/

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List of Abbreviations / Acronyms

AIP: Continental Africa Water Investment Programme

BWB: Basin Water Board

BWO: Basin Water Office

ESG: Environment and social governance

GDP: Gross Internal Product

GIZ: German Cooperation Agency by its acronym in German.

GoT: Government of Tanzania

GWP: Global Water Partnership

ISIC: International Standard Industrial Classification of All Economic Activities

IUCN: International Union for Conservation of Nature

IWRM: Integrated Water Resources Management

IWRMDP: Water Resources Management and Development Plans
JICA: Japanese International Cooperation Agency
MCM: Million Cubic Meters
MoW: Tanzania Ministry of Water
NBS: Tanzania National Bureau of Statistics
NIMP 2018: National Irrigation Master Plan 2018
OECD: Organisation for Economic Cooperation and Development
SEEA: System of Environmental-Economic Accounting
SPSS: Statistical Package for the Social Sciences. Software from IBM.
SNA: System of National Accounts
TZS: Tanzanian Shillings
USAID: United States Agency for International Development
USD: US Dollars
WEI: Water Exploitation Index
WSDP: Water Sector Development Program 2006-2025
WSSR: Water Sector Status Report

Key Quantitative assumptions

- The exchange rate to convert TZS to USD is as follows:
    - For 2021: 2297.84 (TZS/USD)[3] (2021 current prices)
    - For 2020: 2293.49 (TZS/USD)[4] (2020 current prices)
- The consumer price index of 2020 for Tanzania was 3.2%[5].

[3] Average daily mean rate reported by the Bank of Tanzania: https://www.bot.go.tz/ExchangeRate/previous_rates
[4] Ibid.
[5] Average from January to December reported for Tanzania on: https://www.nbs.go.tz/index.php/en/consumer-price-index-cpi/587-annual-headline-inflation-rates-for-some-neighbouring-countries-december-2020

Executive Summary

Abstract

The objective of this pilot study was to value the contribution of water to three of the most important economic sectors in Tanzania, namely agriculture, manufacturing, and mining. The results reveal that the lower bound contribution of water to Tanzania's economy, using estimates limited to the Agricultural, Manufacturing and Mining sectors, is 5,177,107 million USD (2,253,094,565 million TSH), which is equivalent to 3.21% of Tanzania's GDP (based on 2021 prices). At the regional level, the value of water for the Wami/Ruvu basin is equivalent to 0.71% of Tanzania's GDP. This result was reached by implementing scaled-down approaches using market price data and proportional production costs functions as valuation methodologies. These results are the lowest quantifiable bound of the water value in Tanzania, which means that if further efforts were to be made to refine this quantitative exercise, the value of water would only increase. The information used was derived from the Annual Survey of Industrial Production 2016 and the National Agricultural Census Survey 2019-2020. Where nation-wide statistics were lacking, sub-national proxies, especially from the Wami/Ruvu Basin, were used.

The study concludes that Tanzania needs to transition from plans to action and that investments in irrigation for agriculture should have a high priority for Tanzania's government as its economic and social return are not arguable. This needs to be carried out together with investments in monitoring and assessing water resources to deal with scarcity when extreme climate events, such as droughts and floods, impact the country. Consequently, water allocation management, based on reliable hydrological data, becomes an urgent issue to be tackled to avoid water conflicts in the future and the consequent negative impact on Tanzania's economy.

Purpose

The aim of this study is to estimate the contribution of water to the national economy. To achieve this aim, we employed a methodology based on Production Function and Market Prices valuation methodologies combined with scaled-down approaches. The specific objectives of this study are focusing on the value allocated to water, to provide methodological reflections and insights on evaluating the economic contribution of water and suggest recommendations on strengthening the investment rationale for water. As such, the broader intention of this study is to assist decision-makers with valuable insights on the value of water in the selected sectors so that they can take informed decisions to improve public policies and mobilise political will towards investing further in water, recognising the economic value at risk from continued underinvestment in water.

Methodology

The methodological approach used to carry out the study is based on the analytical framework provided by the *"World Water Development Report 2021: Valuing Water"* (United Nations, 2021) and in IUCN's guide *"Value, Counting Ecosystem as Water Infrastructure"* (Emerton, L., and Bos, E., 2004). The overall approach consisted of identifying an initial group of methodologies that could be implemented, determining information requirements, and then collecting the available information. The latter allowed the authors to conclude that cost-based approaches had the best possibilities for the study. The available information, mainly from the Annual Survey of Industrial Production 2016

(NBS, 2018a) and the National Agricultural Census Survey 2019-2020 (NBS, 2020b), allowed the authors to develop the final calculations based on scaled-down approaches of the Production Function and Market Prices valuation methodologies.

Key Findings

The valuation results reveal that the lower bound contribution of water to Tanzania's economy, using estimates limited to the Agricultural, Manufacturing and Mining sectors, is 5,177,107 million USD (2,253,094,565 million TSH), which is equivalent to 3.21% of Tanzania's GDP (based on 2021 estimates). This result does not consider non-economic values of water, such as for spiritual, cultural, health or recreational purposes. The value of water in the agricultural sector is the most significant, followed by the value of water in the mining sector.

Consolidated results of water valuation for Wami/Ruvu Basin and Tanzania Mainland (Current prices 2021)

Sector	Subsector	*Value of water for the Wami/Ruvu Basin (TZS/year)*	*Value of water for the Wami/Ruvu Basin (USD/year)*	*National Value of water (TZS/year)*	*National Value of water (USD/year)*	*Proportion of the value of water in the 2021 GDP*
Agriculture	Crops	978,487,170,397	425,829,744	4,152,426,123,400	1,807,342,935	2.57%
	Livestock	87,877,363,246	38,243,521	786,836,132,180	342,600,801	0.49%
Manufacturing		10,829,121,823	4,712,747	31,587,910,123	13,332,301	0.02%
Mining and Quarrying		63,085,303,440	27,454,216	206,257,522,364	89,818,527	0.13%
Total		**1,140,278,958,905**	**496,240,228**	**5,177,107,688,068**	**2,253,094,565**	**3.21%**

Source: Elaborated by authors.

Other main findings include:

- **Expected return ratio of bean irrigation is more than 4100%:** Based on a partial quantitative analysis for every TZS spent on irrigation for Beans Crop in the short Rainy Season, an output increase of 0.005 Kg will be achieved. In 2021 US Dollars, this means that for every USD 1 spent on bean irrigation during the short-rainy season, an increased output of 11.43Kg was estimated. Based on the price of Beans in 2021 of $ 3.64 USD/Kg, the expected return ratio of bean irrigation is more than 4100%.
- **Regarding the unit value of water for livestock: It was found that each cubic meter of water consumed by the livestock generates the following income:**
  - Cattle: 5,356 (TZS /m^3) (2.34 USD/m^3)
  - Goat: 2,169 (TZS /m^3) (0.95 USD/m^3)
  - Sheep: 1,114 (TZS /m^3) (0.49 USD/m^3)

  The latter means that cattle generate the most income per volume of water, followed by goats, which generate almost twice as much as sheep. This is a point to be considered in terms of public policy on the types of livestock that should be encouraged solely based on the income that it generates.
- **The manufacturing sector pays little for water**: Water costs, both supply and water treatment, represent an average of 0.05% of the income from the manufacturing sector. On the other hand, 99.7% of the water costs that were reported correspond to water

treatment. This means that getting access to water corresponds to 0.0004% of the production costs in the manufacturing sector of Tanzania.

- **The Government of Tanzania needs to go from plans to action:** The water sector in Tanzania has numerous diagnostics and third-party recommendations on water resources management compiled in public policy documents (sectoral strategies and implementation plans) that have not been translated into sufficient investments in water resources management to protect and potentialise its water endowment. As per 2020, SDG 6, in particular "Implementation of Integrated Water Resources Management (IWRM)" has a medium-to-low performance related to "*Instruments to monitor and manage water resources"* and *"Budgets and revenue raising for IWRM and infrastructure".*
- **Basin Water Boards (BWBs) are underfunded:** The evaluation of Water Sector Development Programme (WSDP) Phase I and Phase II regarding Water Resources Management reiterates that underfunding of BWBs and the Ministry of Water (MoW) due to national budget restrictions and prioritisation of investments in urban and rural water access and sanitation over water resources management has derived in understaffing of these institutions and, consequently, in a low capacity to execute urgent investments to face water insecurity in the long-term.
- **Investments in irrigation for agriculture need to be reprioritised:** As the calculation of cost-benefit analysis demonstrates, investments in irrigation have high economic and social returns. However, they need to be carried out together with investments in monitoring and assessing water resources to deal with scarcity when extreme climate events, such as droughts and floods, impact the country. Consequently, water allocation management, based on reliable hydrological data, becomes an urgent issue to be tackled to avoid future water conflicts. Not only are investments in data and information essential but also in water infrastructure to hedge against water scarcity and the impact of climate change.

Limitations and Interpretation

Water resources information is not centralised in a single source (e.g., MoW or the National Bureau of Statistics). General information on the water sector is compiled in government or independent organisations' reports carried out in different periods and formats. However, no data is collected systematically and periodically, which is essential to implement any valuation methodology and manage water resources appropriately and successfully. The geographic scale used to report information varies by thematic area. For example, water allocations are reported by basin. In contrast, statistics on production and prices are reported by region, but one region can be split into two or more basins. Based on the available information and due to the importance of the basin, we selected the Wami/Ruvu watershed as a case study for deriving basin-level calculations and estimates.

The valuation results that equate to 3.21% of Tanzania's 2021 GDP are the lowest quantifiable bound of the value of water in the selected sectors; this means that if further efforts were to be made to refine and expand this quantitative exercise, the value of water would only increase. This allows the authors to conclude that what users currently pay for water in the different sectors does not reflect the value of water.

Structure of the document

Chapters 1 provides context on Tanzania's socio-economic development and its water resources, the objective of the study, and the criteria for deciding on sectors for valuation. Chapter 2 explains in detail the methodological approach and the limitations of information. Chapters 3, 4, and 5 show results on valuations for Agriculture, Manufacturing, and Mining respectively, and their interpretation. Chapter 6 analyses strategies and implementation plans that focus on investments in water resources management and their impact on water security, suggesting recommendations for future water valuations.

1 Introduction

1.1 Background

> *"Our economic systems by and large fail to account for the value of water. This leads to the excessive and unsustainable use of finite freshwater resources and a corresponding lack of access for the poor and vulnerable in many places. We must systematically incorporate the values of water into decision-making, so it can be used far more efficiently in every sector, more equitably in every population and more sustainably, both locally and globally. Consistent with the 2022 Global Biodiversity Framework, we must move forward in accounting for the multiple benefits of freshwater, which is a core element of the Earth's natural resources. Water must be made visible on public and private balance sheets through natural resource accounting."*
>
> *Global Commission on the Economics of Water (2023: 20)*

As United Nations argues, "*better measurement, monitoring and understanding of the values of water, and their incorporation into improved decision-making frameworks enable the equitable comparison of multiple values of water held by multiple stakeholder groups, and are essential for achieving sustainable water resources management*" (UN, 2021: 20). Put simply, giving value to water incentives its efficient use and avoids its wastage, misuse, and misappropriation by different stakeholders. Indeed, neglecting the real value to water has been a key barrier to adopt an Integrated Water Resources Management approach (IWRM), which is fundamental for any society to achieve water security in the long-term.

The quote used to introduce this report is indicative of the global urgency to assign an economic value to water but also to recognise its intangible cultural values. Valuing water is a first step to allocate more investments to water source protection and conservation, water access and sanitation for urban and rural populations, water infrastructure to increase productivity and competitiveness, and hedging the economy against extreme whether events and climate change impacts. From an instrumental perspective, water stands as one of the most strategic resources for economic growth and well-being.

This study aims to estimate the contribution of water to the economy of Tanzania. By doing so, it seeks to equip decision-makers with valuable insights on the value of water in selected economic sectors so that they can make informed decisions to improve public policies and mobilise political will towards investing further in water security. This study is aligned with the Continental Africa Water Investment Programme (AIP), a political initiative that has made a pledge of USD $50 billion annually for water investments to achieve SDG 6 by 2030. As argued by AIP, African countries are currently losing up to US$200 billion/year due to insufficient investment, coupled with the impacts of climate change and inefficiencies. Moreover, Sub-Saharan Africa loses 5% of its GDP annually (estimated at US$170 billion per year) because of a lack of water, contaminated water, or poor sanitation (AIP, 2023: 11).

In the case of Tanzania, valuing water becomes an opportunity to increase investments in water resources management. SDG 6 *"Ensure access to water and sanitation for all"* tracks performance of IWRM implementation through Indicator 6.5.1, which reports that Tanzania achieved 54% (Medium-High) of its goal in 2020, above the average of other African countries (United Nations, 2020). However, a detailed analysis shows the country is not performing well (Medium-Low) for Management Instruments (instruments to monitor and manage water resources and ecosystems, 46%) and Financing (budgets and revenue raising for IWRM and infrastructure, 42%).

The process of valuing water in a country like Tanzania faces considerable methodological challenges. Information related to water resources management is scarce, dispersed, and heterogeneous. On the other hand, most of water valuation methods that have been developed in the context of developed countries (TEEB, 2010), which means that little evidence and guidance exist on how to adapt them to countries like Tanzania. Nonetheless, results must be reliable enough to guide decisions on investments. Such reliability not only depend on how closely each methodology is followed, but also on the rigour applied when carrying out the analysis of available data and decisions on alternative routes to reach valuation results. As the United Nations Environment Program recommends, "*make the method fit the audience and the objectives of the study, and the valuation will be valuable*" (Rietbergen McCracken and Abaza, 2000).

A similar study conducted in Bangladesh by the World Bank and WRG 2030 provides insights on how to approach these methodological difficulties. It suggests starting with a simple approach to valuing water, for which data is already available, and then move to a more complex and holistic approach (Möller Gulland et al, 2020). Following that recommendation, this study employs a methodology based on Production Function and Market Prices combined with scaled-down approaches. This methodology uses information from solid national sources and interpreted them as market signals. By doing so, it obtains the lower bound of water's contribution to Tanzania's economy, specifically for the Agricultural, Manufacturing and Mining sectors. The lower bound is understood as the lowest value that can be extracted using the available information. Therefore, the overall value of water would increase by improving sources of information and including other type of values.

As this study also reports, Tanzania has not been investing enough resources in its water endowment, in particular activities such as institutional strengthening and data collection and processing. A recent evaluation shows that in the period 2016 to 2021, the Government mobilised US $864.5 million for the water sector. From that amount, only USD $41.6 million, equivalent to 4.81%, was invested in water resources management. Comparing the initial investment plan (USD $803.6 million) with the actual budget allocation (USD $41.6 million), effective expenditure was only 5.18%.

1.1.1 Socio-economic development

Tanzania has a total area coverage of 945,087 km2. Tanzania's Mainland is 881,300 km2, and 2,700 km2 is the size of Tanzania Isles (Zanzibar Islands). The projected population in 2021 was 59.4 million people, of which 57.7 million reside on the mainland, and 1.7 million are in Zanzibar (NBS, 2021). The population growth rate is 3.1%, where 54% of its population are youth (15 - 65 years old) and 43% are children (less than 15 years old), making it a nation of young people. In addition, 3% are elderlies (above 65 years old). Life expectancy is 66.3 years. 77% of its population resides in rural areas while 33% reside in urban areas. The urban population occupies 2% of the total geographical area (NBS, 2022b)[6].

In 2020, GDP was TZS 151.1 trillion (Table 1), growing at an average of 6.2% from 2015 to 2021 (Table 2). Main economics activities by GDP participation are Agriculture, Forestry, and Fishing with 28.5%, Industry and Construction with 32.1%, and Services with 39.4%. The total value of exports in 2020 was TZS 19,629,078 million, of which Goods represent 74.5% and Services 25.5% (Table 3). Gold is the main export product, which accounts for 48.6% of total exports. On the other hand, the seven main crops exported sum up less than 14% of total exports (Table 4).

Table 1. Gross Domestic Product by Kind of Economic Activity – Current Prices (TZS Million)

Sector	2015	2016	2017	2018	2019	2020r	2021p
Agriculture, forestry & fishing	25,234,560	29,739,111	34,154,594	35,962,728	37,192,537	39,965,584	42,233,161
Industry and Construction	23,103,647	26,937,139	29,735,584	34,851,874	39,944,212	44,950,342	47,844,421
Services	38,146,529	42,747,407	45,066,596	48,059,561	51,417,505	55,219,451	59,019,313
All economic activities	86,484,736	99,423,658	108,956,774	118,874,163	128,554,255	140,135,377	149,096,895
Taxes on products	7,864,579	8,938,667	9,787,724	10,169,738	11,087,600	11,031,006	12,428,863
GDP at Market Prices	**94,349,316**	**108,362,324**	**118,744,498**	**129,043,901**	**139,641,854**	**151,166,383**	**161,525,759**

Notes: r = revised; p = provisional **Source:** NBS, 2021a.

Table 2. Annual Growth Rates of Gross Domestic Product at 2015 Prices by Economic Activity for Tanzania Mainland, 2015 – 2021

Year	2015	2016	2017	2018	2019	2020r	2021p	2015-2021
Agriculture, Forestry & Fishing	5.4	4.8	5.9	5.3	4.4	4.9	3.9	**4.9**
Industry and Construction	9.7	11.7	10.6	9.7	11.6	7.3	5.5	**9.4**
Services	6.4	6.3	5.3	6.3	6.0	4.3	5.0	**5.7**
GDP at Market prices	**6.2**	**6.9**	**6.8**	**7.0**	**7.0**	**4.8**	**4.9**	**6.2**

Source: NBS, 2021a.

Table 3. Exports of Goods and Services - Current Prices, Tanzania Mainland, 2015–2021 (TZS Million)

Item	2015	2016	2017	2018	2017	2020r	2021p
Goods	8,708,690	9,177,377	10,057,801	9,720,087	12,305,450	14,620,151	15,522,420
Services	7,429,677	8,539,835	8,541,363	9,090,084	9,795,843	5,008,927	7,163,196
Total	**16,138,367**	**17,717,213**	**18,599,164**	**18,810,171**	**22,101,293**	**19,629,078**	**22,685,616**

Notes: r = revised; p = provisional | **Source:** NBS, 2021a.

Table 4. Major Exports by Type, Tanzania, 2017 – 2021 (TZS Billion)

Product	2016	2017	2018	2019	2020	2021	Part. % 2020
Tea	96.9	109.0	103.3	104.0	73.9	75.2	0.53%
Cashew nuts	756.9	1.200.5	287.9	821.9	824.6	363.0	5.94%
Coffee	224.2	282.4	337.5	351.0	331.5	354.8	2.39%
Cotton	100.5	80.3	157.2	212.0	199.8	185.9	1.44%
Cloves	22.5	121.2	0.7	20.8	38.9	118.4	0.28%
Sisal	32.3	57.7	46.9	53.8	40.1	46.1	0.29%
Tobacco	783.8	434.5	609.7	389.5	339.4	291.4	2.44%
Diamonds	164.3	143.0	184.2	185.0	46.1	19.4	0.33%

[6] Population statistics validated with *2021 Tanzania in Figures*, published by National Bureau of Statistics, United Republic of Tanzania. Cited in *IWRM Baseline and Action Rationale Document - United Republic of Tanzania,* draft document provided by GWP in August 2022.

Gold	3,072.7	3,418.9	3,435.7	5,043.1	6,752.4	6,257.3	48.64%
Subtotal	**5,254.1**	**5,847.5**	**5,163.1**	**7,181.1**	**8,646.7**	**7,711.5**	**62.28%**
Total	**10,611.0**	**10,054.0**	**10,064.0**	**11,379.0**	**13,883.0**	**14,385.0**	**100%**

Source: Calculated by authors. Based on NBS, 2021a and NBS, 2022b.

1.1.2 Water Resources Endowment

The total area of freshwater cover is 54,337 km2, about 6.1% of the country's surface area[7]. Based on national and basin *Water Resources Factsheets* provided by the MoW, in 2015, the average renewable water resources were 125,763 mcm/year (groundwater 21,195 mcm/year and surface water 104,568 mcm/year). A proxy of Tanzania's water endowment is the *Macroscopic Water Balance per Basin,* calculated by the National Irrigation Master Plan 2018 (NIMP 2018 herein after - see Table 5 and

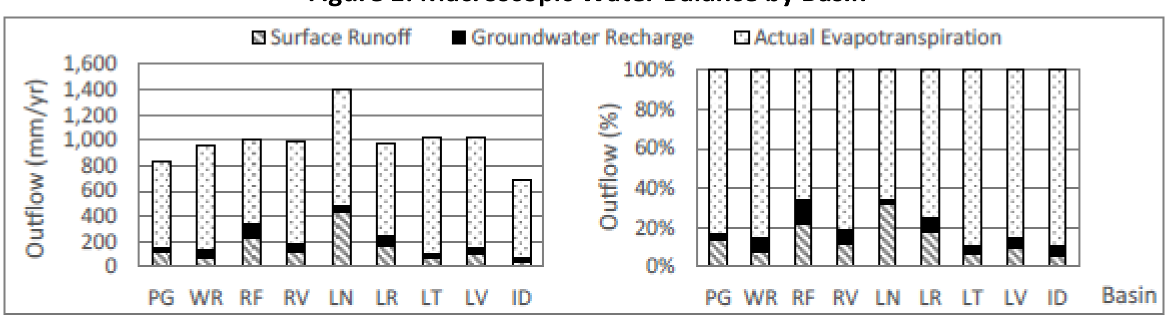
Figure 1) which contrasts water inflows (rainfall) and outflows (surface runoff, groundwater recharge and actual evapotranspiration).

Table 5: Macroscopic Water Balance by Basin

			Inflow (mm/yr)	Outflow (mm/yr)		
Basin	**Code**	**Catchment Area Km²**	**Rainfall**	**Surface Runoff**	**Groundwater Recharge**	**Actual Evapotrans-piration**
Pangani	PG	59,102	838	118	25	695
Wami Ruvu	WR	66,295	961	73	64	823
Rufiji	RF	183,791	1,013	223	123	667
Ruvuma & S. Coast	RV	105,582	987	111	79	797
Lake Nyasa	LN	27,594	1,394	442	39	913
Lake Rukwa	LR	74,965	981	173	71	737
Lake Tanganyika	LT	149,5	1,026	71	37	918
Lake Victoria	LV	85,63	1,027	99	52	877
Internal Drainage	ID	143,1	689	42	31	616
Total (km2) / Ave. (mm/yr)	**National**	**895,559**	**955**	**128**	**64**	**763**

Source: JICA, 2018. For detailed information, see Chapter 3 - Present Conditions of the Water Sector

Figure 1: Macroscopic Water Balance by Basin



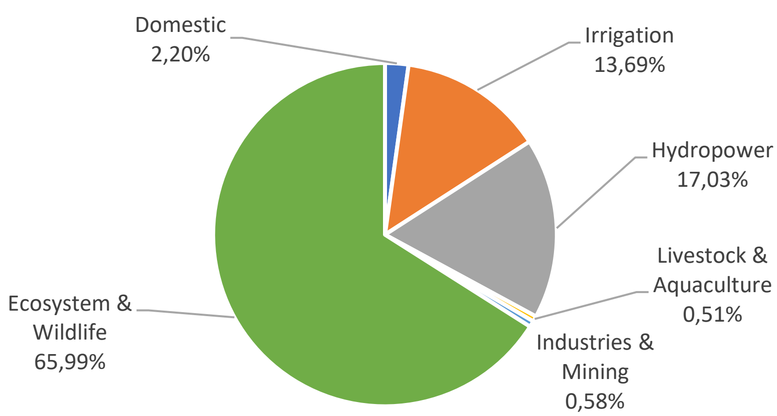
Source: JICA, 2018. For detail information see Chapter 3 - Present Conditions of Water Sector

[7] Cited in IWRM Baseline and Action Rationale Document - United Republic of Tanzania, draft document provided by GWP in August 2022.

1.1.3 Water Usage by Sector

Based on the information provided by the MoW for 2015, the highest demand for water corresponds to Hydropower Generation that amounts to 17.3%, followed by Agriculture, 14.2% (Irrigation and Livestock & Aquaculture combined); Domestic, 2.2%; and Industry & Mining, 0.58% (see Figure 2**Error! Reference source not found.**). Using projections for 2025 and 2035 from NIMP 2018, 8 out of 9 basins will have enough to cover water demand and preserve environmental flows for Ecosystems & Wildlife. Pangani is the only basin that shows a negative water balance by 2035 (-135 MCM) that could be compensated by groundwater (587 MCM). For detailed statistics, see Annex 4.

Figure 2: Water Demands by sector, Tanzania, 2015

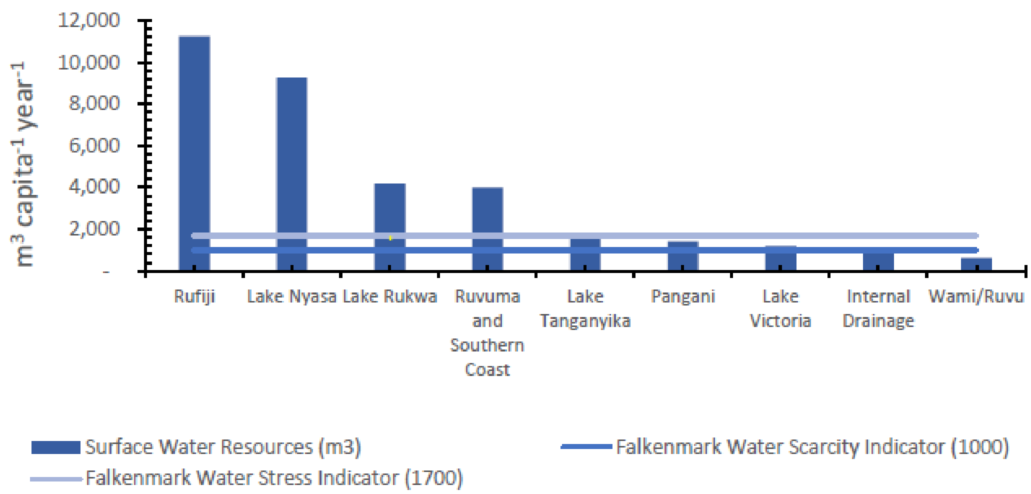


Source: Adapted by the authors from Water Resources Factsheets, MoW, n.a..

1.1.4 Water Balance and Water Stress

Nonetheless, Tanzania is facing increasing water stress as the per capita renewable water resources has been consistently declining, due to the growing population (USAID, 2020b: 8). Based on data per capita annual renewable water resources in 2018, it is argued that there is a high spatial variation across the country regarding water availability (see Figure 3). Using the Falkenmark Water Stress Indicator, as a measure of water scarcity, it can be argued that four basins have abundant water resources (Rufiji, Lake Nyasa, Lake Rukwa, and Ruvuma and Southern Coast), while the other five already face stress (Pangani, Lake Victoria, Internal Drainage, and Wami Ruvu). This contrasting view relies on the fact that all basins have enough water resources, as showed by their water balance, but face what is called *economic water scarcity*, defined as "a situation when renewable water resources are adequate but where there is a lack of significant investments in water infrastructure in order to make these resources available" (Rijsberman, 2006, cited in MoW, 2020b: 32).

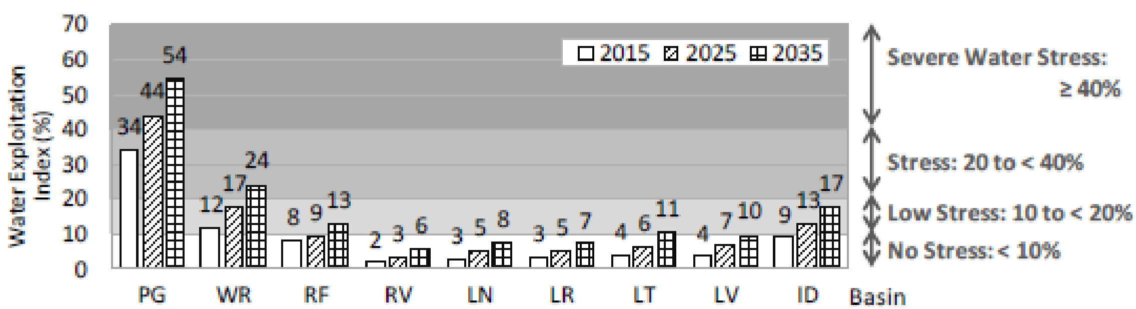
Figure 3: Per Capita Annual Renewable Water Resources for Basins in Tanzania 2018



Source: MoW,2020b: 31

Metrics from the water exploitation index (WEI) also demonstrate significant water stress. WEI is calculated as a percentage of total water demand to internal renewable water resources, which consist of surface runoff and groundwater recharge. A region is considered under "*water stress*" if it surpasses the threshold of 20% and under "*severe water stress*" when exceeding 40%. Using the projections of water demand for 2025 and 2035**Error! Reference source not found.**, "it was found that the Pangani basin is almost under severe water stress even in the current condition and the water stresses of all the basins will progressively increase towards 2035" (JICA, 2018: 3-16 – Figure 4). This analysis also coincides with other analyses in that Pagani Rufiji, and Wami/Ruvu basins might face a water shortage in the future exacerbated by population growth (USAID, 2020b: 9).

Figure 4: Water Exploitation Index by Basin



Source: JICA, 2018, pp 3-17.

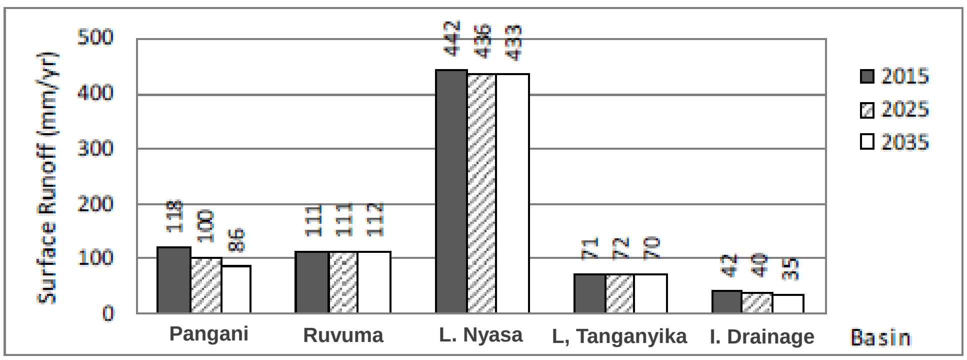
1.1.5 Impact of Climate Change on Future Water Availability

In recent years, Tanzania has experienced an increase in the frequency and intensity of extreme events such as strong wind, heavy rainfall, hailstorm, and higher temperatures which have had a direct effect on rain-fed agriculture, (NBS, 2020: 25). Based on global climate models, the NIMP 2018 reports that:

> *"Rainfall in Tanzania is expected to have slight increase in north area and decrease in south area. Especially, remarkable rainfall decrease is predicted in October to December… The biggest challenge in water sector is the localized seasonal water shortages especially during peak irrigation periods. The situation surrounding water resources has become more difficult due to climate change effect as well as increase in water demands for various sectors" (JICA, 2018: 3-18).*

At the basin level and based on information from their Integrated Water Resources Management Development Plans (IWRMDPs), the NIMP 2018 reports that rates of increase or decrease in the runoff, from 2015 to 2035, in the Ruvuma, Lake Nyasa, and Lake Tanganyika basins fall within 2%, and reductions are relatively significant in the Pangani and Internal Drainage basins with the rates of 27% and 17%, respectively. The other four basins, Wami Ruvu, Rufiji, Lake Victoria, and Lake Rukwa, did not have enough information on climate change's impact on water resources at the time of reporting (JICA, 2018 – Figure 5).

Figure 5: Surface Runoff with Climate Change by Basin



Source: JICA, 2018, pp. 3-12

Most recent calculations estimate that the widespread impact of climate change on the economy of Tanzania is "at around 1% of GDP annually and it could go up to 2% of GDP by 2030; about USD 500 million is required annually to reduce current vulnerability to climate change, and a further USD 100-150 million per year will be required to build capacity and enhance resilience to future climate change" (GoT, 2019; 142). Moreover, the expected impacts of climate change on the industry sector include (GoT, 2021a: 50-51):

- Decrease in industrial production due to unstable power supply, water supply, low or inadequate supply of agricultural raw materials, damage of infrastructure, which means a limited inflow of foreign currency.
- Increase in industrial production costs due to imported materials and technology, which would mean more capital flight.
- Increased occupational health risk due to high temperatures and inadequate water for sanitary activities; and
- Increase in unemployment rate due to decreased industrial investment and production.

1.1.6 Overview of Public Expenditures and Investments on Water Resources Management

The Water Sector Development Programme 2006-2025 (hereinafter WSDP) is the primary planning instrument for the water sector in Tanzania. The WSDP operationalises the national strategic goals set out by Tanzania's Development Vision 2025, the National Water Policy 2002, and National Water Sector Development Strategy 2005-2015. The programme defines priority interventions and investment requirements in water resources management, urban water supply and sewerage services, and rural water services, with a focus on institutional strengthening and capacity building (USAID, 2020b: 7). Its implementation has been divided into three phases:

- The first phase of the programme (WSDP I) started in July 2009 and ended in June 2016.
- The second phase of the programme (WSDP II) began in July 2016 and ended in June 2022.
- The programme's third phase (WSDP III) started in July 2022 and is projected to end in June 2026.

In 2006, the total cost of the WSDP was estimated at TZS 4,207,980 million (USD 3,366.38 million), to be invested over the 2006 – 2025 timeframe (MoW, 2006: 5-2). In terms of Water Resources Management, the WSDP identified its main challenge as:

"Water security remains an elusive goal in Tanzania, despite the fact that it is relatively well endowed with freshwater resources. Water insecurity is compounded by (a) inadequate investments in constructed water storage and other water resources infrastructure to buffer against the impact of droughts and floods (climate variability) and inadequate investments in water quality management and pollution control; (b) investments in costly but unreliable infrastructure, and (c) inadequate investments in water resources management systems, institutions, and regulations, which has created a climate of poor governance and is contributing to water-use conflicts, threatening water sources and the destruction of natural storage capacities… Water resources institutions are poorly resourced and poorly functioning. Huge infrastructure gaps—for water supply, for meeting energy demand and for food security needs—remain… The concept of integrated water resources management adopted in the past decade is not uniformly understood, accepted, or properly supported". (MoW, 2006: 1-4)

To overcome this situation, the WSDP established as the focus of its action the decentralisation of water resources management through the institutional strengthening of the nine Basin Water Boards (BWBs). Consequently, investments would prioritise activities related to:

- Water resources monitoring, assessment, and enforcement
- Water quality management and pollution control
- Water demand management
- Strengthening legislation and enforcement
- Integrated water resources planning
- Trans-boundary water management

- Cross-cutting activities (disaster management, public awareness, inter-agency networking and establishing a water resources management information system).

Apart from the importance of making the Basin Water Offices (BWOs) operational through specific investments in developing technical capacity for their teams and building basic infrastructure to host them, there was considerable interest in strengthening Water Resources Monitoring, Assessment, and Enforcement. To achieve this objective, the WSDP set out specific investments in:

- Water resource monitoring systems (hydro-meteorological, hydrogeological, water quality, and sediment).
- Operation and maintenance of stations (new equipment and retrofitting of the existing one).
- Assessment of water resources (baseline studies).
- Strengthening enforcement of legislation (management of surface water and groundwater allocations).

The total estimated investment of WSDP in its Water Resource Management component for 2006 – 2025 was USD 333.2 million (MoW, 2006: 5-3) plus a Sector Institutional Strengthening and Capacity Building component valued at USD $ 114.6. It is worth noting that investments in capacity building, basic infrastructure, and specialized equipment for assessment and monitoring need to be analysed as a whole, as they are interdependent; each one depends on the other to achieve their effectiveness. Therefore, the authors conclude that the total investment needed to achieve the policy outcome of water security through strengthening water resources management in Tanzania from 2006 to 2025 was USD 477.9 million.

In 2014, for implementing Phase II (2016-2022), this amount was reviewed, and the Government included a sub-component on Water Quality Management. The Water Resources Management component reached USD $803.6 million plus USD $84.8 for Capacity Development. The evaluation of WSDP II allows to have a glimpse of actual investments in the water sector for the period 2016-2021. The GoT mobilised US $864.5 million for WSDP Phase II; USD $489.1 million from own funds and USD $375.3 million from external donors (see Table 6). From that amount, only USD $41.6 million, equivalent to 4.81%, was invested in the water resources management component. Comparing the initial budget plan (USD $803.6 million) with the actual budget allocation (USD $41.6 million), it represents 5.18% of budget execution.

Table 6: Actual Budget Expenditures (in USD $) of Government of Tanzania own Funds and External Donor Funds During WSDP II Period

Water Sector Budget Line (USD $)	2016-2017 to 2020-2021				
	GoT Own Funds ($)	%	Donor Funds ($)	%	Total per Category
Water sector institutional strengthening	2,648,498	93%	196,227	7%	2,844,725
Water sector performance monitoring	620,146	43%	827,176	57%	1,447,322
Water sector capacity development	3,431,380	46%	4,044,771	54%	7,476,151
Water resources development	9,281,389	34%	17,773,521	66%	27,054,910
Water Quality Management	1,195,117	43%	1,591,222	57%	2,786,339

Water Sector Budget Line (USD $)	2016-2017 to 2020-2021				
	GoT Own Funds ($)	%	Donor Funds ($)	%	Total per Category
Rehabilitation and expansion of water supply schemes in small towns and district centres	30,491,103	36%	53,976,495	64%	84,467,598
Rehabilitation and expansion of water supply schemes in regional centres	75,587,731	24%	242,164,278	76%	317,752,009
Improvement of water supply schemes in new regional centres	3,469,986	100%		0%	3,469,986
Management support to urban water utilities	2,692,515	88%	351,05	12%	3,043,565
RUWASA- New rural water schemes & rehabilitation and expansion	359,700,637	87%	54,414,409	13%	414,115,046
Totals	**489,118,503**	**57%**	**375,339,147**	**43%**	**864,457,651**

Source: USAID, 2021: 49

Finally, in 2022, the Government reorganised the programme, taking out the Water Quality Management subcomponent, and dividing Water Resources Management component into two subcomponents, Water Resources Management (USD $134,9 million) and Water Resources Development (USD $1.9 billion), plus the Institutional Strengthening and Capacity Building component (USD $464. 1).

Based on the WSDP, the National Five-Year Development Plan 2021/22 - 2025/26 (GoT, 2021b) has given priority to investments in water resources management, in particular projects related to:

- Strengthen supply infrastructures for clean and safe water.
- Construct strategic water reservoirs.
- Strengthen conservation and protection programmes of water resources and water sources.
- Strengthen water resources research systems, data collection, processing, storage, and dissemination of water statistics.
- Establish programmes and mechanisms for management, monitoring and assessment of water and wastewater quality.
- Strengthen the availability and reliability of electrical power by increasing generation capacity, transmission, and distribution networks.

1.2 Objective of the study

The objective of this study is to evaluate the contribution of water to the national economy. The results of this study are expected to be the starting point for revaluating water in the country. As such, the broader ambition of this research is to provide information for policy makers that help them evaluate and prioritize water investments based on their contribution to economic growth, productivity, and well-being for the most relevant sectors of the economy. The specific objectives of this study are:

- To conduct a study that focuses on the value allocated to water in a limited number of economic activities/sectors with major water performance issues, to be jointly selected by the consultant(s) and the Ministry of Water of Tanzania (MoW).

- To provide methodological reflections and insights on the process of evaluating the economic contribution of water, including on the necessary informational needs and requirements.
- To suggest recommendations on strengthening the investment rationale for water though a cost-benefit approach.

Therefore, this study aims to contribute to Tanzania´s ongoing water valuation efforts by quantifying use-values of water in the Agriculture, Manufacturing, and Mining economics sectors, implementing revealed preference and cost-based methods. It is essential to outline the latter because the first Bellagio Principle on Valuing Water is to "Consider the multiple values to different stakeholders in all decisions affecting water." Therefore, this study could help the country to continue to frame the discussion on the value of water and to determine the following steps to quantify additional values of water.

1.3 Scope of the study

Based on a preliminary economic analysis and scoping of the available statistics, it was agreed to focus the study on three economic sectors: Agriculture, Manufacturing, and Mining. In 2020, these sectors represented 53.2% of GDP, 42.4% of exports, and 14.8% of renewable water resources use (Table 7).

Table 7. Water Usage, GDP per Economic Activity and Exports

Sector	Million Cubic Meter / Year 2015	Percentage of Water Usage 2020	Percentage of GDP 2020	Percentage of Exports 2021
Ecosystem & Wildlife	50,627	66.0%	N.A.	25.8%
Hydropower	13,062	17.0%	0.9%	N.A.
Irrigation	10,500	13.7%	21.9%	8.6%
Livestock & Aquaculture	395	0.5%		
Domestic	1,686	2.2%	N.A.	N.A.
Industries & Mining	445	0.6%	31.3%	33.9%
Total	**76,715**	**100%**		

Source: Water Sector Status Report 2015-2020, MoW, 2020b; National Accounts of Tanzania Mainland 2015 – 2021, NBS 2022a; Tanzania Invest, 2022.

Based on the economic relevance and relative availability of data, the Wami/Ruvu Basin was selected as a case study to carry out water sectorial valuations, which in combination with other country-wide datasets could be then extrapolated to the country level (Figure 6). A first approach to quantifying the economic size of the basin indicated that its GDP participation was 21.5%. This calculation was carried out using statistics by region, reported in the national accounts, grouping the regions within the basin's limits. However, if two or more basins shared a particular region, economic statistics were divided using an arithmetic average (Table 8).

Figure 6. Tanzania geographical segmentation by basin and regions

Source: Provided by MoW, 2022.

Table 8. GDP Participation by Basin 2020

Basin	Economic participation	Ranking
Internal Drainage	13.1%	3
Nyasa	4.6%	9
Pangani	9.1%	4
Rufiji	8.2%	6
Rukwa	4.6%	8
Ruvuma	8.5%	5
Tanganyika	7.1%	7
Victoria	23.2%	1
Wami Ruvu	21.5%	2

Source: NBS,2022a.

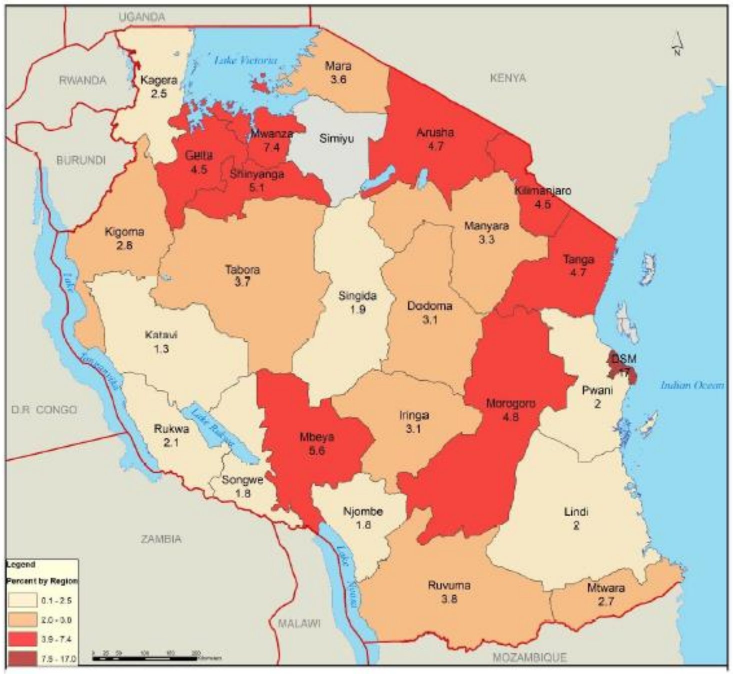
However, to avoid underestimating the economic weight of sectors under analysis, the Wami/Ruvu basin include the whole statistics of the regions that make it up: Dodoma, Morogoro, Pwani, Tanga, Dar Es Salaam, and Manyara, increasing economic participation to 35.02% (Table 9, Figure 6 and Figure 7).

Table 9. Regional GDP - Wami/Ruvu Basin and Mainland Tanzania, 2015–2021

Region	2015	2016	2017	2018	2019	2020r	2021p
Wami Ruvu	32,840,130	37,425,054	41,592,338	45,433,775	48,822,671	52,943,481	56,401,676
Tanzania	94,349,316	108,362,324	118,744,498	129,043,901	139,641,854	151,166,383	161,525,759
Participation	**34.81%**	**34.54%**	**35.03%**	**35.21%**	**34.96%**	**35.02%**	**34.92%**

Notes: r = revised; p = provisional | **Source:** NBS, 2021a.

Figure 7. Map with % Share of Gross Domestic Product by Region in Mainland Tanzania, 2020

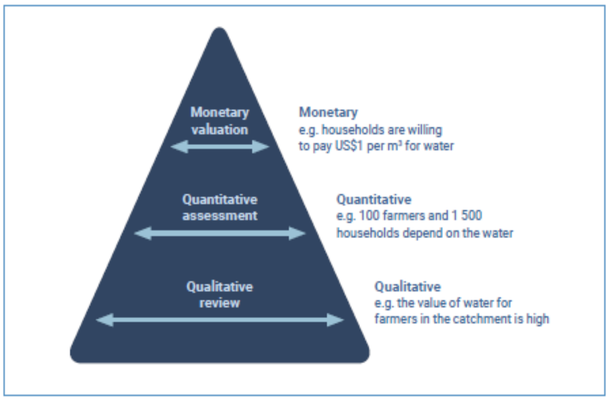


Source: NBS, 2021a

2 Methodology

The methodological approach proposed to carry out a water valuation in Tanzania is based on the analytical framework adopted in the *World Water Development Report 2021: Valuing Water* (United Nations, 2021). This document recommends that water valuation be the result of a systematic approach that begins with developing a broad qualitative understanding of the water sector, validating information availability, and finally, carrying out a monetary valuation. In other words, the valuation methodology and its applicability will depend entirely on the availability of information (**Error! Reference source not found.**).

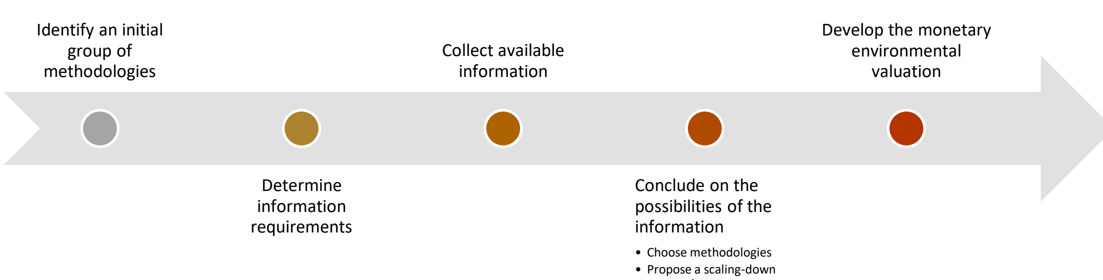
Figure 8. Methodological framework to carry out a water valuation



Source: United Nations, 2021.

It was agreed with the MoW that the value of water would be determined for three economics sectors: Industry, Agriculture, and Mining. Additionally, water valuations would focus on the Wami/Ruvu Basin. Choosing the valuation techniques was a pragmatic and systematic process: To begin with, a broad range of methodologies were reviewed in terms of time and budget constraints, narrowing them down to a preliminary group. After that, this group of methodologies was analysed to determine their information requirements. From this preliminary analysis, it was possible to contrast demand and availability of information for each sector. Finally, the most pertinent valuation techniques were applied to carry out water valuations (Figure 9).

Figure 9. Process to choose the water valuation techniques for each economic sector

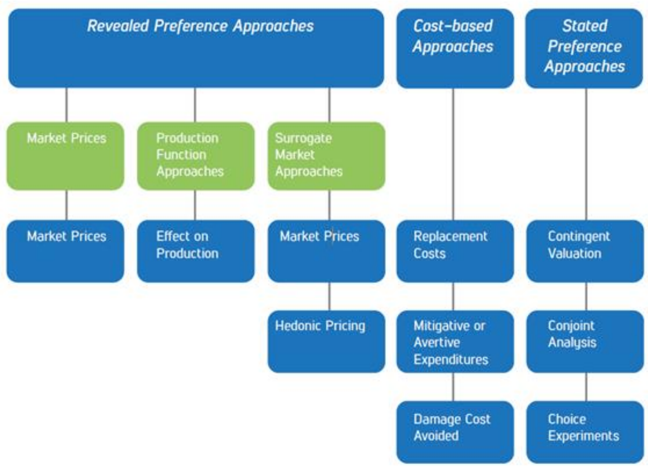


Source: Elaborated by authors.

2.1 Identification of an initial group of methodologies.

To have a starting point to identify the initial group of methodologies, it was important not to make a general overview of all environmental valuation methodologies but to focus on those that are most relevant for water. A useful reference is IUCN's reference document *Value, Counting Ecosystems as Water Infrastructure* (Emerton and Bos, 2004) which identifies a group of methodologies that instrumentalizes the *Total Economic Value Principle*, that is, the overall economic value of a particular natural resource, considering both use and non-use values (Figure 10 and Table 10).

Figure 10. Environmental techniques for water valuation



Source: Emerton and Bos, 2004.

Table 10. Typology of values

Value Type	Value Sub – Type	Meaning
Use Values	Direct use values	Results from direct human use of biodiversity (consumptive and non-consumptive)
	Indirect use values	Derived from the regulation services provided by species and ecosystems
	Option value	Relates to the importance that people give to the future availability of ecosystem services for personal benefit
Non-Use Values	Bequest value	Value attached by individuals to the fact that future generations will also have access to the benefits from species and ecosystems
	Altruist value	Value attached by individuals to the fact that other people of the present generation have access to the benefits provided by species and ecosystems
	Existence value	Value related to the satisfaction that individuals derive from the mere knowledge that species and ecosystems continue to exist

Source: TEEB, 2010.

The economic sectors were assessed in terms of "use values" as valuation results are aimed to engage decision-makers, from public and private sectors, in discussions about prioritising water uses and investments for fostering economic growth and human well-being. Therefore, results must be concrete and easy to explain to show clear causality correlations among water uses and their impact on economic and social prosperity.

The selection of the valuation methodologies is also based on a maximisation rationale to obtain the best possible outcome with the available information. Thus, one of the first decisions made during the process was that due to time and budget constraints, water valuations would be carried out relying entirely on secondary information. Consequently, the initial group of valuation methodologies do not include any stated preference techniques as they focus mainly on non-use values, which in turn require collecting primary information. Moreover, the Hedonic Pricing methodology is discarded because information requirements focus heavily on the housing market and the connection with a specific environmental service, making it not aligned with the prioritised sectors (Champ et al, 2003). The final group of valuation methodologies assessed was:

- Market prices
- Effect on production
- Replacement cost
- Mitigative or aversive expenditure
- Damage cost avoided.

2.2 Determination of information requirements

Once the initial group of methodologies was identified, an information request was sent to MoW to determine data availability. Information was divided into topics: context information for Wami/Ruvu Basin; and specific information for Manufacturing Agriculture, and Mining sectors, both country wide and Wami/Ruvu Basin. In addition, the authors also carried out a desktop review of existing databases with economic and social statistics (national accounts, census, sectorial surveys), public policy documents (sectorial strategic plans, environmental reports), and academic and grey literature related to the water sector in Tanzania. A first batch of files was received from various sources. They were thoroughly analysed to extract data that was necessary and useful for applying the valuation methodologies.

2.3 Collection and limitations of available information

There are multiple reports and datasets with statistics that describe Tanzania's water endowment in detail. Among the most important ones are the following[8]:

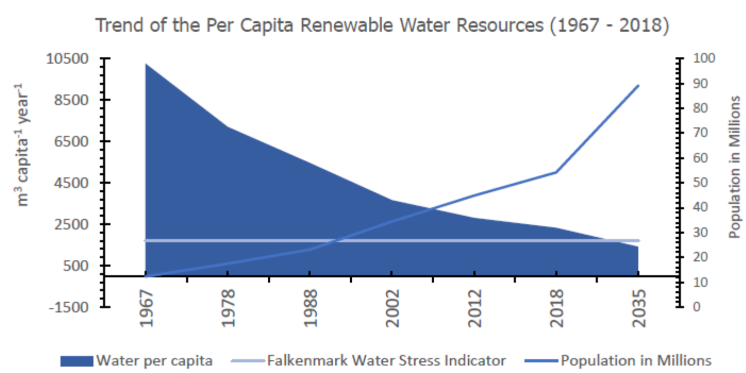
- *Water Resources Factsheets (n.a.)*, published by MoW, include information for the country and its nine basins as of 2015.
- *National Environment Statistics Report (2017)*, published by the Government of Tanzania (GoT), present a comprehensive repository of environmental statistics related to water resources in mainland Tanzania.
- *The Project on the Revision of National Irrigation Master Plan in the United Republic of Tanzania - Final Report (2018)*, developed by JICA on behalf of the MoW, presents the National Irrigation Master Plan 2018 (NIMP 2018) and provides a detailed account of water resources and water resources demand for 2015, 2025, and 2035.

[8] A list of relevant documents delivered by MoW was included in *Deliverable 2. Draft report with results of initial high-level findings and analyses*, November 23rd, 2022.

- *Tanzania Water Resources Atlas (2019)*, developed on behalf of MoW by YEKOM Consulting Engineers, is a repository of maps and statistics on Tanzania's water resources.
- *State of the Environment Report 3 (2019)*, published by the Vice-president's Office, intended to inform policymakers about the environmental challenges and provide policy recommendations to support the country's sustainable growth.
- *Water Sector Status Report 2015-2020 (2020)*, published by MoW, consolidates the progress and issues on the water sector's components.
- *Tanzania Water Sector Assessment for Strategy Development (2020)*, published by USAID, presents an overview of the most critical water resources challenges and stress factors, including climate change[9].

Official documentation and statistics related to water resources are, however, not harmonised which limits the range of valuation methods that can be employed. One of the major limitations with current water-related datasets is that they use different baseline years, sources of information, and methodologies to calculate water indicators (e.g., water stress, water balance, etc.). For example, the *Water Sector Status Report 2015-2020*[10], considered the most up-to-date official source of water statistics, estimates that the total national annual renewable water resources for 2018 amounts to 126,262 MCM which combines groundwater (21,195 MCM) and surface water (105,067 MCM). This estimate is equivalent to an average of 2,330 m3/cap/yr, which is above the Falkenmark Water Stress Indicator of 1700 m3 /cap/yr (MoW, 2020b - Figure 11).

Figure 11: Tanzania per capital annual renewable water resources trend as population increases from 1967 to 2018



Source: MoW,2020b, pp. 33

In contrast, the *Water Resources Factsheets*, also developed by the MoW, show for 2015 the same amount of annual renewable water resources but an average of 2,250 m3 /cap/yr, implying a population decrease or an increase in annual renewable water resources in 2018[11]. Moreover, the

[9] For a summary of findings, see *Tanzania Water Resources Profile Overview*, available at: https://www.globalwaters.org/resources/assets/tanzania-water-resources-profile

[10] The main source of information of this report are the basins' Water Resources Management and Development Plans (IWRMDPs) formulated by the MoW.

[11] As the MoW argues, *"Historical assessment of per capita total annual renewable water resource in Tanzania is carried retrospectively using the current total annual RWR of 126,262 MCM and rationing it across to 1967 population to 2018 population. This implies that assumptions are made that the past RWR were the same as the current water resources (126 km3). In reality, this is an underestimation of the actual amount of annual renewable water resource, since the country had much more pristine watersheds than we currently have and is therefore expected to have had much more than 126 km3 RWR by 1967."* (MoW, 2020b: 33).

Tanzania Water Sector Assessment for Strategy Development, produced by USAID, reports a totally different picture. It estimates that annual renewable water resources in 2015 were 96.27 MCM, corresponding to about 1,919 m3 /cap/yr, using information from FAO statistics (USAID, 2020b: 9).

A similar situation occurs with water demand statistics. Information on water consumption is indicative because it is calculated indirectly. After reviewing different official reports (Water Sector Status Report 2015-2020; Tanzania Water Resources Atlas 2019; Water Resources Factsheets), water consumption seems to be calculated based on water permits allocated by Basin Water Boards. Even though the MoW collects this information from these institutions, it is neither done on a periodic and systematic basis nor consolidated in a single database. Therefore, the reports mentioned above group information based on availability at the time of elaboration, which consequently seems to cause differing water demand results. In other words, this practice might lead to overestimating or underestimating actual consumption.

For example, in the case of agriculture, small-scale farmers do not request water permits. The National Sample Census of Agriculture 2019–2020 reports 7,657,184 small-scale farmers in Mainland Tanzania. In contrast, the MoW reports 2,629 granted permits for agriculture activities. Thus, calculating water demand based on water permits might underestimate real consumption (Table 11).

Table 11. Water Permits 2022

Water Use	Water Permits
Agriculture	2,629
Commercial	1,275
Domestic	3,395
Industrial	659
Mining	213
Power	139
Public Supply	1,053
Total	**9,363**

Source: Data provided by MoW.

Another similar case is the demand for non-consumptive uses. For example, the MoW points out that Tanzania has 600 dams, 20 have a capacity that exceeds 1,000,000 m^3, and six of them are currently used for Hydroelectric Power Generation, generating a total of about 561MW and using 13,062 mcm/year, that is, 17.03% of water demand as of 2015 (MoW, 2020b). However, this information is not consistently reported or systematically consolidated. Moreover, there is no detailed information on water used by other types of dams, such as those dedicated to irrigation or human consumption (supplying urban/rural aqueducts). As stated in the *Tanzania Water Sector Assessment for Strategy Development*, “This differing in water statistics from different sources calls for the need to harmonize Tanzania’s water resources accounting and statistics for better development planning” (USAID, 2020b: 10).

2.4 Conclusion on potential use of information

This data collection process allowed the following general conclusions to be drawn:

- There is not a single unified source that compiles information on production and water consumption that allows causal relationships to be made. Water information is not collected and managed by a single institutional "owner" (e.g., MoW). This led to building ad hoc datasets using national or international proxies.
- There is general information on the water sector compiled in government or independent organisations reports, carried out in different periods of time. However, there are no data collected systematically and periodically which would be essential to successfully implement any valuation methodology, and to manage water resources appropriately.
- The main format of information, when available, is PDF which obliges to transfer data manually to other formats for calculation (e.g., Excel). This operation, prone to typing errors, was time consuming to guarantee data quality.
- Several sources of information are cited in sectorial reports. In some cases, those original sources were not available. This situation led the authors to make specific information requests to different institutions, a process that was also time consuming.
- The geographic scale used to report information varies by thematic area. For example, water allocations are reported by basin while statistics on production and prices are reported by region, but one region can be split up into two or more basins.

What follows are the conclusions on the data available and which can be used to derive water valuations in the three sectors of interest:

- **Agriculture:** The sector that has the best information was agriculture, mainly contained in the National Agricultural Census 2019 – 2020 (NBS, 2021a). Final reports are publicly accessible through the National Bureau of Statistics' website. In addition, there is public access to the survey's anonymized microdata which served as the basis for building the Census, thus giving the possibility of having a more robust quantitative approach. It is important to highlight that this survey has information on irrigation costs for smallholder farmers which allows to explore quantitative relationships between production and water consumption.
- **Industry:** For the industrial sector, in particular manufacturing and industrial mining, the statistical report of the Annual Survey of Industrial Production 2016 (NBS, 2018a) is an important source of consolidated data. Nonetheless, there is no access to anonymized microdata. Thus, the possibility of building a quantitative approach is more difficult and less robust than those presented for the agriculture sector.
- **Mining:** The mining sector has fewer public data and information available to carry out a water valuation. Even though there is consolidated information on production and prices, there is no data on water consumption by type of mineral extracted nor by extraction technique. This would require identifying proxies based on international sources.

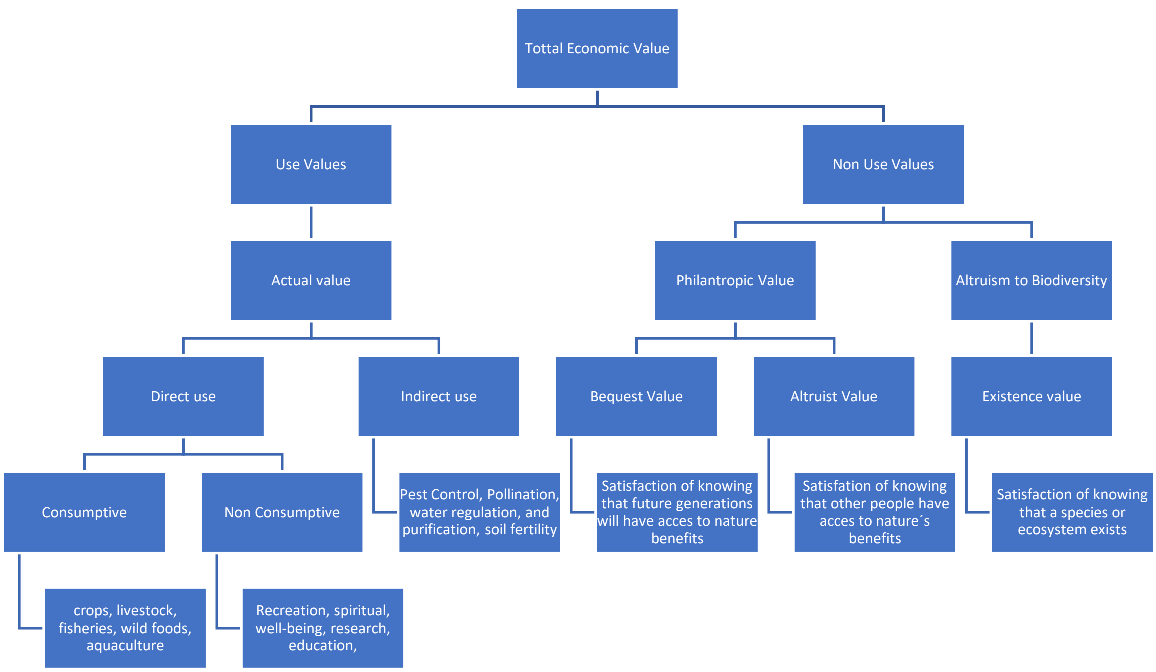
Based on these considerations, a specific methodological approach for developing the environmental valuation of water for each sector was carried out. This included explaining technical assumptions to select the initial methodology that was implemented, modifications that were made to the methodology so that it could be adapted to the available information, and the technical arguments that support those decisions. The present valuation exercise is understood as a starting point for Tanzania to continue developing a broader study. Thus, documenting in detail this process will allow building on the results achieved.

2.5 Study Limitations

Environmental valuation is a quantitative exercise that aims to translate the importance of the environment into economic terms so decision-makers can efficiently develop public policy that ensures that the environment is well taken care of. The latter has a starting point: a human science such as economics wishes to interpret an incredibly complex relationship. That is why there was a need for a framework capable of interpreting such complexity, and that is how the Total Economic Value Framework was born.

Figure 12 shows a graphic representation of the Total Economic Value Framework that was indicated on Table 10, presenting two main groups of value; Use value and non-Use Value. This initial differentiation aims to recognize that the environment, in this case, water, is valuable regardless of its use. Each of those two categories has subcategories, so in the case of use value, it recognises that water has direct and indirect use, and in terms of direct use, it shows two further subcategories, consumptive and non-consumptive.

Figure 12. Total Economic Value Framework



Source: (TEEB, 2010)

The principle of this approach is that it is impossible to have a Total Value of an environmental good or service unless all its values are considered. The latter is essential to outline because of the limitations of this study, and its goal was to determine the contribution of water to the economy of Tanzania in three specific economic sectors using second-hand information.

The authors used the methodological framework proposed by (Emerton & Bos, 2004) to choose the best possible valuation methodologies to quantify the contribution, but the point here is for the reader to understand that regardless of the comprehensive of this study, its result is only scratching the surface because to quantify the full value of the water of Tanzania it would be required at least to:

- Expand the reach of the consumptive value to more economic sectors with better information tools such as water consumption and water costs.
- Include non-consumptive direct uses.
- Include indirect use values.
- Include non-use values.

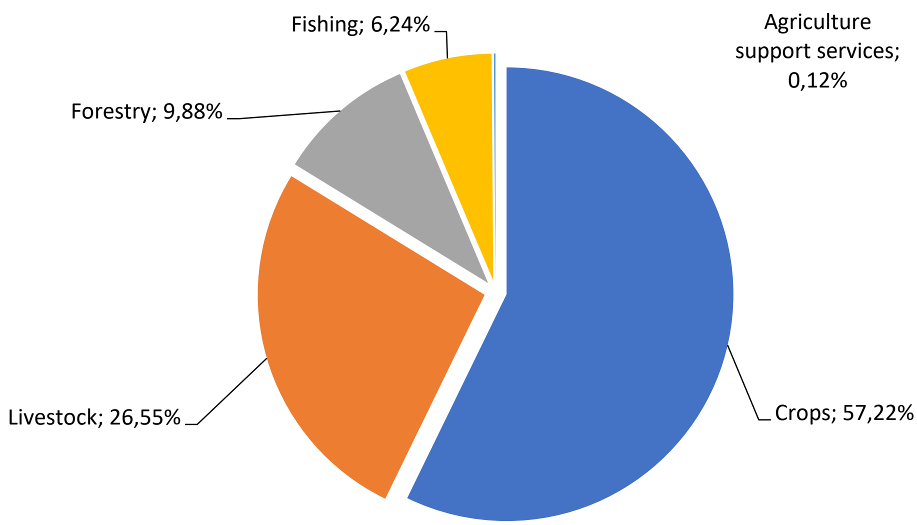
The latter means that the quantitative results of this study will be *the lowest quantifiable bound of the value of water in Tanzania, and this means that if further efforts were to be made to refine this quantitative exercise, the value of water would only increase.*

3 Valuation of Water in Agriculture

3.1 Introduction

Agriculture is the main economic activity engaging 65% of the population[12] and contributing 28.5% to GDP (See Annex 1: Economic and Social Statistics). This sector is divided into Crops, Livestock, Forestry, Fishing, and Agriculture Support Services (Figure 13). Crops and Livestock subsectors represent 83.8% of total agriculture production, that is why the authors concluded that quantifying the contribution of water to these two sub sectors was representative of the Agriculture Sector. It is also important to outline that the information found for Forestry and Fishing was not as robust as for Crops and Livestock, therefore, the consultants chose to cover as much as possible with the best available information.

Figure 13. Agriculture Subsectors 2020



Source: NBS,2022a.

Based on the available information from the crops component of the Agricultural Census Survey 2019-2020, the production function methodology was implemented, concluding that its initial results required a scaling-down approach. In addition, although the livestock subsector was also part of the Agricultural Census Survey 2019-2020, it did not have the same information as the crop subsector; therefore, a different approach was chosen for its valuation, implementing another scale-down approach inspired by the production function methodology.

The results of implementing both the scale-down approaches show that water in the crop subsector contributes nearly 4,152,426 million TZS[13] (1,807 million USD) and 786,836 million TZS (342 million USD) for the livestock subsector. Therefore, the water valuation of these two subsectors equates to 3.06% of the GDP of Tanzania in 2021.

[12] Cited in IWRM Baseline and Action Rationale Document - United Republic of Tanzania, draft document provided by GWP in August 2022.

[13] 2021 current prices

A partial result that the authors obtained from the only production function they considered quantitatively acceptable was that; *for* every TZS that is spent on irrigation for Beans Crop in the short Rainy Season, an increase of output of 0.005 Kg will be achieved (In 2021 USD figures, this means that for every 1 USD spent on beans crop irrigation during the short rainy season, will increase output by 11.43 Kg).

3.2 Valuation of Water for Crops Through Production Function

The initial approach that the authors took to value the contribution of water to the crop subsector was the production function methodology after determining it was the most reliable possibility among the methodologies that were initially assessed (Figure 10) because it used statistical data of a marketed good and the inputs that it required. However, after implementing this approach, the authors concluded that only the production function of the beans crop had the required quantitative features, making it unfeasible to continue using this method for the entire crop subsector.

3.2.1 Data Sources

The information for this subsector was taken from the National Agricultural Census Survey 2019-2020, specifically from anonymized microdata available online at the National Bureau of Statistics website (NBS, 2020b). Anonymized microdata is the individual responses to each survey developed as part of the agricultural census, not including the respondent's identity, which is why it is considered anonymous. Its use allows additional quantitative analyses to those presented in census reports.

The dataset contains information for *Small Scale Farmers or Smallholders* (households that have from 25 square meters to 20 hectares of planted land) and *Large-Scale Farmers* (production units that have at least 20 hectares of planted land):

- Smallholders 33,808 surveys, 32,008 in mainland Tanzania and 1,800 in Tanzania Zanzibar
- Large-scale farmers 1,903 surveys, 1,018 in mainland Tanzania and 885 in Tanzania Zanzibar

The sample structure allows it to be concluded that the bulk of the country's agriculture sector comprises smallholders (7,657,184 were in Mainland Tanzania), an element of analysis that will be explored throughout this document. For smallholders, the survey collects 294 variables of different types: information on the location (by region), socio-economic information for each household, and general characteristics in terms of production. For example, it inquires on infrastructure to process its products, receives technical advisory services and/or support from the state, implementation of conservation practices for agriculture, and average distance to different facilities and/or shared use resources. One of the essential pieces of information collected is that related to the costs of growing crops by each household, which includes:

- Planting
- Preparation
- Weeding control
- Cultivation
- Transportation

- Seeds
- Agrochemical inputs (such as fertilizers, herbicides, fungicides, and insecticides)
- Irrigation
- Quantities and sales prices

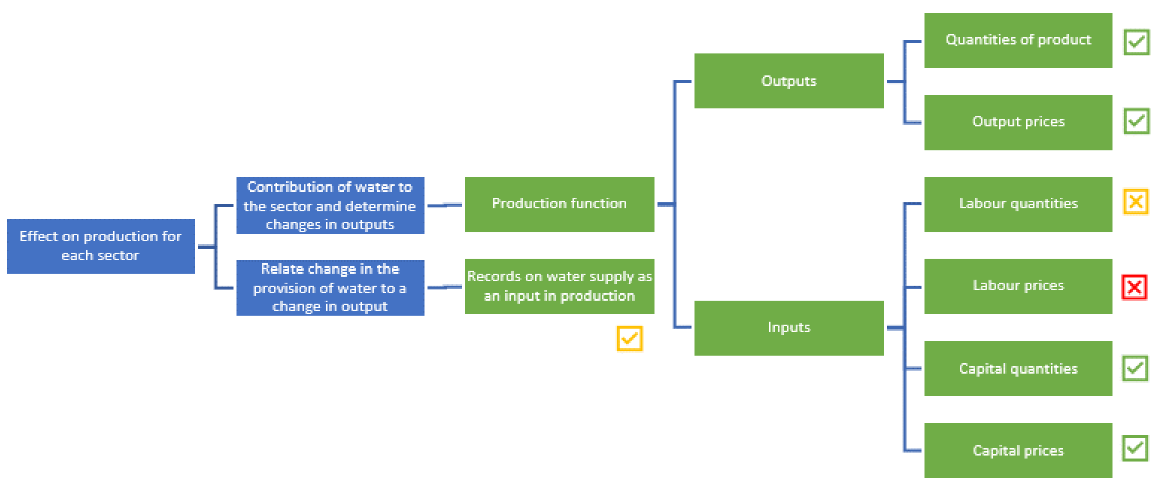
The information on crops (NBS, 2020b) is presented seasonally as follows:

- Short rainy season: between October and January of the following year
- Long rainy season: between March and May
- Permanent crops: Crops that are planted only once and occupy the land for a few years, and do not need to be replanted after the annual harvest

3.2.2 Methodological approach and rationale for applying a production function methodology for valuing water for crops

The Production Function Methodology was selected based on information from the National Agricultural Census Survey 2019-2020. Figure 14 shows the information requirements of this methodology; on the right side, it is concluded whether each requirement is met.

Figure 14. Analysis of information requirements for Production Function Methodology



Source: Elaborated by Authors (Emerton & Bos, 2004)

In terms of outputs, the census contains information on quantities and sale prices for each crop. Regarding water as a production input, the survey enquires about the cost of irrigation but not on average water consumption. Even though the survey does not detail specific labour costs[14], some variables make it possible to conclude whether household members worked growing crops. Finally, the authors observed that the survey contained information on capital costs associated with other production inputs (e.g., preparation, agrochemicals).

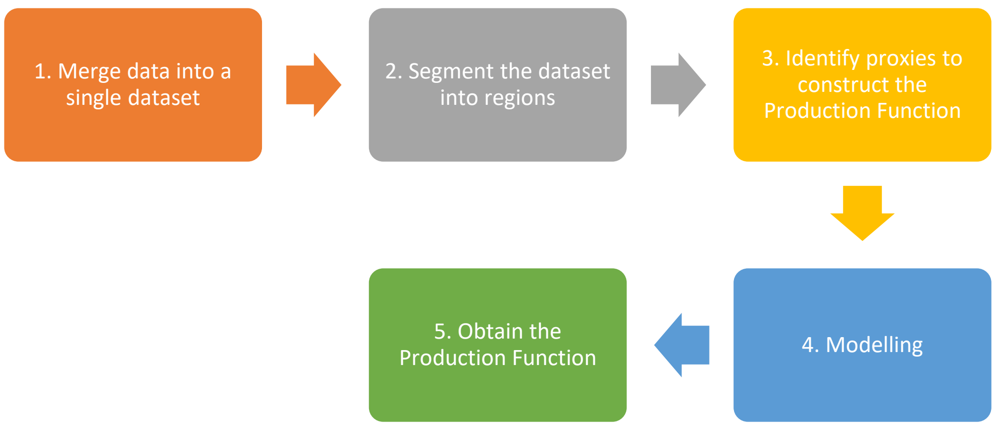
[14] The labour costs mentioned here refer to the ones that take place during Planting, Preparation, Weeding Control, Cultivation, Transportation, Irrigation and Harvesting

It is essential to highlight that the Production Function methodology aims to *"…relate changes in the production of a traded good or service with a measurable change in the quality or quantity of ecosystem goods and services, establishing a biophysical or dose-response relationship between the quality of the ecosystem, the provision of particular services and the related production*" (Emerton and Bos, 2004). Therefore, this methodology is the best possible option from a technical perspective to the extent that it would derive water values associated with marketable goods that affect the daily life of people.

3.2.3 Steps and analysis using the production function methodology.

To apply this methodology, the Authors carried out a process divided into five steps (Figure 15)

Figure 15. Steps of the Production Function Methodology



Source: Elaborated by Authors.

Merging the data into a single dataset consisted of consolidating the data available on the National Bureau Statistics website and merging it using SPSS[15] software. The following variables were chosen as tracers:

- Household identification
- Region
- District
- House number

Step 2 involved carrying out geographic segmentation. As stated before, the valuation of water for the agriculture sector focuses on Wami/Ruvu basin. However, the information reported in the census database is segmented by region. This means that, in some cases, census information by region does not coincide with the geographic scope of the basin. In particular, the regions that make up the Wami/Ruvu basin cover a much larger area than the basin. In addition, these regions are part of neighbouring basins such as the Rufiji and Pangani (see Figure 6).

[15] Statistical Package for the Social Sciences. Software from IBM

Therefore, it was proposed that the best alternative was to assume as representative the entire area of the regions that make up the basin (Dodoma, Morogoro, Pwani, Tanga Dar Es Salaam, and Manyara). This region configuration was confirmed with the MoW. As a recommendation for the future census, surveys should include a variable identifying which watershed households belong. Once data was segmented, the final dataset included:

- Smallholders, 294 variables and 7,506 registries
- Large-Scale Farms, 163 variables, 1,000 registries

In Step 3, because the National Sample Census for Agriculture 2019-2020 was not designed to implement the Production Function methodology, it was necessary to identify specific variables from the segmented dataset that met information requirements (Perman et al., 2003). Thus, the Production Function could be represented as:

Equation 1. Functional form of the Production function.

$$Q = f(L, K, E)$$

Where:

- *Q;* Output
- *L:* Labour
- *K:* Capital
- *E:* Environmental Indicator

Through an iterative analysis of the survey for smallholders, using data for Short Rainy Season, Long Rainy Season, and Permanent Crops, it was possible to identify variables that fit the information requirements (Perman et al., 2003). The result of this process was:

- ***There were no quantitative proxy variables for labour***. The closest was a variable that indicated whether the household members were involved in the agricultural process (q301c2)
- ***There were no variables on water consumption or water quality***. The best available proxy was "Cost of Irrigation" for the Short Rainy Season (q811c8e), Long Rainy Season (q821c8e) and Permanent Crops (q831c8d). This variable reports the cost of irrigation per season but does not specify the amount of water it gives the farmer. The irrigation cost is reported in TZS per season, but the survey nor the final report of the Census brings further definitions on what this cost entails.
- The "**Capital**" variable was handled by aggregating the following cost variables:
  - *Preparation:* Short Rainy Season (q811c6), Long Rainy Season (q821c6)
  - *Planting:* Short Rainy Season (q811c7b), Long Rainy Season (q821c7b)
  - *Harvesting:* Short Rainy Season (q811c9f), Long Rainy Season (q821c9f)
  - *Weeding:* Short Rainy Season (q811c8f), Long Rainy Season (q821c8f)

- The "**Output**" variable was a perfect fit because there was a variable for each subset that detailed the total output per crop / per season in kilograms: Short Rainy Season (q811c9e), Long Rainy Season (q821c9e) and Permanent(q831c9e)

For modelling, and to simplify the process, the authors assumed a **Linear Production Function**, therefore used SPSS software to develop a ***linear regression using Ordinary Least Squares.*** The function was calculated as follows:

- **Dependent variable:** Output per crop / per season in kilograms
- **Independent variables[16]:**
  - **Capital:** Continuous variable in Tanzanian Shillings (TZS), built aggregating the values of Preparation, Planting, Harvesting, Weeding
  - **Labour:** Dummy variable with two possible values, Yes/No, to the question, Are household members involved in the agricultural process?
  - **Environmental Indicator:** Cost of Irrigation per crop / per season in TZS

After the variables were consolidated and just before running the model, the dataset was refined by identifying and eliminating outliers. The process was made for each variable initially analysing it through box graphs, spotting possible outliers and eliminating them and then going through a thorough and continuous process of the descriptive statistics.

Finally, it is also worth noting that the census reports more than 100 crops in the country. Therefore, the authors decided that the best approach was to build a group of functions representative of the crop subsectors and calculate the water value based on those. Under this rationale, two options were initially assessed for the Smallholders set, specifically the Short Rainy Season (Table 12).

Table 12. Crops chosen to calculate the value of water in the crop sub-sector

Option 1: Main crops identified for smallholders.	Option 2: Group all crops present in the census according to subcategories[17]
• Maize • Paddy • Beans • Sunflower • Pigeon Pea	• Cereals • Legumes • Fruits • Vegetables • Permanent cash crops • Permanent Crops

Source: Elaborated by Authors

The two previous options were analysed from the quantitative point of view; that is, 11 iterations of the models were developed using the configuration, and their results were evaluated based on the following:

- Adjusted R^2 of the model[18]

[16] The definition of the used variables can be obtained from https://www.nbs.go.tz/tnada/index.php/catalog/31 using the variable codes listed in the previous group of bullets

[17] Categories mentioned in National Sample Census for Agriculture 2019- 2020, Smallholders Questionnaire.

[18] "*R^2 is a corrected goodness-of-fit (model accuracy) measure for linear models. It identifies the percentage of variance in the target field that is explained by the input or inputs" "Adjusted R^2 is always less than or equal to R^2. A value of 1 indicates a model that perfectly predicts values in the target field. A value that is less than or equal to 0 indicates a model that has no predictive value. In the real world, adjusted R2 lies between these values*" (IBM, 2023a).

- The significance[19] of the variables, especially the irrigation cost

Finally, in Step 5, the following conclusions were reached once the process for the Smallholders Farmers was completed.

- Not all crops have the same information. For example, some registries do not show responses for irrigation costs or harvesting.
- Only one crop, Beans, rendered an acceptable model for both Short and Long Rainy seasons.
- Only the Legumes group rendered an acceptable model because Beans were included.
- The production functions for other crops did not render satisfactory results regarding R^2 and Significance, meaning their explanatory ability was not acceptable. Therefore, they were deemed as not reliable for decision-making.

3.2.4 Results and Interpretation of Production Function Methodology

The fact that only one crop for Smallholders rendered an acceptable model allowed it to be concluded that even though data requirements were apparently met, this methodology was not adequate to calculate the value of water in the subsector of crops in the agricultural sector. Despite this result, the authors consider it necessary to show the Production Function for Beans crop results as some important conclusions can be drawn. Thus, Table 13 indicates that the function is acceptable quantitatively because its adjusted R^2 is close to 1, and the irrigation cost variable is significant within the model.

Table 13. Summary of the Model for Beans

Model	R	R^2	Adjusted R2	Standard Error
Beans	0.993[a]	0.996	0.984	344.58487
a. Predictors: (Constant), Irrigation Costs Short, is household involved?				

Coefficients [a,b]					
	No standardized Coefficients		Standardized Coefficients		
Model	B	Error Deviation	Beta	t	Sig.
(Constant)	288.889	303.895		.951	.359
Is household involved?	27.778	181.612	.005	.153	.881
Irrigation costs Short	.005	.000	.995	29,51	<.001
a. Dependent Variable: Total Kg Short					
b. Selection of cases only for Crop Code Short = Beans					

Source: Elaborated by Authors

Thus, the Production Function presented in Table 13**Error! Reference source not found.** for the Beans crop would have the following quantitative representation (see Equation 2**Error! Reference source not found.**):

[19] "*The significance value, or p value, is the probability that a result occurred by chance. The significance value is compared to a predetermined cut-off (the significance level) to determine whether a test is statistically significant. If the significance value is less than the significance level (by default, 0.05), the test is judged to be statistically significant*" (IBM, 2023b).

Equation 2. Production Function for Beans

$$Q = 288.88 + 27.77 \times L + 0.005 \times E$$

Where:

- ***Q***: Quantitative Variable that indicates Total Kg produced of beans during the short rainy Season
- ***L:*** Dummy Variable indicating if the members of the household were involved in the agricultural process of the beans or not
- ***K:*** Quantitative Variable expressed in TZS calculated by adding up the costs related to Preparation, Planting, Weeding and Harvesting. (The model dropped this variable, that is why it is not included in the equation)
- ***E:*** Quantitative variable expressed in TZS that represents how much money the household expends on irrigation (operation and equipment) for that crop during the Short Rainy Season

Results from this production function reveal that for every TZS spent on irrigation for Beans Crop in the short Rainy Season, an output increase of 0.005 Kg will be achieved. In 2021 USD figures, this means that for every 1 USD spent on beans crop irrigation during the short rainy season, an increased output of 11.43Kg was estimated. Based on the price of Beans in 2021 of 3.64 USD/Kg[20], the expected return ratio of bean irrigation is more than 4100%. The results of this analysis for beans suggest that investments in irrigation can improve physical and economic crop productivity.

3.3 Valuing water for crops through a Scaling Down Methodology and Analysis

Box 1. What do we understand by a Scale Down Methodology?

It is understood as an ad-hoc simplification of a well-defined methodology based on the available information to implement it. The simplification is made keeping the principles of the methodology in place, so it reflects the same type of values after its implementation and allows to follow the same rationale of interpretation.

In the case of the Production Function methodology, the scaled down approach elicits use values based on secund hand information reported mainly in the *National Agricultural Census Survey 2019-2020*. The obtained results, for example, for the crop subsector quantify the value of water as a portion of the costs of production of a specific product.

[20] This price was calculated using the data from Table 17 and taking it to USD of 2021 using the CPI of 2020 and the exchange rate for USD/TZS

3.3.1 Rationale for applying a scaling down methodology for valuing water for crops

After implementing the production function methodology, the authors inferred that a satisfactory result of the value of water for each specific crop could not be achieved. Therefore, the authors proposed a scaling-down approach[21] for a broader valuation of water in the entire crop sub-sector. This scaling-down approach is based on the principles of the Production Function methodology and uses National Agricultural Census microdata to produce an alternative model which renders the best possible results given the data limitations. This approach is built on the following rationale:

- The Production Function methodology builds on the principle that there is a relationship between water, as an input, and agricultural products, as the output.
- There are many costs within the agricultural crop process, and water is one of those costs.
- Water consumption takes place regardless a farmer profits from an agricultural product.
- The cost of irrigation incurred by a farmer is a proxy for the value that this person assigns to water because it shows a lower bound on the willingness to pay for having a specific amount of water reach its crop. The latter is consistent with what is considered in (Perman, Ma, McGilvray, & Common, 2003) that in some cases, production function approaches can be implemented following principles of Averting Expenditure methodologies and the quantitative response to this would be to include a variable that represents how much does a firm invest for having an environmental good or service that does not have a good enough quality.

  Following the latter rationale and considering that the National Agricultural Census 2019 – 2020 contains no variables that report neither water quantity or quality consumed by the farmers, and that using the data from the Census is essential to add trust to the study and to eventually achieve more joint efforts between the Ministry of Water and the National Bureau of Statistics.
- The ratio between the cost of water and other production costs (hereinafter, Water Cost Ratio) is a quantitative representation of the value the farmer assigns to water. This ratio is important because it allows to interpret the proxy value within the other production inputs quantitatively. By doing so, it follows the rationale of the production function Methodology.
- This proportion can be extrapolated to the income from agricultural products because there is no production without water. It could be assumed that this extrapolation represents an acceptable assessment of the value of water because:
  - It is recorded regardless of whether there is a profit or not.
  - It is understood within a framework of production costs.
  - It gives a better estimate than the one proposed by the market price methodology since it follows the logic of the Production Function methodology.

[21] "To date, valuing water has often been restricted in practice by the complexity of data needs and analyses… Acknowledging that data requirements do not allow for these advanced techniques at the moment, simpler approaches are proposed" (Möller Gulland, Hone, & Pohlner, 2020).

3.3.2 Steps and analysis using the scaling-down methodology

The quantitative representation of the scaling-down process is:

Equation 3. Value of water per crop

$$VWA_{Cn} = P_{Cn} \times Q_{Cn} \times Wp_{Cn}$$

Where:

- VWA_{Cn}: Value of water of crop *n* in TZS
- P_{Cn}: Price of crop *n* in TZS/metric tonnes
- Q_{Cn}: Output of crop *n* in metric tonnes
- Wp_{Cn} : Proportion of income related to water in %

The **proportion of income related to water** would be calculated as follows (see **Error! Reference source not found.**):

Equation 4. Proportion of income related to water

$$Wp_{Cn} = \frac{IC_{Cn}}{IC_{Cn} + C1_{Cn} + \cdots + CN_{Cn}} \times 100$$

Where:

- Wp_{Cn}: Proportion of income related to water in %
- IC_{Cn}: Irrigation cost per hectare of crop *n* incurred by the farmer during a harvesting season in TZS/ha
- $C1_{Cn}$: First cost per hectare of crop *n* incurred by the farmer during a harvesting season in TZS/ha
- CN_{Cn}: Cost N cost per hectare of crop *n* incurred by the farmer during a harvesting season in TZS/ha

Calculation initially focused on consolidating the different production costs available for the Smallholder Farmers dataset. These costs were reported by crop and season (Short Rainy Season, Long Rainy Season and Permanent Crops). They were extracted from the anonymized microdata for the same group of regions used to calculate the production functions.

In addition, it is worth noting that the census does not report irrigation costs for Large-Scale Farms. Those costs cannot be extrapolated from Smallholders because irrigation technologies depend on the farm's size. For example, the primary irrigation method for the Smallholders is Bucket (in terms of registries, 51.0% Short Rainy, 45.7% Long Rainy, and 78.3% Permanent Crops). However, Large-Scale Farms have, by definition, at least 20 hectares of cultivated land, making inefficient the use of buckets in terms of labour.

On the other hand, the authors didn't analyse all crops, only those with the most significant planted area (80% of the area planted), which is why Table 14 presents the Aggregated row representing the percentage of aggregated area for the main crops on a specific season, for example, for the Short Rainy Season crops from Maize, Paddy, Beans and Cassava, together account for 74.4% of the planted area for the analysed area (for small farmers). Under this assumption, the crops presented in Table 14 are considered a representative sample of the region's reality. This approach requires retrieving information from anonymized microdata, the census sample. Consequently, the results are a sample of the reality of the geographical area analysed.

Table 14. Planted area by crop type and season

Short Rainy Season		
Crop	**Area (ha)**	**Aggregated %**
Maize	14,581	58.7%
Paddy	2,015	66.8%
Beans	1,886	74.4%
Cassava	1,547	80.6%

Long Rainy Season		
Crop	**Area (ha)**	**Aggregated %**
Maize	19,075	38.3%
Paddy	9,250	56.9%
Sunflower	3,860	64.7%
Sorghum	3,557	71.8%
Beans	2,325	76.5%
Groundnut	2,253	81.0%

Permanent Crops		
Crop	**Area (ha)**	**Aggregated %**
Cashew nut	1,630	32.3%
Cassava	702	46.2%
Orange	435	54.8%
Banana	429	63.3%
Coconut	395	71.1%
Sugarcane	236	75.8%
Mango	231	80.3%

Source: Elaborated by Authors based on anonymized microdata from NBS, 2021b.

Table 14 shows the main crops that are planted in each period of cultivation, indicating the area reported in the survey and the aggregated percentage of the total area planted in each period according to the survey, that is:

- **Short Rainy Season**, 24,834 hectares
- **Long Rainy Season**, 49,778 hectares
- **Permanent Crops**, 5,050 hectares

Information in Table 14 suggests that for the two rainy seasons, the two main crops are maize and paddy, and the third crop is different for both; on the other hand, permanent crops are more heterogeneous and have in main place Cashew Nut and Cassava. Thus, cost information for all crops recorded in Table 14 was collected from the anonymized dataset, finding out that for some of them, there was no cost information, namely:

- Sunflower
- Pigeon pea
- Sesame/Simsim
- Sorghum
- Groundnut
- Coconut

The latter meant that the following crops would be subject to unit analysis since only unit cost information was reported for them:

- Maize

- Paddy
- Beans
- Cassava
- Orange
- Banana
- Sugar cane
- Mango

It is worth mentioning that unit costs are reported by season, Short Rainy and Long Rainy. For example, in the case of maize, it was necessary to consider the cost information for each of these periods so that it was possible to use the explanatory power of the dataset and have the best possible result. According to this, it was concluded that the best way to consolidate the information was:

- A weighted average would be calculated for crops that report cost information in the two rainy seasons (Short and Long).
- Only the information reported in that growing period would be used for the permanent crops.

The proportion of cultivated area in each period was used as a weighting criterion to calculate the weighted average. Thus, the information in Table 15 shows a consolidated amount of area reported by the anonymized microdata for the selected regions. Based on this information, it is concluded that the Long Rainy season almost doubles the area planted in the Short Rainy season, so the latter's costs should have a lower weight within the weighted average.

Table 15. Reported planted area per season

Season	Planted area per season (ha)	Percentage of planted area
Short Rainy Season	24,834	33%
Long Rainy Season	49,778	67%
Total	**79,663**	**100%**

Source: Elaborated by Authors based on anonymized microdata from NBS, 2021b.

The weighted average of costs was then calculated based on the following logic (see Equation 5**Error! Reference source not found.**):

Equation 5. Weighted average calculation

$$C_{WA} = C_S * P_S + C_L * P_L$$

Where:

- C_{WA}: Cost Weighted average (TZS/ha).
- C_S: Reported cost in the Short rainy season (TZS/ha).
- P_S: Percentage of area planted in the Short rainy season (%)

- C_L: Reported cost in the Long rainy season (TZS/ha).
- P_L: Percentage of area planted in the Long rainy season (%)

3.3.3 Results and Interpretation of the Scaling down methodology

This equation was applied to crops that report production costs for Smallholders. Table 16 shows results for production costs reported in the Smallholders survey, that is:

- Planting
- Preparation
- Weeding
- Harvesting
- Transport
- Seeds
- Fertilizer
- Herbicide
- Fungicide
- Insecticide
- Irrigation

Regarding costs, some others are not included, such as labour, taxes, and storage, among others. This fact must be considered when interpreting results. Nonetheless, the validity of the calculation maintains as the Proportion of Water Cost incorporates data from a national information source with high credibility. Table 16 shows the average costs per hectare for each crop and adds them to calculate later the *proportion of income related to water* based on Equation 5**Error! Reference source not found.**.

Table 16. Calculation of weighted average costs per crop (TZS /ha) and proportion of income related to water

Type of cost	Maize	Paddy	Beans	Cassava	Orange	Banana	Sugar cane	Mango
Planting	243	3,556	627	30				
Preparation	1,011	8,731	2,607	363				
Weeding	806	3,676	165	221				
Harvesting	69	3,309	80	-	196			
Transport	81	1,974	79	-				
Seeds	23,736	962	2,611	243	6,807	954	19,198	2,213
Fertilizer	4,672	121,877	20,014	14	13,357,027	137,809		
Herbicide	41,198	14,252	26,027	-		79,074		
Fungicide	-	20,598	12,027	-		741,315		
Insecticide	39,258	19,770	8,677	-		78,456		32,947
Irrigation	16,109	25,722	23,619	10,990	36,608	10,499	18,448	78,058
Total Costs	**127,183**	**224,427**	**96,536**	**11,861**	**13,400,638**	**1,048,107**	**37,646**	**113,218**
Proportion of income related to water	**12.7%**	**11.5%**	**24.5%**	**92.7%**	**0.3%**	**1.0%**	**49.0%**	**68.9%**

Note: Reported in current TZS of 2020. This period is assumed because costs are retrieved from the National Sample Census for Agriculture 2019-2020. |**Source:** Elaborated by Authors.

The results of Table 16**Error! Reference source not found.** confirm that not all crops have the same amount of information. Maize, Paddy, and Beans have the best available figures. Conversely, Cassava, Orange, Banana, Sugar cane and Mango present a few costs. Therefore, to guarantee robustness in the analysis and assuming a similar behaviour, only results for Maize, Paddy, and Beans would be used and extrapolated to the crop sector to derive the *proportion of income related to water*. According to the GDP of 2020, shown in Table 1, this proportion is equivalent to an average ranging from 11.5% to 24.5%. Considering the previous finding, proposing a group of assumptions that would allow the information on these three crops to be extrapolated to the entire Crops Subsector is necessary:

- The grouping of crops used in National Sample Census for Agriculture 2019-2020, that is, *CEREALS, ROOTS & TUBERS, PULSES, OIL SEEDS & NUTS, FRUITS & VEGETABLES, CASH CROPS, and OTHER CROPs* (see Annex 2 – Table A2-1) have similar characteristics for each group of crops specified in them.
- Based on the previous, the information calculated on the proportion of income related to water for the three crops is robust enough to be assumed as representative for the crop groups as follows:
  - CEREALS and TUBERS & ROOTS use average results for Maize and Paddy (12.1%)
  - PULSES, OIL SEEDS & NUTS, and FRUITS & VEGETABLES use results for Beans (24.5%.)
  - CASH CROPS and PERMANENT CROPS use the average results from the previous groups (CEREALS and TUBERS & ROOTS and CASH CROPS and PERMANENT CROPS) (18.3%)

Consequently, it**Error! Reference source not found.** is applied to all the crops with information on sale prices and quantity sold. The *proportion of income related to water* for this calculation is assumed per the previously mentioned groupings. Table 17 shows the result of the calculation exercise as follows:

- **Name of the crop:** The crops for which quantities cultivated for that year in the analysis area were included, both for the Short and Long Rainy seasons and for permanent crops.
- **Amount harvested:** The amount harvested of each crop is presented in Tons per year (Ton/year) for the period 2019 - 2020, which was calculated by adding the reports of the Short and Long Rainy seasons, and Permanent Crops (see Annex 2: Crops Statistics – Table A2-1). Quantities were extracted from the National Sample Census for Agriculture 2019-2020 retrieving system (NBS, 2023).
- **Prices:** These are presented in TZS/ton and result from calculating the arithmetic averages of the records extracted from the anonymized microdata of the analysis area from the National Sample Census for Agriculture 2019-2020. These prices are presented in current TZS of 2020.
- **Income:** This is presented in TZS/year and is calculated by multiplying the price of each product by the amount harvested in current TZS of 2020.
- **Proportion of income related to water:** This proportion is presented in percentage (%) and is taken from the categories indicated above.
- **Value of water per crop:** It is presented in TZS per year and is calculated by taking the income by the proportion of the income related to water. This value is shown in current TZS of 2020.

Table 17 shows that the annual value of water in analysis for the crops subsector is about TZS 948,146 million. This amount is equivalent to 17.66% of the income generated by those crops in the period analysed.

Table 17. Calculation of value[22] of water per crop

Crop	Quantity Harvested 2020 (Tons/year)	Prices (TZS/ton)	Income (TZS/year)	Proportion of income related to water (%)	Value of water per crop (TZS/year)	Value of water per crop (USD/year)
CEREALS AND ROOTS & TUBERS						
Maize	1,680,768	496,888	835,152,953,203	12.1%	100,748,989,012	44,071,920
Paddy	770,377	739,585	569,759,650,306	12.1%	68,733,168,611	30,066,830
Sorghum	270,405	607,418	164,248,747,358	12.1%	19,814,209,097	8,667,583
Bulrush Millet	109,615	958,000	105,011,170,000	12.1%	12,668,061,787	5,541,552
Finger Millet	7,177	17,800,500	127,754,188,500	12.1%	15,411,674,333	6,741,726
Wheat	85,015	1,125,000	95,641,875,000	12.1%	11,537,793,378	5,047,125
Cassava	486,969	876,885	427,015,630,074	12.1%	51,513,190,317	22,534,074
Sweet potatoes	23,753	791,833	18,808,398,134	12.1%	2,268,958,147	992,539
Irish potatoes	153,663	1,053,500	161,883,970,500	12.1%	19,528,933,356	8,542,791
Yams	632	1,700,000	1,074,400,000	12.1%	129,610,646	56,697
Cocoyam	1,749	923,000	1,614,327,000	12.1%	194,744,942	85,190
PULSES, OIL & FRUITS						
Beans	153,475	8,064,083	1,237,635,190,822	24.5%	302,813,133,790	132,463,426
Cowpeas	47,518	1,030,500	48,967,299,000	24.5%	11,980,865,907	5,240,944
Green gram	2,895	1,166,000	3,375,570,000	24.5%	825,903,253	361,285
Pigeon pea	15,699	1,173,500	18,422,776,500	24.5%	4,507,514,594	1,971,780
Chickpeas	2,955	17,926,000	52,971,330,000	24.5%	12,960,535,186	5,669,493
Bambaranuts	7,948	3,618,000	28,755,864,000	24.5%	7,035,718,891	3,077,725
Field peas	409	1,216,500	497,548,500	24.5%	121,735,566	53,252
Kiwi	3,634	1,447,500	5,260,215,000	24.5%	1,287,020,764	562,998
Sunflower	288,488	508,000	146,551,904,000	24.5%	35,856,964,671	15,685,371
Sesame/Simsim	37,858	4,189,000	158,587,162,000	24.5%	38,801,640,306	16,973,498
Groundnut	207,762	1,367,500	284,114,535,000	24.5%	69,514,517,151	30,408,625
Soyabeans	653	1,400,000	914,200,000	24.5%	223,678,002	97,846
FRUITS & VEGETABLES, CASH CROPS, PERMANENT CROPS						
Banana	288,177	909,000	261,952,893,000	18.3%	47,846,498,393	20,930,106
Onion	27,402	1,323,000	36,252,846,000	18.3%	6,621,693,382	2,896,612
Ginger	3,665	792,500	2,904,512,500	18.3%	530,518,106	232,071
Garlic	172	2,667,000	458,724,000	18.3%	83,787,344	36,652
Roselle	359	833,000	299,047,000	18.3%	54,621,851	23,894
Cabbage	11,797	637,500	7,520,587,500	18.3%	1,373,658,346	600,897
Spinach	7,468	1,539,000	11,493,252,000	18.3%	2,099,277,687	918,314
Carrot	2,089	773,500	1,615,841,500	18.3%	295,138,400	129,106
Chilies	4,026	5,750,000	23,149,500,000	18.3%	4,228,327,093	1,849,651
Amaranths	25,461	2,016,500	51,342,106,500	18.3%	9,377,793,038	4,102,248
Pumpkins	9,411	1,004,000	9,448,644,000	18.3%	1,725,823,772	754,949
Cucumber	1,430	908,500	1,299,155,000	18.3%	237,294,641	103,803
Egg Plant	1,451	1,384,500	2,008,909,500	18.3%	366,933,474	160,512
Watermelon	29,627	939,000	27,819,753,000	18.3%	5,081,363,111	2,222,806
Okra	29,429	2,452,000	72,159,908,000	18.3%	13,180,228,256	5,765,596
Tomatoes	117,455	1,270,000	149,167,850,000	18.3%	27,245,964,775	11,918,551
Bitter tomato	3,853	2,163,500	8,335,965,500	18.3%	1,522,589,636	666,046
Sweet/bell pepper	615	1,602,000	985,230,000	18.3%	179,955,278	78,720
Sweet potato leaves	17,910	624,500	11,184,795,000	18.3%	2,042,937,071	893,668
Mnavu/Mnafu	656	1,171,000	768,176,000	18.3%	140,309,700	61,377
Tobacco	190	2,000,000	380,000,000	18.3%	69,408,164	30,362

[22] Economic information reported in 2020 current prices

Crop	Quantity Harvested 2020 (Tons/year)	Prices (TZS/ton)	Income (TZS/year)	Proportion of income related to water (%)	Value of water per crop (TZS/year)	Value of water per crop (USD/year)
Sugar cane	45,351	546,000	24,761,646,000	18.3%	4,522,790,499	1,978,462
Tea	9,475	624,000	5,912,400,000	18.3%	1,079,917,972	472,402
Coffee	1928	2,595,000	5,003,160,000	18.3%	913,842,501	399,754
Sisal	33165	1,870,000	62,018,550,000	18.3%	11,327,878,150	4,955,299
Cashew nut	43186	2,221,000	95,916,106,000	18.3%	17,519,370,598	7,663,723
		Total	5,368,178,462,897	Total	948,146,482,943	414,759,855

Source: Elaborated by Authors.

Quantitative control of information was carried out to cross-reference the data presented in Table 17, specifically the income with statistics from the Gross Domestic Product for 2020 (Table 18**Error! Reference source not found.**). The calculations developed by the Authors conclude that income derived from crops in the study area corresponds to a little more than 5 trillion (Million) TZS in 2020. This figure can be crossed with the value presented for crops within the GDP of Tanzania Mainland of that same year (22.8 billion TZS), corresponding to 23.5%.

This calculation was made for what was produced in 6 regions (Dodoma, Morogoro, Pwani, Tanga Dar Es Salaam, and Manyara) in the crops subsector. Considering that Tanzania has 26 regions, it could be inferred that the explanatory power of the calculation is highly correlated to the country's GDP, therefore, the results are representative of the economy.

Table 18. GDP by Kind of Economic Activity (Current Prices 2020)

	ECONOMIC ACTIVITIES	2020 (TZS Million)	2020 (USD Million)
A	***Agriculture, forestry, and fishing***	***39,965,584***	***17,483***
	Crops	22,867,540	10,003
	Livestock	10,609,888	4,641
	Forestry	3,947,993	1,727
	Fishing	2,494,162	1,091
	Agriculture support services	46,001	20
	Industry and Construction	***44,950,342***	***19,663***
B	Mining and quarrying	9,947,971	4,352
C	Manufacturing	12,531,009	5,482
D	Electricity supply	398,084	174
E	Water supply; sewerage, waste management	745,222	326
F	Construction	21,328,055	9,330
	Services	***55,219,451***	***24,155***
G	Wholesale and retail trade; repairs	12,935,145	5,658
H	Transport and storage	11,172,778	4,887
I	Accommodation and Food Services	1,506,711	659
J	Information and communication	2,196,758	961
K	Financial and insurance activities	5,259,757	2,301
L	Real estate	4,253,172	1,861
M	Professional, scientific, and technical activities	986,133	431
N	Administrative and support service activities	3,992,260	1,746
O	Public administration and defence	5,530,738	2,419
P	Education	3,440,525	1,505
Q	Human health and social work activities	2,060,600	901
R	Arts, entertainment, and recreation	416,049	182
S	Other service activities	1,217,190	532

	ECONOMIC ACTIVITIES	2020 (TZS Million)	2020 (USD Million)
T	Activities of households as employers;	251,635	110
	All economic activities	**140,135,377**	***61,301***
	Taxes on products	11,031,006	4,825
	GDP at Market Prices	**151,166,383**	***66,127***

Source: NBS, 2022a

The consulting team assumes that the relationship between the *value of water* and the income generated by those crops that was calculated (17.66%) can be extrapolated to the national value of crops. Thus, the national value of water for Tanzania in 2020 can be obtained as follows (See **Error! Reference source not found.**):

Equation 6. National value of water for the crop subsector

$$NA_{Cwv} = C_{GDP} * P_{Cwv}$$

Where:

- NA_{Cwv}: National Value of Water for Crops in Tanzania in 2020
- C_{GDP}: Value of Tanzania's GDP for the crops subsector in 2020
- P_{Cwv}: Proportion value of water for the crops subsector in 2020

By substituting the values in **Error! Reference source not found.**, the following result was obtained:

$$NA_{Cwv} = 22{,}867{,}540 * 17.66\%$$

$$NA_{Cwv} = \ 4{,}038{,}945\ Million\ TZS\ (1{,}766\ \text{Million USD})$$

Applying this value to the GDP, the value of water for the crop subsector corresponds to 2.67% of the GDP.

3.4 Valuation of Water for Livestock

The authors developed the valuation of water for livestock using an interpretation of the market prices methodology (Figure 10) inspired by *Value, Counting Ecosystems as Water Infrastructure (*Emerton and Bos, 2004) and by *"Catchment Ecosystems and Downstream Water: The Value of Water Resources in the Pangani Basin, Tanzania"* (IUCN, 2005). The valuation approach used the average water consumption of livestock for both the herd and the animals that generate income to infer the unitary value of water and, based on that, calculate the value of water for the subsector equivalent to 85,152,483,765 TZN/year *(37,249,341 USD).*

Because this scaled-down approach is made on a volumetric basis, an interesting finding was made regarding the unit value of water, meaning that each cubic meter of water consumed by the livestock generates the following income:

- Cattle: 5,356 (TZS /m^3) (2.34 USD/m^3)
- Goat: 2,169 (TZS /m^3) (0.95 USD/m^3)
- Sheep: 1,114 (TZS /m^3) (0.49 USD/m^3)

The latter means that cattle generate the most income per volume of water, followed by goats, which generate almost twice as much as sheep. This is a point to be taken into account in terms of public policy on the types of livestock that should be encouraged solely based on the income that it generates.

3.4.1 Data sources

The Smallholder National Agricultural Census Survey 2019-2020 has a robust livestock[23] component that is built on the same surveys indicated for crops that includes data on (see Annex 3):

- Characterisation of livestock population by type (cattle, goats, and sheep)
- Livestock intake/offtake for the year by type (cattle, goats, and sheep)
- Milk production by season (wet and dry) and type (cattle and goats)
- Average price per type (cattle, goats, and sheep)
- Number of livestock per type sold (cattle, goats, and sheep)

Nonetheless, data reported in the survey did not include the following:

- Production costs by type of livestock
- Water consumption by type of livestock
- Costs associated with carrying water for livestock consumption.

3.4.2 Rationale for applying a Market Prices methodology for valuing water for livestock

After analysing the information available for this subsector, the first conclusion is that it is insufficient to implement any of the two methodological approaches used for the crop subsector. For this reason, an alternative approach had to be considered. To maintain the consistency of the methodological approach, the authors re-assessed the possibilities of the methodologies of Figure 10, concluding that:

- There was not enough information to apply a surrogate market approach because the National Agricultural Census Survey 2019-2020 registries do not record water as a feature that affects the price of livestock, making it impossible to infer its quantitative relationship.

[23] Surveys includes information on other type of livestock (chicken and hens, pigs, and others), however, it was not consolidated in the National Bureau of Statistics – Agriculture Census 2019-2020 (NBS, 2023). Livestock does not include donkeys.

- Neither of the cost-based approaches could be implemented because:
  - Although the Smallholder Survey included a quantitative variable that indicated the average distance from a farm to a common-use water resource, it did not specify if that was the source of water for livestock used by the farmer. The latter meant that although it was quantitatively plausible, too many uncertain assumptions needed to be made and doing so would have affected the credibility of the results.
  - Although the authors could have made assumptions to implement the damage cost avoided, they would not have used the information in the survey, which allowed them to link the contribution of water to the livestock subsector to the economy of Tanzania.
- The Market Prices valuation methodology was the best possible approach because "*Value, Counting Ecosystems as Water Infrastructure" (*Emerton and Bos, 2004) presents an example of valuing freshwater wetlands in the Zambezi Basin, Southern Africa, using marketed goods income associated with the wetlands such as Tourism earnings, livestock, and crops.

Another reference used to select this approach was *"Catchment Ecosystems and Downstream Water: The Value of Water Resources in the Pangani Basin, Tanzania"* (IUCN, 2005). This study was significant for the current study's authors because using it as a reference allows them to use what has been done in Tanzania regarding water valuation.

The approach proposed by IUCN (2005) goes as follows:

- First, they calculated the income associated with cattle in the basin, adding the income from the sale of cattle, goats, and sheep and the income from cow and goat milk.
- Next, they calculated the water consumed, determining the amount needed to generate income and used the average consumption per animal.
- Finally, they divided the revenue by the amount of water consumed, which gives a volumetric economic valuation of consumed water per animal.

Based on this rationale, the authors from the IUCN (2005) study interpret water's value as the income it generates for the livestock subsector. This interpretation is consistent with the market prices methodology presented in the methodological framework that this consultancy adopted (Figure 10).

3.4.3 Steps and analysis using the market prices methodology for valuing water for livestock

Based on the information available for livestock in the Smallholder National Agricultural Census Survey 2019-2020 and the methodology from IUCN (2005), the authors found the starting point to value water in the livestock subsector. However, to implement it, it is essential to make the following considerations:

- The National Agricultural Census Survey 2019-2020 quantifies all the livestock in Tanzania and records it as **The Herd**. The latter means that the Census reports the Herd of cows, goats, sheep and chickens, hens, pigs, and others present in each region of the country.

- As for the crops subsector, data is not reported by basin but by region. Therefore, it is assumed that the Wami/Ruvu basin comprises the regions of Dodoma, Morogoro, Pwani, Tanga, Dar Es Salaam, and Manyara.
- Most of the income from the livestock subsector is derived from milk production, the rest of the income is generated by animals that are sold off in a year, i.e., a subset of The Herd.
- Only a portion of the entire herd generates income for the farmers (e.g., not all livestock can be milked, and not all is bought or sold)
- The scaled-down approach proposed by the authors is made on a volumetric basis of water consumed by the animals. So, it is essential to note that the water required to generate income equates to the water that the entire Herd consumes.
- The latter also can be interpreted as that not all livestock in the Wami/Ruvu basin generates income, but regardless of if it does, it consumes water.

Based on the previous considerations, Equation 7 presents the quantitative representation of the proposed scaled-down approach to value water for the livestock subsector.

Equation 7. Value of Water for the Livestock Subsector

$$VWA_L = \boldsymbol{U_{WL}} * CW_{Ei}$$

Where:

- (VWA_L): Value of Water for the Livestock Subsector
- $(\boldsymbol{CW}_{\mathrm{Ei}})$: Consumption of animals that generate income (m^3/year)
- $(\boldsymbol{U_{WL}})$: Unit Value of Water (TZN/m^3)

The Authors proposed the following steps (Figure 16) to develop the scaled-down approach embodied in Equation 7:

Figure 16. Process followed to calculate the value of water in the livestock subsector

Source: Elaborated by Authors

- **Calculate Livestock Income:** In this first step, the authors calculated the income generated by the livestock subset. This calculation considers the income resulting from selling milk and buying and selling livestock.
- **Calculate Livestock water consumption:** In this second step, the authors calculated the water consumption that is composed by the following two groups of livestock:
  - Animals that generate the effective income
  - Animals that make up the herd

- **Calculate the Unit Value of Water:** In this third step, the authors calculate the Unit Value of water by taking the total income generated by the livestock subsector and dividing it into the total water consumption of the herd.
- **Calculate the value of water in the livestock subsector:** In this fourth step, the authors calculate the value of water for the livestock subsector by taking the Unit Value of Water and multiplying it by the water consumption of the subset of animals that generate the effective income. This is to say that the economic value of the water consumed by the livestock only monetizes itself once the livestock are purchased/sold off.

3.4.3.1 Livestock income

The income calculation seeks to determine how much the livestock subsector generates. The assumptions proposed by IUCN (2005) are adopted as follows:

- Cattle, goats, and sheep are representative of the livestock subsector.
- Only milk is analysed as a by-product. Therefore, only cattle and goat milk will be considered for this calculation because The National Agricultural Census Survey 2019-2020 reports milk sold solely for those two types of livestock.

Therefore, the income generated by the livestock subsector would have the following quantitative representation:

Equation 8. Livestock Income

$$L_i = E_i + M_i$$

Where:
L_i : Livestock Income
E_i : Effective Income
M_i: Milk Income

Effective Income (Ei) is calculated using the following variables from the National Agricultural Census Survey 2019-2020 in its livestock component:

- **Cattle Offtake by Category and Region During 2019/20**, that is, the number of cattle that leave the cattle herd, which consists of the following data:
  - Total number of livestock sold/traded and average price per head
  - Total number consumed
  - Total number given away
  - Total number stolen
  - Total number dead
- **Cattle Intake by Category and Region During 2019/20**, which refers to the number of cattle that enter the herd, reported as follows:

- Total number of livestock purchased and average price per head
- Total number of livestock received as a gift
- Total number of livestock born

It is assumed that a farmer makes investments (cattle Intake) and eventually sells cattle to make a profit (cattle offtake) to maintain the herd and derive income. Therefore, in this line, the Effective Income (Ei) would be a difference between these two parameters, meaning the profit that the farmer would derive from having a herd in a year and would have the following quantitative representation:

Equation 9. Effective Income

$$E_i = (O_S - I_P) * P_A$$

Where:

- O_S : Offtake Sale. Total number of cattle sold by the farmer during the year
- I_P : Intake Purchase. Total number of cattle purchased by the farmer during the year
- P_A : Price Average. Average sale price per head for the Wami/Ruvu basin

Table 19. Calculation of effective income (Current prices 2020)

	Cattle	Goat	Sheep
$(O_S - I_P)$ **(Animal /year)**	549,536	752,977	144,368
P_A **(TZS/Animal)**	433,245 *(189.5 USD)*	38,250 *(16.7 USD)*	41,271 *(18.1 USD)*
E_i **(TZS/year)**	238,083,488,805 (104,147,909 *USD*)	28,801,219,655 (12,598,886 USD)	5,958,258,888 (2,606,397 USD)

Source: Elaborated by Authors using data retrieved from NBS,2023.

A smallholder farmer's income from selling milk is the largest contributor to its overall income (assuming that its income is configured as presented in Equation 8). The statistics on smallholder farmers' milk production are shown in the National Agricultural Census 2019-2020. These figures include:

- The number of animals that are milked per season
- The number of days that the animals are milked per year
- The milk production per season
- The milk that is sold per season
- The average selling price of the milk

Based on the available information, Milk Income (Mi) was relatively simple to calculate because it was based solely on the quantities of milk that were reported as sold per season. Therefore, the Milk Income (Mi) was calculated by adding the milk sold during the year (wet and dry seasons) and multiplying it by the average sale price. Table 20 shows the result of this calculation.

Table 20. Milk income calculation

(Current prices 2020)

	Cattle	Goat
Milk sold (Litters/year)	848,416,244	4,691,910
Average price (TZS/Litter)	1,102 *(0.48 USD)*	2,175 *(0.48 USD)*
(Mi) (TZS/year)	934,530,492,766 *(408,803,638 USD)*	10,204,903,715 *(4,464,062 USD)*

Source: Elaborated by Authors using data retrieved from NBS, 2023[24]

It is imperative to note that although the figures presented in the National Agricultural Census 2019 – 2020 showed how many cows were milked in a year, a set of issues arose:

- Not all the milk that is produced is sold, meaning there is a portion that is used for self-consumption.
- In the case of cattle, two main types of cows produce milk (Improved and Indigenous), and these two have different yields (improved yields almost three times as much as the indigenous cows)
- The wet season has an overall higher milk yield than the dry season.
- The number of days that the animals are milked during each season is slightly different.
- It is unclear which of the animals purchased or sold generate milk income and for whom.
- Not all livestock reports income related to milk (sheep do not have records on the census)

Based on the latter and the available information, the authors could not establish an undisputable quantitative relationship between the milk reported as produced (see Table 20) and the livestock named *Effective Income (See* Table 19*)*. This can be further explained by the figures presented on Table 21 because the animals that generate the Effective Income are a subset of each herd, the same as the number of milked animals per season.

Table 21. Livestock figures for the WRB according to the National Agricultural Census 2019 – 2020

Item	Cattle	Goat	Sheep
Number sold/traded (Animal /year)	815,103	893,552	191,567
Number Purchased (Animal /year)	265,567	140,575	47,199
$(\mathbf{O_S} - \mathbf{I_P})$ **(Animal /year)**	**549,536**	**752,977**	**144,368**
Size of the herd for the WRB (Animal)	7,997,970	7,039,942	2,093,772
Number of animals milked during the WET season (Animal/season)	1,228,882	23,774	0
Number of animals milked during the DRY season (Animal/season)	947,544	27,670	0

Source: Elaborated by Authors using data retrieved from NBS, 2023

[24] Available at: http://data.nbs.go.tz:81/kilimo/index.php/ded/viewDashboard

The latter presents a possibility of improvement in further studies, and for this specific publication, the authors assumed that the subset of animals that generate the Effective Income (E_i) have a water consumption that is representative of the water that is consumed by the animals that generate the Milk Income (M_i).

Based on the latter assumption, closing this first part of the calculation is possible. The results of Table 19 and Table 20 are grouped, obtaining Table 22.

Table 22. Calculation of Livestock Income (Li)

	Cattle	Goat	Sheep	Total
E_i (TZS/year)	238,083,488,805 (104,147,909 *USD)*	28,801,219,655 (12,598,886 USD)	5,958,258,888 (2,606,397 USD)	272,842,967,347 *(119,353,356 USD)*
(Mi) (TZS/year)	934,530,492,766 *(408,803,638 USD)*	10,204,903,715 *(4,464,062 USD)*		944,735,396,481 *(413,268,269 USD)*
Livestock Income (Li) (TZS/year):	1,172,613,981,571 *(512,952,254 USD)*	39,006,123,370 *(17,062,971 USD)*	5,958,258,888 *(2,606,401 USD)*	1,217,578,363,828 *(532,621,971 USD)*

Source: Elaborated by Authors using data retrieved from NBS, 2023.

3.4.3.2 Livestock water consumption

To develop this calculation, it is essential to emphasize what is stated in the estimate of the Livestock Income component to the extent that the farmer can only generate income associated with livestock if it has a herd. Its income has two main streams: buying and selling livestock and selling milk.

When this situation is translated into water consumption, it can be interpreted that the entire herd must consume water for a farmer to generate income. Therefore, two groups of water consumption for livestock are calculated:

- **Consumption of animals that generate the effective income** ($\mathrm{CW_{Ei}}$): Total water consumed by animals that generate effective income, that is, ($\mathrm{O_S - I_P}$) (See Table 23). It is essential to recall the assumption made by the authors that the subset of animals that generate the Effective Income (E_i) have a water consumption that is representative of the water that is consumed by the animals that generate the Milk Income (M_i).
- **Consumption of animals that make up the herd** ($\mathrm{CW_C}$): Total water the herd consumes (data retrieved from NBS, 2023).

This calculation is carried out for cattle, goats and sheep and is based on the water consumption per type of animal reported by (IUCN, 2005):

- Cattle: 27.38 (m^3/year)
- Goat: 2.56 (m^3/year)
- Sheep:2.56 (m^3/year)

The calculation of Livestock Water consumption is presented in Table 23**, and it was made by multiplying** the water consumption per animal by the number of animals that comprise each of the two water consumption groups mentioned above.

Table 23. Calculation of livestock water consumption per year

	Cattle	Goat	Sheep
Animals that generate effective income. CW_{Ei} (m^3/year)	15,043,548	1,923,856	368,860
Animals that make up the herd. CW_C (m^3/year)	218,944,429	17,987,052	5,349,587

Source: Elaborated by Authors using data retrieved from NBS,2023

3.4.3.3 Unit value of water

This calculation of the Unit Value of Water (U_{WL}) follows the developed rationale, which concerns the amount of water required to generate income for the subsector. The Unit Value of Water would be the result of dividing the income generated by the cattle subsector for the Wami/Ruvu basin in one year by the amount of water that the livestock herd of the Wami/Ruvu basin would consume in one year. The quantitative exposure of this calculation is as follows:

Equation 10. Calculation of the unit value of water for the livestock subsector

$$U_{WL} = \frac{L_i}{\boldsymbol{CW_C}}$$

The calculation indicated in Equation 10 was made for cattle, goats and sheep and is presented in Table 24.

Table 24. Calculation of the unit value of water for the livestock subsector (Current prices 2020)

	Cattle	Goat	Sheep
Unit Value of Water (U_{WL}) ***(TZS[25]/m³)***	5,356 *(2.34 USD)*	2,169 *(0.95 USD)*	1,114 *(0.49 USD)*

Source: Elaborated by Authors

3.4.3.4 Value of water in the livestock subsector

According to the assumption made by the authors that the ***Consumption of water by animals that generate the Effective income*** ($\boldsymbol{CW_{Ei}}$) ***(See*** Table 23***)*** is representative of both of the income streams for livestock (buying and selling livestock and selling milk). Thus, Equation 7 presents the quantitative expression that would be followed to obtain the Value of Water for the Livestock Subsector (VWA_L), that is the water consumed by animals that generate the effective income times the unit value of water for the livestock subsector.

Table 25. Value of Water for the Livestock Subsector (Current prices 2020)

Item	Cattle	Goat	Sheep	Total

[25] Current prices of 2020

Consumption of animals that generate effective income. CW_{Ei} (m^3/year)	15,043,548	1,923,856	368,860	
Unit Value of Water (U_{WL}) ***(TZS[26]/m³)***	5,356 *(2.34 USD)*	2,169 *(0.95 USD)*	1,114 *(0.49 USD)*	
Value of Water for the Livestock Subsector (VWA_L)(TZN/year)	80,569,644,169 *(35,244,611 USD)*	4,172,010,758 *(1,825,016 USD)*	410,828,839 *(179,714 USD)*	**85,152,483,765** *(37,249,341 USD)*

Source: Elaborated by Authors using data retrieved from NBS, 2023.

Table 25 shows the result of applying Equation 7 to Cattle, Goats and Sheep; the value of the water of the livestock subsector is 85,152,483,765 TZN/year *(37,249,341 USD).*

3.4.4 Results and Interpretation of the market prices methodology for valuing water for livestock

The value of the water of the livestock subsector (85,152,483,765 TZN/year - *37,249,341 USD)* is equivalent to about 9% of the calculated crop value. Following the same procedure for the crop subsector, the relationship between the value of water in a year and the income generated by this value was calculated (Table 25). The result is the water value proportion for the Livestock subsector in 2020 (P_{Lwv}) and corresponds to 6.99% of the income generated by the livestock subsector.

Equation 11. National Value of Water for Livestock Subsector

$$NA_{Lwv} = L_{GDP} * P_{Lwv}$$

Where:

- NA_{Lwv}: National Value of Water for Livestock Subsector in Tanzania 2020
- L_{GDP}: Value of Tanzania's GDP for the Livestock Subsector in 2020
- P_{Lwv}: Proportion of value of water for Livestock subsector in 2020

By substituting the values in **Error! Reference source not found.**, the authors obtained the following result:

$$NA_{Cwv} = 10{,}609{,}888{,}000{,}000 * 6.99\%$$

$$NA_{Cwv} = 742{,}012{,}000{,}000\, TZS\ (324{,}587{,}809\ USD)$$

When comparing this value to the GDP, it is concluded that the value of livestock water corresponds to 0.491%.

[26] Current prices of 2020

3.5 Conclusion

The value of the water in the agricultural sector was calculated using different methodological approaches; The crop subsector used a scale-down approach of the production function methodology, obtaining a value of 4,038,945 million TZS (1,766 million USD) in a year for Tanzania. On the other hand, the livestock subsector used an approach inspired by the market price methodology, obtaining a value of 742,012 million TZS (324 million USD). Both results equate to 3.1% of Tanzania's 2021 GDP.

These results are the lowest quantifiable bound of the value of water in the agricultural sector of Tanzania, and this means that if further efforts were to be made to refine this quantitative exercise, the value of water would only increase.

The methodological approaches that were used differ from one another because, for crops, water was registered as a cost that the farmer incurs for irrigation, and no information on water consumption was used. On the other hand, Livestock registered water as a volumetric proxy and did not use any information regarding the cost of water.

The result from the crops subsector is then derived from how much of the cost of water irrigation represents on the overall costs of each crop, and the result from the livestock subsector is determined based on the amount of income generated by each unit of water. Both results, although in economic terms, have different backgrounds, and their interpretation can bring different possibilities regarding public policy.

As the results from the livestock subsector are based on a Unit Value of Water, this value can be compared with the current price of water assigned by the water boards. On the other hand, the results from the crop subsector allow policymakers to understand how a modification to the current water price could affect farmers' cost structure. The latter means that these two results separately can become essential tools to inform significant national discussions on the value of water and how that value is translated into the price of the resource.

The authors chose the approaches based on the available information that, in both cases, consisted mainly of highly reliable statistics documents from the National Bureau of Statistics. Neither of these documents reports water consumption, allowing us to conclude that including these variables in further national agricultural and industrial surveys would be significantly beneficial for Tanzania.

4 Valuation of Water in Manufacturing

4.1 Introduction

The National Accounts System classifies "Manufacturing" as a subsector of the "Industry" sector (see Annex 1) alongside "Mining and quarrying", "Electricity supply", "Water supply, sewerage and waste management", and "Construction". Manufacturing is the third most important contributor to the economy of Tanzania after the Crops and Wholesale subsectors in 2020. Manufacturing encompasses, for example:

- Food production
- Beverages
- Textiles
- Clothing
- Paper

According to Table A4-2, Manufacturing usage of water cannot be desegregated from the rest of the industry and mining sector; however, it consumes less than 1% of the country's water. Therefore, the value of this water was calculated using a similar approach to the one used in the crop's subsector, meaning a production function scaled-down approach from the production function methodology based on the information reported on the Annual Survey of Industrial Production 2016 (NBS, 2018a).

According to the calculations, the manufacturing sector's water value was 31,466 million TZS (13.76 USD Million). The latter result corresponded to 0.021% of GDP in 2020. Water costs (calculated by adding up the cost of water use as an input and water treatment) represent an average of 0.05% of the income from the manufacturing sector. On the other hand, 99.7% of the water costs that were reported correspond to water treatment. This means that getting access to water (water as an input) corresponds to 0.0004% of the production costs in the manufacturing sector of Tanzania.

The beverages industry presented the highest proportion of *income related to water,* with nearly 0.9% of their costs corresponding to water, mainly to water treatment. The second-highest industry was Food products with nearly 0.1% of *income related to water.*

4.2 Production function methodology and analysis

4.2.1 Data Sources

The primary source of information available is the Annual Survey of Industrial Production 2016 (NBS, 2018a), jointly developed by the National Bureau of Statistics and the Ministry of Industry, Investment and Trade. This survey consulted 2,462 establishments (with ten or more workers). It adopts the guidelines of the International Standard Industrial Classification (ISIC), covering the following subsectors, which are also divided into industrial activities:

- Manufacturing: 1,931 surveys (78.4%)
- Mining and Quarrying: 385 surveys (15.6%)
- Water supply; Sewerage and waste management: 110 (4.5%)
- Electricity, Gas, Steam and Air conditioning Supply: 36 (1.5%)

The survey shows consolidated results by subsector related to:

- Number of establishments
- Number of employed people

- Labour costs
- Gross Production
- Production costs

After reviewing the scope of this survey, it can be inferred that:

- Gross production yielded metrics that could be proxies of the income generated by each subsector.
- The production costs contained prices of water and water treatment costs, these being potential proxies to calculate the value of water.
- Labour and production costs allowed for an accurate mapping of the production costs of each subsector.

4.2.2 Rationale for using production function for valuating water for manufacturing

Even though the information reported in the survey is robust, there is no access to the anonymized microdata and no direct traceability between the information reported and its geographical origin. For example, data on water treatment costs by subsector is registered, but it is impossible to know how each region contributes on average to this cost. Therefore, the quantitative analysis is initially developed nationally and later regionalized.

The Annual Survey of Industrial Production 2016 (NBS, 2018a) presents variables that allow quantitative relationships between income and the main production factors such as labour, capital, and water. The latter is important because it follows the principle of the production function methodology.

As discussed in the crops subsector valuation, the production function is very reliable and fits the study's objective, meaning value the contribution of water to the economy, making it the best possible methodological option from Figure 10 because it uses market data from public sources of Tanzania and allows to understand the cost of water in a broader cost structure.

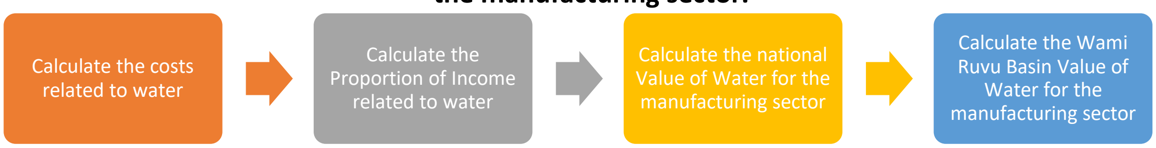
Based on the latter, the authors decided to implement the same principle of the scaled down approach that was used to value water for the crops subsector (See 3.3) but with the consolidated results from the results of the survey. The whole idea is to understand how the cost of water relates to the value added generated by the subsector. In 4.2.3 the authors detail how this rationale was applied.

4.2.3 Steps and Analysis for Implementing the production function methodology

Figure 17 shows the process that was followed to quantify the value of water for the manufacturing sector and as it can be seen, some aspects are similar to the process implemented for valuing water on 3.3 and that is because it is a scaled down approach of the production function methodology based on the available information for this sector :

- Step 1. Calculate the costs related to water: The authors went thoroughly into the Annual Survey of Industrial Production 2016 (NBS, 2018a) to quantify the water costs reported in the survey.
- Step 2. Calculate the Proportion of Income related to water: The authors went thoroughly into the Annual Survey of Industrial Production 2016 (NBS, 2018a) to determine the overall production costs and add them up and finally, the authors quantified the weight of the water costs in the overall production costs.
- Step 3. Calculate the national Value of Water for the manufacturing sector: The authors multiplied the results from step 1 by the total added value of the sector.
- Step 4. Calculate the Wami/Ruvu Basin Value of Water for the manufacturing sector: Because the results from Step 2 were on a national level, using GDP data, the consultants calculated the value of water for the manufacturing sector for the Wami/Ruvu Basin.

Figure 17. Process followed to implement the scaled-down valuation approach to value water in the manufacturing sector.



Source: Elaborated by Authors.

The quantitative representation of the scaled-down approach is presented in Equation 12:

Equation 12. Value of water for the manufacturing sector

$$VMW = VA_M \times Wp_M$$

Where:

- VWM: Value of water for the manufacturing sector in TZS
- VA_M: Value Added of the manufacturing sector in TZS
- Wp_M : Proportion of income related to water in %

It is worth noting that Equation 12**Error! Reference source not found.** differs from Equation 6**Error! Reference source not found.** in that it uses "Value Added", defined as *"… equal to Gross Output less the value of the Intermediate Consumption/Production Cost. The sum of the value added of all domestic producers gives the contribution to the Gross Domestic Product"* (NBS, 2018a). This definition suggests that this variable has a quantitative relationship with the output of the manufacturing sector and a direct quantitative relationship with GDP. For example, the Value Added of the industrial sector reported in the survey corresponds to 11,143,918 million TZS, while the corresponding industrial subsectors for the GDP in 2016 represent 14,672,489 million TZS[27]. This means the Survey data explains more than 75% of GDP for the manufacturing subsector it reports.

Similarly, the calculation of the proportion of income to water (Wp_M) also suffers some modifications based on available information related to costs. Thus, **Error! Reference source not found.** is expressed as:

Equation 13. Proportion of income to water for the manufacturing sector

$$Wp_M = \frac{PW_M + PWT_M}{C1_M + \cdots + CN_M} \times 100$$

Where:

- Wp_M : Proportion of income related to water in %
- PW_M: Yearly cost of water as an input[28] for the manufacturing sector in TZN/year
- PWT_M: Yearly water treatment[29] cost for the manufacturing sector TZN/year
- $C1_M$: Cost 1 incurred by the establishment in TZS in a year
- CN_M: Cost N incurred by the establishment in TZS in a year

The costs considered for the calculation indicated in Equation 13 **Error! Reference source not found.** are:

- **Group Cost 1:** Electricity, Water and Fuels Consumed by Industrial Activity
  - Electricity
  - Fuels for Machines and vehicles
  - Gas
  - Other fuels
  - **Water**
  - Wool, Coal, and Peat
- **Group Cost 2:** Total Labour Costs
  - Gross wages and Salaries
  - Overtime Payments
  - Travel Costs
  - Payment in Kind
  - Contribution of employer
  - Training costs
  - Other Labour Costs

[27] Sum of the "Manufacturing, Mining and Quarrying", "Water supply, Sewerage and Waste Management", and "Electricity, Gas, Steam and Air Conditioning" subsectors presented in the Annual Survey of Industrial Production 2016.

[28] The methodology component of the 2016 Annual Survey of Industrial Production specifically (3.5.4) outlines the groups of production costs, and it mentions water as an Input, however, the document does not supply any additional information about that variable, therefore, during this document it will me mentioned as Water as an Input.

[29] The 2016 Annual Survey of Industrial Production lists water treatment as a Non-Industrial Service and reports it in tables 24 and 25. Besides, in the methodology component, specifically 3.5.4 mentions nonindustrial services, but not water treatment perse, therefore, the document does not give any definition for the water treatment variable.

- **Group Cost 3: Capital Goods and Raw Materials:**
  - Capital Goods Purchased / Imports
  - Capital Goods Purchased / Local
  - Raw Materials / Imports
  - Raw Materials / Local
- **Group Cost 4: Industrial Services**
  - Industrial Activities
    - Contract and Commission
    - Cost of repairs and maintenance work
    - Waste treatment costs
    - Other
  - Non-Industrial Activities
    - Product certification (TBS)
    - Market studies
    - Marketing and publicity
    - **Water treatment costs**
    - Other

4.2.4 Results and Interpretation of the production cost analysis

Table 26 presents the implementation results**Error! Reference source not found.**, where the calculation is carried out for all industrial activities for the manufacturing subsector, arranged in the four groups mentioned above. It also presents specific costs associated with water and calculates the proportion of water-related income. Once the proportion of income related to water is calculated (Table 27),**Error! Reference source not found.** it can then be applied, obtaining the following result:

Table 26.Calculation of the proportion of income related to water for the manufacturing sector (000 TZS/year – current prices 2016)

ISIC	Industrial Activity	Group Cost 1	Group Cost 2	Group Cost 3	Group Cost 4	Total cost	Water as an input Cost	Water Treatment cost	Total Water costs	Proportion of income related to water (%)
100	Manufacture of food products	444,117	526,218,394	3,205,441,677	201,240,542	**3,933,344,730**	15,819.4	4,088,706	**4,104,525**	0.104%
110	Manufacture of beverages	128,435	368,056,044	653,870,690	151,535,205	**1,173,590,374**	10,864.6	10,714,579	**10,725,444**	0.914%
120	Manufacture of tobacco products	14,524	67,282,959	129,062,072	8,330,891	**204,690,446**	229.9		**230**	0.000%
130	Manufacture of textiles	28,125	24,810,423	143,625,531	12,213,526	**180,677,605**	1,122.5	9,250	**10,373**	0.006%
140	Manufacture of wearing apparel	14,635	102,021,133	75,106,425	7,054,441	**184,196,634**	1,511.0	270	**1,781**	0.001%
150	Manufacture of leather and related products	3,282	5,811,906	37,106,052	1,526,959	**44,448,199**	251.9	13,020	**13,272**	0.030%
160	Manufacture of wood and of products of wood and cork, except furniture (…)	13,099	10,647,426	38,609,157	2,754,534	**52,024,216**	282.3	3,324	**3,606**	0.007%
170	Manufacture of paper and paper products	20,002	12,979,083	33,820,662	8,926,176	**55,745,923**	45.7		**46**	0.000%
180	Printing and reproduction of recorded media	6,197	100,698,712	86,780,720	4,750,396	**192,236,025**	263.1	6,650	**6,913**	0.004%
190	Manufacture of coke and refined petroleum products	388	1,963,070	34,081,272	757,791	**36,802,521**	6.4	1,200	**1,206**	0.003%
200	Manufacture of chemicals and chemical products	25,883	27,452,500	252,982,782	17,984,706	**298,445,871**	642.4	52,134	**52,776**	0.018%
210	Manufacture of pharmaceuticals, medicinal chemical, and botanical products	3,672	12,099,239	71,950,763	7,268,971	**91,322,645**	125.1	1,469	**1,594**	0.002%
220	Manufacture of rubber and plastics products	24,411	23,954,965	193,321,545	4,818,085	**222,119,006**	1,671.5	6,934	**8,605**	0.004%
230	Manufacture of other non-metallic mineral products	206,677	84,591,016	291,190,199	44,744,641	**420,732,533**	1,576.0	24,955	**26,531**	0.006%
240	Manufacture of basic metals	31,658	15,582,048	154,515,259	4,550,704	**174,679,669**	881.7	55,556	**56,438**	0.032%
250	Manufacture of fabricated metal products, except machinery and equipment	14,275	72,358,557	230,355,351	6,284,141	**309,012,324**	211.5	1,754	**1,965**	0.001%
260	Manufacture of computer, electronic and optical products	607	4,589,011	10,471,493	291,527	**15,352,638**	11.5	10,247	**10,258**	0.067%
270	Manufacture of electrical equipment	5,345	11,885,080	69,190,840	5,228,516	**86,309,781**	261.3		**261**	0.000%

ISIC	Industrial Activity	Group Cost 1	Group Cost 2	Group Cost 3	Group Cost 4	Total cost	Water as an input Cost	Water Treatment cost	Total Water costs	Proportion of income related to water (%)
280	Manufacture of machinery and equipment n.e.c.	14,184	4,824,081	11,807,494	1,598,642	**18,244,401**	48.2	930	**978**	**0.005%**
290	Manufacture of motor vehicles, trailers, and semi-trailers	1,322	5,055,567	44,244,099	650,854	**49,951,842**	82.6	3,600	**3,683**	**0.007%**
300	Manufacture of other transport equipment	210	57,980,651	6,855,846	1,803,219	**66,639,926**	36.4		**36**	**0.000%**
310	Manufacture of furniture	5,117	19,162,926	145,690,603	3,991,014	**168,849,660**	307.1	21,044	**21,351**	**0.013%**
320	Other manufacturing	3,677	7,581,615	326,704,782	1,255,115	**335,545,189**	135.6	4,416	**4,552**	**0.001%**
330	Repair and installation of machinery and equipment	221	2,198,277	553,456	37,549	**2,789,503**	14.8	1,142	**1,157**	**0.041%**
	Totals	**1,010,063**	**1,569,804,683**	**6,247,338,770**	**499,598,145**	**8,317,751,661**	**36,403**	**15,021,180**	**15,057,583**	

Source: NBS,2018a.

Table 27. Calculation of the value of water for the manufacturing sector (000 TZS/year - Current prices 2016)

ISIC	Industrial Activity	Proportion of income related to water in %	Value Added	Value of Water
100	Manufacture of food products	0.104%	2,596,278,485	2,709,270
110	Manufacture of beverages	0.914%	1,689,870,247	15,443,726
120	Manufacture of tobacco products	0.000%	75,514,553	85
130	Manufacture of textiles	0.006%	159,953,944	9,183
140	Manufacture of wearing apparel	0.001%	323,107,537	3,124
150	Manufacture of leather and related products	0.030%	20,373,611	6,083
160	Manufacture of wood and of products of wood and cork, except furniture (…)	0.007%	136,723,623	9,478
170	Manufacture of paper and paper products	0.000%	140,898,679	1160
180	Printing and reproduction of recorded media	0.004%	262,787,837	9,450
190	Manufacture of coke and refined petroleum products	0.003%	5,577,502	183
200	Manufacture of chemicals and chemical products	0.018%	303,133,078	53,605
210	Manufacture of pharmaceuticals, medicinal chemical, and botanical products	0.002%	49,979,435	872
220	Manufacture of rubber and plastics products	0.004%	226,892,700	8,790
230	Manufacture of other non-metallic mineral products	0.006%	907,370,323	57,218
240	Manufacture of basic metals	0.032%	68,675,291	22,188
250	Manufacture of fabricated metal products, except machinery and equipment	0.001%	244,044,748	1,552
260	Manufacture of computer, electronic and optical products	0.067%	15,060,508	10,063
270	Manufacture of electrical equipment	0.000%	44,351,980	134
280	Manufacture of machinery and equipment n.e.c.	0.005%	7,184,129	385
290	Manufacture of motor vehicles, trailers, and semi-trailers	0.007%	16,186,651	1,193
300	Manufacture of other transport equipment	0.000%	86,384,027	47
310	Manufacture of furniture	0.013%	157,126,120	19,869
320	Other manufacturing	0.001%	30,701,114	416
330	Repair and installation of machinery and equipment	0.041%	8,505,169	3,527
	Total		**7,576,681,291**	**18,370,559**

Source: Elaborated by Authors based on NBS, 2018a.

Table 27 shows that the annual value of water in Tanzania for the manufacturing subsector in 2016 was 18,366,060,000 TZN[30]. In line with the analysis developed for the crop and livestock subsectors, the *Proportion Value of Water for the Manufacturing Sector* (P_{Mwv}) was calculated for 2016 and corresponded to 0.25%. This was the result of dividing the value of water by the added value generated by the manufacturing sector in 2016.

Equation 14. National value of water for the manufacturing sector

$$NA_{Mwv} = M_{GDP} * P_{Mwv}$$

Where:

- NA_{Mwv}: National value of water for the manufacturing sector of Tanzania of 2020
- M_{GDP}: GDP value of the manufacturing sector of Tanzania in 2020.
- P_{Mwv}: Proportion value of water for the manufacturing sector in 2016

[30] Current prices 2016.

To calculate the value of water in Tanzania for 2020, the *Proportion Value of Water for the Manufacturing subsector in 2016* (P_{Mwv}) can be applied to the GDP values of 2020 because it is dimensionless: it is a proportion that would not change in time with the available information.[31] By substituting the values in Equation 14, the following result was obtained:

$$NA_{Cwv} = 12{,}531{,}009{,}000{,}000 * 0.24\%$$

$$NA_{Cwv} = \ 30{,}382{,}913{,}483\ TZS\ (\ 13{,}290{,}787\ USD)$$

The latter result corresponded to 0.02% of GDP in 2020. Because it is a national value, it is necessary to calculate it for the Wami/Ruvu Basin. It is essential to observe that the Annual Survey of Industrial Production 2016 only reports information on nine regions (Dar es Salaam, Manyara, Morogoro, Arusha, Kilimanjaro, Mara, Singida, Mbeya and Mwanza), and only three are part of the basin (Dar es Salaam, Manyara and Morogoro).

To calculate the value for the Wami/Ruvu Basin, it was decided to use the contributions to GDP by region for 2016 (Table 28), identifying those regions that make up the Wami/Ruvu Basin (highlighted in green). They accounted for 34.5% of the national GDP in 2016. Therefore, the authors concluded that *the value of water for the manufacturing sector in the Wami/Ruvu basin was 10,493,335,099 TZS in 2020 (4,590,234 USD).*

Table 28. Regional GDP at current market prices 2016 (Million TZS)

Region	2016	% Per Region
Dodoma	3,029,944	2.9%
Arusha	4,876,972	4.7%
Kilimanjaro	4,607,203	4.4%
Tanga	4,845,840	4.7%
Morogoro	4,980,758	4.8%
Pwani	1,867,779	1.8%
Dar -es salaam	17,640,153	17.0%
Lindi	2,033,780	2.0%
Mtwara	2,801,644	2.7%
Ruvuma	4,046,849	3.9%
Iringa	5,099,161	4.9%
Mbeya	5,831,818	5.6%
Singida	1,919,649	1.9%
Tabora	3,943,084	3.8%
Rukwa	3,735,532	3.6%
Kigoma	3,009,195	2.9%
Shinyanga	6,163,660	5.9%
Kagera	4,098,730	4.0%
Mwanza	10,050,581	9.7%
Mara	3,808,189	3.7%
Manyara	3,465,761	3.3%

[31] In other words, if it were projected until 2020 with inflation, the proportion would remain intact.

Region	2016	% Per Region
Songwe	1,888,324	1.8%
Tanzania Mainland	**103,744,606**	

Source: NBS, 2022a.

4.3 Conclusion

The quantitative results from the process show that none of the industries that comprise the manufacturing sector has a *proportion of income related to water* higher than 1%. On top of that, more than 99% of the costs associated with water are attributed to water treatment. These two results can be the basis of national debates on how these figures relate to the water tariffs the water basin boards currently charge to water users.

The latter does not mean that the *proportion of income related to water* needs to increase; however, if the country and the water boards demand improvement in integrated water management, a higher budget allocation is required.

The information in the Annual Survey of Industrial Production 2016 presents an excellent entry point for water valuation for the country. Further quantitative relations could have been inferred if the authors would have had access to the anonymized data of the survey; nevertheless, the results obtained are significant because they are derived from the survey developed by the National Bureau of Statistics, a very influential and reliable institution in Tanzania.

The overall result for the value of water for the manufacturing sector of Tanzania in 2020 was 31,466 million TZS (13 million USD), less than 1% of the value of water calculated for the agriculture sector. It is important to outline here that, in terms of GDP, the agricultural sector contributes nearly three times as much as the manufacturing sector.

The latter can also be analysed considering the results from Table 26 that show that water costs, both acquisition and water treatment, represent an average of 0.05% of the income from the manufacturing sector. Out of those costs, 99.7% correspond to water treatment. This means that water as input costs correspond to only 0.0004% of the production costs in the manufacturing sector of Tanzania.

If water is a prerequisite for the manufacturing sector, it is worth asking whether this sector's economic contribution to water management is consistent with the importance of the resource. In terms of further valuation studies for the manufacturing sector, the authors suggest that:

- Water consumption variables are included in the next Annual Survey of Industrial Production.
- Make sectoral-specific studies that analyse costs associated with water within the manufacturing sector, such as transporting and cooling.

- The valuation of the contribution of water to the electricity sector is made because hydropower contributes nearly 35% of the country's electricity[32].

5 Valuation of Water in Mining

5.1 Introduction

The Mining sector is the Mining and Quarrying component of Tanzania´s GDP. This sector is included in the Annual Survey of Industrial Production 2016 (NBS, 2018a) and defines it as "… activities relating to extraction of minerals occurring naturally as solids (coal and ores), liquids (petroleum) or gases (natural gas). Extraction can be achieved by different methods…". The latter includes[33]:

- Mining of coal and lignite
- Extraction of crude petroleum and natural gas
- Mining of metal ores
- Other mining and quarrying
- Mining support service activities

A scaled-down approach of the production function methodology was used, based on the data from the Annual Survey of Industrial Production from 2016, to calculate the value of water in the mining sector. The results show that the value of water in mining for 2020 was 177,186 million TZS (77.5 USD Million). This value is nearly six times larger than the value of water for the manufacturing sector.

5.2 Production function methodology and analysis

5.2.1 Data sources

The review of secondary sources of information for the mining sector yielded consolidated data on quantities, prices, and income for the main minerals that are exploited. This review consistently showed that gold was the main contributor to the economy. However, no specific information was found for this mineral associated with:

- Main extraction methods and their associated costs
- Water consumption
- Costs of acquiring and treating water

[32] https://data.worldbank.org/indicator/EG.ELC.HYRO.ZS?locations=TZ
[33] https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf

To overcome the lack of information on gold and other minerals for the economy, an official request for information was made through the Ministry of Water and reinforced during the field visit. However, no information was received on the gaps indicated above.

Based on the latter and on the analysis developed to calculate the value of water in the manufacturing sector, the authors revisited the Annual Industrial Production Survey 2016, finding that the Mining and Quarrying sector was also included there. Therefore, in line with the above, the Authors sought to understand if:

I. The information reported for Mining and Quarrying in the survey included gold.
II. The information reported for Mining and Quarrying in the survey could somehow explain the mining sector in terms of GDP.
III. The information reported for Mining and Quarrying in the survey could be used to calculate the water value in this sector.

For the point I, the survey defines Mining and Quarrying as:

> *"Mining and quarrying includes activities relating to extraction of minerals occurring naturally as solids (coal and* ***ores****), liquids (petroleum) or gases (natural gas). Extraction can be achieved by different methods such as under-ground or surface mining, well operation, seabed mining, etc. Also, included are supplementary activities aimed at preparing the crude materials for marketing, for example, crushing and grinding, cleaning, drying, sorting, concentrating ores, liquefaction of natural gas and agglomeration of solid fuels." (NBS, 2018a)*

Additionally, the ISIC code - International Standard Industrial Classification of All Economic Activities (United Nations, 2018), under which the Mining and Quarrying activity is registered, was reviewed, focusing on gold:

- B: Mining and Quarrying
  - 7 Mining of metal ores
    - 72 Mining of non-ferrous metal ores
      - 729: Mining of other non-ferrous metal ores
        - This class Includes:
          - Mining and preparation of ores valued chiefly for non–ferrous metal content:
            - Aluminium (bauxite), copper, lead, zinc, tin, manganese, chrome, nickel, cobalt, molybdenum, tantalum, vanadium, etc
            - Precious metals: **Gold**, silver, platinum

Based on the definitions above, it can be inferred that "gold" is included in the Annual Industrial Production Survey 2016.

To conclude on Point II, the survey reports "Value Added", this variable is defined as *"…equal to Gross Output less the value of the Intermediate Consumption/Production Cost. The sum of the value added of all domestic producers gives the contribution to the Gross Domestic Product".* Table 29 shows the Value Added reported in the Annual Industrial Production Survey 2016 for Mining and Quarrying subsector.

Table 29. Value Added for Mining and Quarrying subsector reported in the Annual Industrial Production Survey 2016

ISIC Rev.4	Industrial Activity	Value Added (Million TZS /year)
5	Mining of coal and lignite	392.74
7	Mining of metal ores	2,239,309.13
8	Other mining and quarrying	348,793.95
9	Mining support service activities	4,184.05
	Total	**2,592,679.87**

Source: Elaborated by Authors based on NBS, 2018a.

When comparing the total value presented in Table 29 with the value shown for Mining and Quarrying in the GDP of 2016 (See Annex 1: Economic and Social StatisticsAnnex 1: Economic and Social Statistics), it can be observed that the results of the survey explain more than 48% of the GDP of this sector, which means that the survey does not fully explain the GDP of this subsector.

Finally, regarding point III, the Authors conclude that the Annual Survey of Industrial Production 2016 can be used as a basis to calculate the value of water for the mining subsector using what is reported in the Survey as Mining and Quarrying because it includes the main mineral exploited by Tanzania, gold, and has the same amount of information used in the calculation made for the manufacturing subsector.

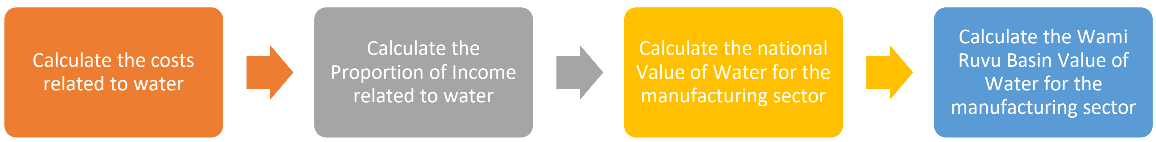
5.2.2 Rationale for using production Function for valuating water for Mining

As mentioned before, the production function methodology was the best methodological approach for the study because it quantifies the value of water based on a marketed good or service, and the study's objective is to value the contribution of water in the chosen sectors to the Economy of Tanzania.

It is important to note that the production function valuation methodology quantifies the value of an environmental good or service by interpreting it as input alongside other inputs, such as labour and capital, to determine their marginal value in terms of production of the marketed good or service. Once the authors concluded that the survey contained registries of companies that mined gold, the same principle for the manufacturing sector was used: a scaled-down version of the production function methodology. The scale-down was necessary because the authors only had access to the consolidated results of the Annual Survey of Industrial Production 2016 and not to the anonymized data, making it impossible to conclude the production functions to implement the methodology. The scale-down approach aimed to quantify the weight of the water supply and water treatment cost in the overall cost structures and the value added the sector generates.

5.2.3 Steps and Analysis for Implementing the production function methodology

The procedure followed to value water in the mining sector is the same as in Figure 17. The steps that were undertaken are as follows:



Source: Elaborated by Authors.

- Step 1. Calculate the costs related to water: The authors went thoroughly into the Annual Survey of Industrial Production 2016 (NBS, 2018a) to quantify the water costs reported in the survey.
- Step 2. Calculate the Proportion of Income related to water: The authors went thoroughly into the Annual Survey of Industrial Production 2016 (NBS, 2018a) to determine the overall production costs and add them up and finally, the authors quantified the weight of the water costs in the overall production costs.
- Step 3. Calculate the national Value of Water for the manufacturing sector: The authors multiplied the results from step 1 by the total added value of the sector.
- Step 4. Calculate the Wami/Ruvu Basin Value of Water for the manufacturing sector: Because the results from Step 2 were on a national level, using GDP data, the consultants calculated the value of water for the manufacturing sector for the Wami/Ruvu Basin.

The adjusted procedure for the mining sector has the following quantitative representation:

Equation 15. Value of water for the Mining Sector

$$VMG = VA_G \times Wp_G$$

Where:

- VWG: Value of water for the mining sector in TZS
- VA_G: Value Added of the mining sector in TZS
- Wp_G : Proportion of income related to water in %

Equation 16. Proportion of income related to water

$$Wp_M = \frac{PW_G + PWT_G}{C1_M + \cdots + CN_M} \times 100$$

Where:

- Wp_G : Proportion of income related to water in %
- PW_G: Yearly cost of water as input[34] for the Mining sector in TZN/year
- PWT_G: Yearly Water Treatment cost for the Mining sector TZN/year
- $C1_G$: First cost per year incurred by the establishment in TZS/year
- CN_G: First cost per year incurred by the establishment in TZS/year

The costs considered for the calculation indicated in **Error! Reference source not found.** are the following:

- **Group Cost 1:** Electricity, Water and Fuels Consumed by Industrial Activity
    - Electricity
    - Fuels for Machines and vehicles
    - Gas
    - Other fuels
    - Water
    - Wool, Coal, and Peat
- **Group Cost 2: Total Labour Costs**
    - Gross wages and Salaries
    - Overtime Payments
    - Travel Costs
    - Payment in Kind
    - Contribution of employer
    - Training costs
    - Other Labour Costs
- **Group Cost 3: Capital Goods and Raw Materials:**
    - Capital Goods Purchased / Imports
    - Capital Goods Purchased / Local
    - Raw Materials / Imports
    - Raw Materials / Local
- **Group Cost 4: Industrial Services**
    - Industrial activities
        - Contract and Commission
        - Cost of repairs and maintenance work
        - Waste treatment costs
        - Other
    - Non-Industrial Activities
        - Product certification (TBS)
        - Market studies

[34] The methodology component of the 2016 Annual Survey of Industrial Production specifically (3.5.4) outlines the groups of production costs, and it mentions water as an Input, however, the document does not supply any additional information about that variable, therefore, during this document it will me mentioned as Water as an Input.

- Marketing and publicity
- Water treatment costs
- Other

5.2.4 Results and interpretation of the production function

Error! Reference source not found. presents the results of implementing Equation 15, where the calculation is carried out for all industrial activities in the mining sector, arranged in the four groups mentioned above. It also presents specific costs associated with water and calculates the proportion of income related to water.

Table 30. Calculation of the proportion of income related to water for the Mining sector (Current prices 2016 - 000 TZS/year)

ISIC	Industrial Activity	Group Cost 1	Group Cost 2	Group Cost 3	Group Cost 4	Total Cost	Water Cost	Water Treatment Cost	Total Water costs	Proportion of income related to water (%)
5	Mining of coal and lignite [35]	1,058	374,147	-	-	375,205	0.62	-	0.62	0.0002%
7	Mining of metal ores	549,459	312,401,673	32,219,659	47,839,812	393,010,603	127.04	8,055,912	8,056,039	2.0498%
8	Other mining and quarrying	55,094	55,440,342	306,608,276	39,287,945	401,391,657	1,022.56	317,737	318,759.	0.0794%
9	Mining support service activities	2	57,684	1,662,215	12,000	1,731,901	-	-	-	0.0000%
	Totals	**1,010,063**	**1,569,804,683**	**6,247,338,770**	**499,598,145**	**8,317,751,661**	**36,403**	**15,021,180**	**15,057,583**	

Source: Elaborated by Authors based on NBS, 2018a.

Once the proportion of income related to water is calculated, it can then **Error! Reference source not found.**be applied, obtaining as result:

Table 31. Calculation of the value of water in the Mining sector (Current prices 2016 - 000 TZS/year)

ISIC	Industrial Activity	Proportion of income related to water %	Value Added	Value of Water
5	Mining of coal and lignite	0.0002%	392,738	0.6
7	Mining of metal ores	2.0498%	2,239,309,129	45,901,972
8	Other mining and quarrying	0.0794%	348,793,953	276,990
9	Mining support service activities	0.0000%	4,184,045	0
	Totals		**2,592,679,865**	**46,178,963**

Source: Elaborated by Authors based on NBS, 2018a.

[35] This activity does not report information on water Treatment cost in the 2016 Annual Survey of Industrial Production

Table 31 shows that the annual value of water in Tanzania for the mining sector in 2016 is TZN 46,178,963,000 (current prices 2016). In line with the analysis developed for the manufacturing, crop and livestock subsectors, the relationship between the value of water in a year and the added value generated by this value of water is calculated. The result is the proportion value of water for the mining sector in 2016 (P_{Gwv}) and corresponds to 1.78% of the economic value generated by the mining sector.

Equation 17. National value of water in the Mining sector.

$$NA_{Gwv} = G_{GDP} * P_{Gwv}$$

Where:

1. NA_{Gwv}: National value of water for the mining sector of Tanzania in 2020
2. G_{GDP}: GDP value of the mining sector of Tanzania in 2020.
3. P_{Gwv}: Proportion value of water for the mining sector in 2016

Using the same rationale as in the manufacturing subsector, the proportion value of water for the mining sector in 2016 (P_{Gwv}) can be applied to the GDP values in 2020. By substituting the values in **Error! Reference source not found.**, the following result was obtained:

$$NA_{Gwv} = 9{,}947{,}971{,}000{,}000 * 1.78\%$$
$$NA_{Gwv} = \quad 177{,}186{,}000{,}000\, TZS\ (\ 77{,}508{,}741\ USD)$$

This value corresponded to 0.117% of GDP in 2020. To extrapolate this result for the Wami/Ruvu basin, the same procedure used for the manufacturing sector is followed; that is, the regional proportion of the GDP produced by the basin regions is used (34.5%). Therefore, *the value of water for the mining sector in the Wami/Ruvu basin was 61,129,170,000 TZS in 2020 (26,740,515 USD)***.**

5.3 Conclusion

The value of the water in the mining sector in Tanzania was calculated at 177,186 million TZS (77 million USD)[36] per year, and as with the manufacturing sector, it is essential to observe that the cost of water equates to nearly 0.53% of the income of the sector; however only 0.01% corresponds to water supply costs, this means that the economic effort of the sector towards water goes into treatment.

The obtained value of water for the mining sector is almost five times larger than the value obtained for the manufacturing sector: Keep in mind that in 2020 the Manufacturing sector contributed 25% more to the GDP of Tanzania than the mining sector. The latter is attributed to the mining sector having a larger average expenditure on water treatment costs. These results

[36] Both figures presented at 2020 current prices.

invite a discussion on how the price that mining companies pay for water as an input reflects its actual value; and whether that price efficiently contributes to water continuity in the long term.

It is essential to outline that, as with the results from the manufacturing sector, the obtained value suggests that the cost of getting water as an input comprises roughly 0.02% of the companies' production costs. This result must be contrasted with the water tariffs that mining companies face to determine if it is feasible to increase them soon. It is also important to note that, as with the manufacturing sector, the most significant portion of water costs is associated with water treatment. The latter holds even though two out of four mining industrial activities do not present water treatment costs in the 2016 industrial survey.

6 Conclusion and Discussion

6.1 Summary of key findings

This study has applied scaled-down approaches using market price data and proportional production costs functions as methodology to estimate the value of water in three of the most important sectors of the Tanzanian economy: agriculture, manufacturing, and mining. Limited to these three sectors, the results reveal that the low bound estimation of the value of water in Tanzania is estimated to be approximately 5 trillion TZS in 2021, which is the equivalent of 3.21% of the national GDP.

At the regional level, the value of water for the Wami/Ruvu basin is equivalent to 0.71% of Tanzania's GDP in 2021. Table 32 shows the results of water valuation for the Wami/Ruvu basin. As it was stated before, it applies the regions of Dodoma, Morogoro, Pwani, Tanga Dar Es Salaam, and Manyara. Table 32 presents the values that were calculated for 2020. Because 2021 is the last year for which there is consolidated information on GDP, the results from Table 32 are indexed using the consumer price index of 2020 (3.2%). Finally, these values are extrapolated at national level using the Proportion Value of Water multiplied by GDP (Table 32).

Table 32. Value of Water for the Wami/Ruvu basin (Current prices 2020)

Sector	Subsector	TZS/year	USD/Year
Agriculture	Crops	948,146,482,943	414,759,855
	Livestock	85,152,483,765	37,249,341
Manufacturing		10,493,335,099	4,590,234
Mining and Quarrying		61,129,170,000	26,740,515
Total		**1,104,921,471,808**	**483,339,946**

Source: Elaborated by Authors.

Table 33. Consolidated results of water valuation for Wami/Ruvu Basin and Tanzania Mainland (Current prices 2021)

Sector	Subsector	Proportion Value of Water	*Value of water for the Wami/Ruvu Basin (TZS/year)*	*Value of water for the Wami/Ruvu Basin (USD/year)*	*National Value of water (TZS/year)*	*National Value of water (USD/year)*
Agriculture	Crops	**17.66%**	978,487,170,397	425,829,744	4,152,426,123,400	1,807,342,935
	Livestock	6.99%	87,877,363,246	38,243,521	786,836,132,180	342,600,801
Manufacturing		0.24%	10,829,121,823	4,712,747	31,587,910,123	13,332,301
Mining and Quarrying		1.78%	63,085,303,440	27,454,216	206,257,522,364	89,818,527
Total			**1,140,278,958,905**	**496,240,228**	**5,177,107,688,068**	**2,253,094,565**

Source: Elaborated by Authors.

6.2 Discussion on valuations results, interpretation, and limitations

Water is the essence of life and the prerequisite for the development of any human activity; therefore, no valuation method can capture all the economic values that water has in different geographical, social, and environmental contexts. Recognising water's multiple values beyond the economic one[37] would be essential to build broader political discussions. This aligns with the first Bellagio Principle on Valuing Water: "Consider the multiple values to different stakeholders in all decisions affecting water."

The scaled-down approaches that the authors used took information from solid national sources and interpreted them as market signals. By doing so, they obtained the lower bound of water's contribution to Tanzania's economy, specifically for the Agricultural, Manufacturing and Mining sectors. The lower bound must be understood as the lowest value that can be extracted using the available sources; therefore, the overall value of water will always increase by improving the sources of information and including other values.

The results of the study are limited by the availability of information and the possibilities of the valuation methodologies. However, the true value of water equates to the entire economy because water is a prerequisite to its existence. A limitation of the chosen valuation approach is that the obtained results are attached to market transactions; therefore, the calculation does not include water which does not yield economic results.

The calculations did not include the water to grow crops for self-consumption that, according to the NBS (NBS, 2021b), accounts for nearly 39% of the country's crop production. The valuation results show that the water used by the crop subsector has a value equivalent to nearly 2.5% of Tanzania's 2021 GDP. It is also important to mention that water for irrigation equates to almost 13% of the country's water usage. These facts allow the authors to conclude that implementing components of the NIMP 2018 can be highly cost-effective because they could eventually help produce more food with less water. Furthermore, doing so can improve smallholder household economies and increase the country's water endowment. On the other hand, Costs related to

[37] In line with the UN and World Bank Valuing Water Principles

water of the manufacturing sector are, on average, 0.053% of the income of that sector in a year. This fact allows the MoW and the BWBs to assess incremental fees for water because it would have a shallow impact on the economics of that sector.

The results of the valuation of this Study present an opportunity for Tanzania to improve the national debate on budget allocations to the water sector; therefore, the authors recommend that this study serves as a starting point to consolidate national statistics that are updated periodically. These figures can contribute to increased political will, not only among decision-makers but also among the population.

6.3 Water valuations and investment priorities

The importance to invest in information, particularly monitoring and assessment of water resources) has been highlighted in the analysis of the WSDP *(MoW,2006: 4-14)*. The same argument is applied to information for modelling the impacts of climate change on water resources (GoT, 2021a: 46). When water valuation is incorporated in the analysis, not only accurate and timely information on hydrological variables is needed but also socio-economic data to correlate water resources management and society's well-being.

An example of a robust methodology for managing water resources data is Water Accounting using the System of Environmental-Economic Accounting - SEEA (see Box 1). This is an information framework that systematically integrates hydrological information from various data sources with other economic and environmental data. It reveals how changes in, for example, water availability in one part of the economy or environment may affect other parts of the economy or environment. A country requires such information for effective water governance and management (Vardon et al., 2023: 6). As explained by the experts from the Global Commission on the Economics, water accounting works under the following premises (Vardon et al., 2023: 26):

- The data used for water accounting fall into two distinct categories: physical data on the environment (e.g., stocks and flows of water in the environment); and physical and monetary data regarding water and economic units (e.g., flows of water between the environment and the economy and flows of water within the economy, and the related financial information).
- The data sources and methods used to produce the information depend on various factors, including the institutional arrangements and level of human and financial resources available.
- Data on the physical environment is usually collected through direct (scientific) observation by agencies responsible for hydrological and meteorological monitoring and research or by private research institutions or universities that have the know-how and the infrastructure to develop this task.
- Data from or about economic units (e.g., businesses and households) is usually collected by two primary means: accessing data collected for administrative purposes

(e.g., tax, annual reports, water licensing registers, etc.); or by direct survey (e.g., by a national statistical office). In many cases, the original providers of the data and its sources are the same, namely, the economic units and the records kept by these units.

- The national statistical system usually conducts surveys. At the same time, administrative data may be held by various government agencies and some industry associations, and individual companies may produce annual reports with relevant information."

Water accounting has been partially implemented by the NBS when collecting and processing information for national accounts. Using an Input-Output Matrix methodology, it shows how much all economic sectors paid for natural water, water treatment and supply services, and water transport in 2015[38]. Moreover, the information on water valuation for the industry and mining sector comes from the Annual Survey of Industrial Production 2016 (NBS, 2018a), that uses the International Standard Industrial Classification of All Economic Activities (ISIC) Revision 4 (United Nations, 2018). However, this information to be useful for water valuations must be collected and processed periodically and systematically so that it supports water authorities and policy makers decisions on water investments.

There should be no doubt that investments to boost economic growth should focus on irrigation for agriculture. On the one hand, this sector employs 65% of Tanzanians, and 80% of agriculture output comes from rainfed, low-input smallholder farms (USAID, 2018; GIZ, n.a.), being the rural population the most vulnerable in terms of economic and social indicators. On the other hand, the Tanzanian industry, which contributes more than 30% of the GDP, has a strong dependency on agricultural inputs (World Bank, 2017: 32). The high dependence of the industry sector from agricultural raw materials also sets a transmission mechanism of economic vulnerability to climate change (GoT, 2021a: 50).

There is also consensus that agriculture will be the most affected sector by climate change. Food production is projected to decrease by 8% to 13% by 2050 due to increased heat stress, drying, erosion and flood damage as well as post-harvest loss (GoT, 2021a: 39). In 2014, the GoT estimated that the value of loss of agriculture GDP from the impacts of climate change over the coming five decades would be about USD $27 billion, which is an annual average of approximately US$ 540 million (GoT, 2021a: 39).

The National Irrigation Master Plan 2002 underwent a sector-wide restructuring that evolved into the National Irrigation Master Plan 2018 (NIMP 2018). This proposal seeks to foster investments to modernize irrigation systems, aiming to transform 1 million Ha and benefit 358,000 farmers with better annual income by increasing the productivity of crops and livestock and consequently tackling food insecurity. Moreover, it is argued that investments proposed by this plan should hedge the agriculture sector against the harmful effects of climate variability and climate change.

[38] See https://www.nbs.go.tz/nbs/takwimu/na/Tanzania%20-%20Input-Output_Tables_2015.xls

The irrigation master plan estimates irrigation investment needs at USD $4.5 billion from 2018 to 2035 (JICA, 2018: 9-13). It is worth noting that NIMP 2018 is the only program identified by the authors that carried out a detailed cost-benefit analysis. It concludes that such investments would have an Economic Internal rate of Return of 16.4% in a 50-year timeframe, equivalent to a Cost-Benefit ratio of 1.40, and a Net Present Value of TZC $1,468,323 million (JICA, 2018: 9-22). Reviewing the methodologies and assumptions applied to reach the former results are not part of this water valuation consultancy. However, in terms of the distribution of costs and benefits, it is essential to mention:

- Better irrigation for farmers will increase their net income compared to the annual average household expenditure (JICA, 2018: 9-21; 9-23). However, there is no direct relation to poverty reduction. It is assumed that a higher income for farmers with access to improved/new irrigation schemes will generate more employment in rural areas, thus increasing the well-being of their surrounding populations.

- An indirect effect related to increasing farmers' income by accessing better irrigation schemes is the creation of job opportunities for vulnerable populations, such as women and youth (JICA, 2018: 9-27).

- If Tanzania embarks on transforming its irrigation schemes by implementing the NIMP 2018, it will reap the gains of exporting food to neighbouring countries, particularly crops such as rice, where it has a competitive advantage (JICA, 2018: 9-24).

Even though water resources availability projections seem to be well-founded in the calculations made by NIMP 2018, the impact of climate change is looming over Tanzania's plan to transform its agriculture sector through investments in irrigation. Water demand for irrigation in 2015 reached 14% to 17% (MoW, 2020b: 46: JICA, 2018: 3-16). The water demand projection for irrigation will increase to 26% of all water resources under NIMP 2018. As argued by the World Bank, "after accounting for environmental flow requirements, national demand is already 150% of accessible water during dry periods. This figure is on pace to balloon to 216% by 2035" (World Bank, 2017: 36). This issue brings us back to the importance of investments in monitoring and assessment of water resources and the need to manage water allocations properly to avoid issuing more permits than water available, frequently common in other parts of the world (e.g., Colorado River Basin in USA), undermining water governance and deriving in complex water conflicts.

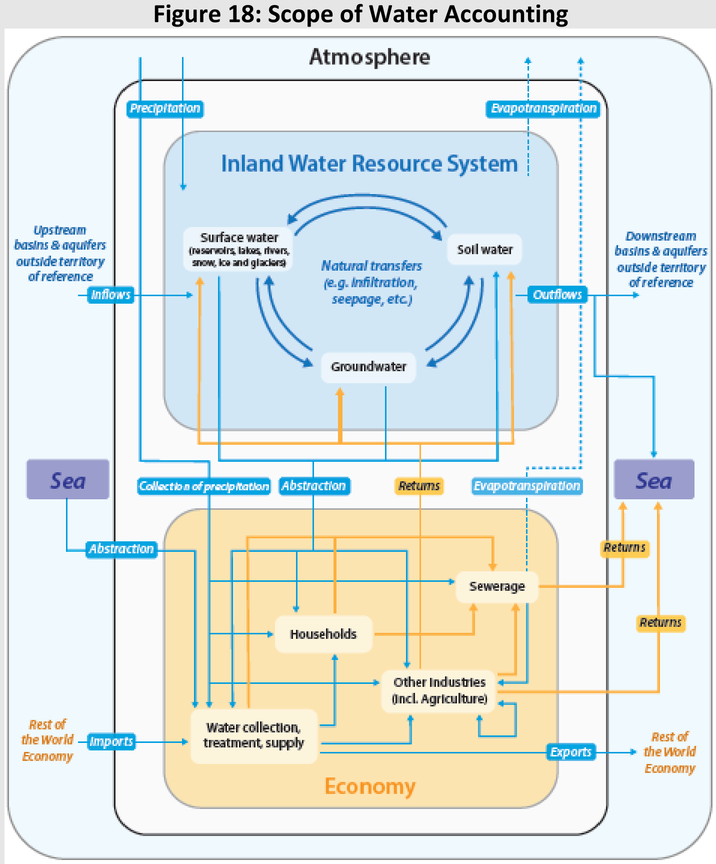
Box 1: Water Accounting and System of Environmental-Economic Accounting (SEEA)

The *System of Environmental-Economic Accounting* (SEEA) is a framework that integrates economic and environmental data to provide a more comprehensive and multipurpose view of the interrelationships between the economy and the environment and the stocks and changes in stocks of environmental assets, as they bring benefits to humanity. It contains the internationally agreed standard concepts, definitions, classifications, accounting rules and tables for producing internationally comparable statistics and accounts.

The SEEA is an extension of the System of National Accounts (SNA) used by virtually every country worldwide for economic management and policy. The relationship between water accounting and SEEA relies on the latter explaining the fundamental concepts of water accounting, the structure of accounts, and how a country can use Water Accounts for water management, governance, and policymaking. Accordingly, United Nations developed in 2012 a guide known as SEEA Water, compiled in *International Recommendations for Water Statistics*. In such way, SEEA enables comparisons between countries.

Water accounting provides a fully integrated information resource through the consistent application of concepts and related definitions and classifications. This framework supports transparency about the connections between water, the broader environment, and the economy, allowing for comparisons between different industries and natural resources, over time and between places.

Figure 18: Scope of Water Accounting



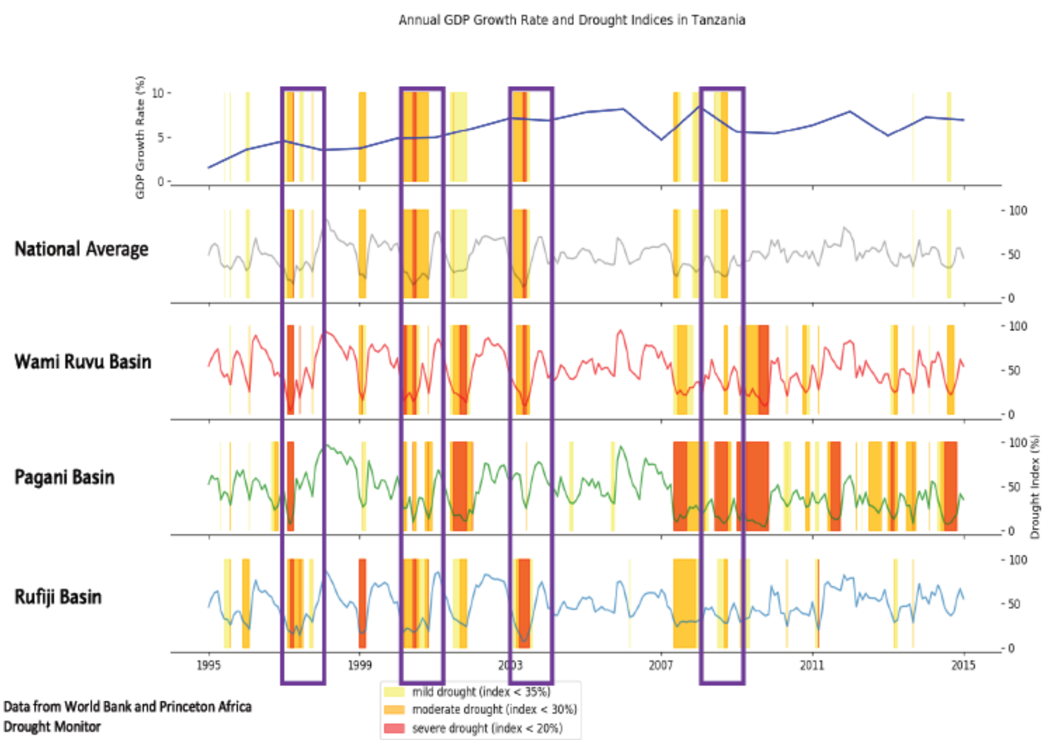
Source: Abstract and figure taken from Vardon et al., 2023.

In relation to the climate variability, in particular extreme weather events, the World Bank conducted a detailed analysis of the impact of floods and droughts at national and basin levels, concluding that a slowdown in GDP growth correlates with severe drought episodes (Figure 19). Some documented examples are (World Bank, 2017: 36):

- In 2017, the agricultural sector suffered an estimated USD $200 million in average annual losses because of weather-related occurrences, primarily due to drought.
- That year, the drought led to food shortages and an increase in aggregate food prices of 12%, with repercussions throughout the region.
- A significant drought in 2009 resulted in the mortality of 80% of livestock in northern Tanzania, undermining the achievement of local and national food security and longer-term development

The NIMP 2018 highlights different adaptation solutions to hedge against climate change, among them the construction of Irrigation Ponds or Small Dams (JICA, 2018: 8-9). This type of infrastructure is also highly regarded by the WSDP (JICA,2018: 7-40; see Annex 6).

Figure 19: Slow-down in GDP Growth is Correlated with Severe Droughts in Tanzania's Major Productive Basins



Source: World Bank, 2017:37

Even though this consultancy does not cover the energy sector, there is also an indirect relationship between the impact of climate change on hydropower generation and the industry sector. The MoW estimates that hydropower generation demands 17% of all water resources (MoW, 2020b: 46); six dams are currently used for this purpose, generating a total of about 561MW (MoW, 2020b: 37). This infrastructure generates 40% of electricity output and only reaches 16% to 18% of the population (USAID, 2018: 3). Tanzania is planning to increase its hydropower capacity from 0.5 gigawatts in 2015 to a planned volume of 3.4 gigawatts in 2030 (GIZ, n.a.: 9). Moreover, power generation from other sources, such as diesel and gas, also require significant amounts of water, without an explicit estimation of current demand.

Flooding and droughts derived from climate change will affect hydropower generation. Current infrastructure is vulnerable to increasing evaporation and siltation from heavy rainfall events and longer dry spells. Variability in precipitation and climatic conditions could severely affect river levels and disrupt hydropower generation (GIZ, n.a.: 9). The GoT is aware of the importance of protecting and conserving water sources for power generation. As mentioned before, WSDP has prioritized investments for building multipurpose dams and designing and implementing dam safety plans for the existing ones to cope with water scarcity and flood management.

6.4 The need to reframe the water investment rationale

The MoW along with other water-related authorities and bodies have traditionally built their argument on the need for water investments around a cost-based perspective rather than from a cost-benefit approach. Traditionally the starting point is thus to look at what would be needed to achieve universal access to safely managed drinking water and sanitation and achieve internationally agreed upon commitments such as SDG 6. Then the logic is to back track and translate those objectives into financial requirements (i.e., to calculate what would be needed in terms of infrastructure, data collection and monitoring systems, technical equipment, staffing, and so on to achieve these envisioned targets). To be more effective in attracting investments, there needs to be a shift in the rationale and the way water authorities frame the need for water investments in Tanzania; they need to move towards a cost-benefit rather than cost-based approach.

6.4.1 A water investment rationale that leads nowhere: the traditional financial requirement and cost-based approach

The traditional and dominant approach to advocate for water investments has been overfocused by discussions on translating objectives into financial requirements, burn rate, actual spending, and budgetary gaps. This is the case of the WSDP *2006-2025*. This programme has gone through two evaluations:

- **WSDP Phase I**, carried out by Oxford Policy Management, with the support of JICA (Japanese Development and Cooperation Agency), on behalf of the MoW in 2013

- **WSDP Phase 2**, carried out by ME&A, Inc. with the support of USAID (US Agency for International Development) on behalf of MoW in 2021

In terms of capacity building, infrastructure investments, and monitoring, assessment & regulatory enforcement of water resources, the evaluation of WSPD Phase I highlighted the following findings:

- BWOs received funds for the renovation or construction of buildings, provision of vehicles, and equipment needed to restore water resource monitoring networks. However, the evaluation of WSPD Phase I found that some of the BWBs were not equally strong at the beginning of the programme; the stronger ones could take more advantage of investments. Consequently, it also observed that the extent to which the BWBs could provide helpful information for water resources management varied, and not all could provide reliable hydrogeological data at the time of evaluation.
- There was a heavy emphasis on hardware investments (buildings, vehicles, and equipment) to the detriment of operational funding and developing the skills needed to use and maintain that infrastructure (JICA, 2013: 35).
- It is worth noting that the evaluators found problematic managing water within hydrological units (the geographical scope of BWBs) instead of within administrative boundaries (economic regions) which would facilitate correlating hydrological variables with economic and social statistics (JICA, 2013: 26). This approach would facilitate economic valuations of natural resources (such as water) or for prospective studies such as the water-energy-food nexus.
- Even though BWBs envisaged that institutional strengthening would derive in a growing source of resources coming from water allocation fees (up to 38% of total funding), evaluators found out that this target was unrealistic as there is no room for raising fees because most of the users in Tanzania were smallholder farmers.
- Evaluators raised some concerns about the disconnection of external authors and BWOs staff in the preparation of Integrated Water Resources Management Plans, a key instrument for setting out long-term strategies and implementation plans to cope with water security at the basin level (JICA, 2013: 27).
- Finally, the evaluation recommended that BWOs be aware of the importance of establishing and maintaining an effective monitoring regime and monitoring data to determine the possible impacts of climate change, which should serve as the basis for making informed decisions.

Regarding funding for Water Resources Management and Institutional Strengthening and Capacity Building components, the evaluators found it impossible to make a detailed financial analysis. Moreover, due to a lack of data and the early stage of implementation of WSDP Phase I at the time of evaluation, it was considered that a cost-benefit analysis was not feasible (JICA, 2013: 63). In general terms, this evaluation highlights low funding as the main cause of understaffing and its consequent impact on achieving the goals of WSDP Phase I.

The evaluation of WSDP Phase II also contains a thorough assessment of the Water Resources Management component. The programme was revised[39] both during the implementation of Phase I (JICA, 2013: i) and after its first evaluation, redefining some of the previously prioritised actions and the investment needs (MoW, 2014: X-XI). Annex 6 presents key findings summarized.

The evaluation is reiterative in stating that the main challenge of WSPD Phase 2 was a lack of funding that translated into an acute staff shortage at national and regional levels. This finding about low funding and budget execution is also shared by other financial evaluation that reviewed the potential of different financing sources for water resources management in Tanzania (COWI, 2019: 12). Another issue affecting funding for the Water Resources Management component was the priority given in terms of competing needs: it ranked last in budget allocations from the national government and external partners (international development organizations) compared to the urban water supply and sewerage services and rural water services, the other two WSDP's components (USAID, 2021: 48-49).

The effect of low funding and understaffing charged a high price on having data on water resources management for policy-making purposes and infrastructure investment decisions. For example, the target of having a "*national water resources database established and operational*" never took off. Moreover, investments in water resources monitoring and assessment were minimal *(USAID, 2021: 18-19).*

Recommendations from evaluations and lessons learned in implementing WSDP been considered for Phase III (MoW, 2022). A close review of strategies and targets indicates that during this phase, the GoT plans to achieve the cumulative targets of phases I and II. However, to achieve these targets, it would need a strong political will to allocate funding to investments that are not politically visible but of the most utter economic and social importance, prioritize investments in building in-country technical capabilities and increasing staff at the national and basin level in a relatively short time (4 years), and implement robust program/project management systems to monitor policy outcomes and specific targets accomplishment, respectively.

6.4.2 Approaching Water Investments through a Cost-Benefit rather can Cost-Based approach

After reviewing the experience of WSDP, the case for advocating a focus on the benefits of investments rather than on a cost-based approach on Water Resources Management should be considered. As argued before, the GoT used a rationale grounded on an efficient allocation of resources amid budget restrictions. The WSDP set a goal in terms of benefits for society (what is considered better in terms of beliefs, ideological affiliations, and electoral return on investments), established that goal's costs, and, based on them, compared that goal with other competing social needs (ex., water resources management versus rural and urban water access

[39] In WSDP Phase II, objectives for the Water Resources Management component were divided into two sub-components: 1) Water Resources Management and 2) Water Quality Management and Pollution Control. The scope of analysis of this consultancy focuses on sub-component 1.

and sanitation). In that way, it calculated the financial gap and, with that in mind, determined whether that goal was worth investing given the availability of resources.

The result of that approach was that the political process prioritised investments in Water Access and Sanitation over Water Resources Management during the last 18 years. However, from a technical perspective and based on the rationale in which water security is built, Tanzania should have prioritised investments in Monitoring and Assessment of water resources, so that the country could have had better information to make informed decisions on the benefits of water investments (such as strategic dams to cope with water scarcity and climate change future impacts). The problem with this approach is that it is difficult to calculate the benefits of investing in information for water resources management. During the documental review, it was not possible to find a single cost-benefit analysis on that topic but the urgence given by external water experts. Moreover, it is complicated to make the investment case for buying/retrofitting a hydrological monitoring station when compared to drilling a water borehole to provide water for a rural community.

In conclusion, none of the evaluations of WSDP used the cost-benefit analysis methodology as an analytical framework. One of the major drawbacks of zooming into the funding requirements, is that we lose sight of the benefits. For policy makers, this means that water investments are presented as *a challenge* rather than *an opportunity*. From a technical perspective, it is reiterated the importance of investing in water resources management. However, it is also emphasized that the GoT has already enough information to decide on strategic water investments. This information is dispersed in institutions at national and regional level and requires that the MoW assume the leadership to collect, organize, and analyse that information and present it to the level of power where decisions are made.

6.4.3 Review of benefits on selected water resources management projects for the Wami/Ruvu Basin

A close review of on the Wami/Ruvu basin's IWRMDP serves to understand the importance to focus on a cost-benefit rather cost-based approach. This plan provides a blueprint for rationally managing and developing the basins and the catchments' water resources for multi-sectoral needs. Investments needs are estimated at USD $2.5 billion in a 15-year timeframe. Published in 2020, it develops a detailed investment plan that includes cost-benefit analyses of selected projects competing for funding, summarized in Annex 7.

Most water investments are for multipurpose dam. It also prioritises investments to expand the area under irrigation. There are other priority investments that are relatively small in terms of costs, but essential for planning and conservation of water resources, such as equipping the basin for hydro-meteorological observations, developing improved systems for water allocation, developing procedures for drought and flood mitigation, and establishing early warning and for decision support systems (MoW, 2020d: 107). None of those projects is objected from an economic and social perspective. Moreover, the plan reiterates the importance of investments in monitoring and assessment of water resources, which includes data collection, processing, and establishment of a system for data and information storage. As argued, *"These activities are essential to enable the WRBWB to evaluate the impact of proposed new projects on environment, socioeconomic potential, social equity, and water allocation. The data are also required to carry out reliable feasibility studies for new projects… these facilitate data exchange with stakeholders and fact-based discussions and decision making when various competing activities and developments need to be prioritized. The data and knowledge projects will improve decision making as well as meaningful communication and coordination. This communication and coordination are essential since the WRBWB is dependent on information of abstractions from other stakeholders to be able to determine the water balance, safeguards and impact, and to decide on water allocations." (MoW, 2020d: 116)*

6.4.3.1 Cost Benefits of Investing in Water Resources Management Information Systems

In the case of the Wami/Ruvu Basin, its IWRMDP estimates that investment needs in hydro-meteorological systems are about USD $4 million over a period of 15 years (USD $0.65 million in *Hardware of hydro-meteorological systems* and USD $3.35 million in *Collecting, storage, processing and sharing of data, better computer connectivity, developing of planning tools and capacity building*). Potential benefits are high and extend to all fields, economic development, social equity, and environmental sustainability (MoW, 2020d: 121), in particular:

- The hydro-meteorological data form the core of any forecast and feasibility and impact assessments in the future as well as for the riparian management, for drought and flood mitigation and early warning systems.
- Even better cost recovery of the Wami/Ruvu Basin Water Board is dependent on permitting fees which related to judicious decisions on water allocation and data of river flows are indispensable for such decisions.
- Related to flood management, the paucity of information clearly shows the fundamental importance of upgrading and expanding the hydro-meteorological monitoring systems and the associated planning tools.

6.4.3.2 Cost Benefits of Investing in Irrigation

In the case of the Wami/Ruvu Basin, the IWRMDP identifies 76,000 ha complying with social and environmental safeguards for improving/developing irrigation schemes and estimates investment needs at USD $370 million. The costs for the irrigation development are based on the per hectare costs from the Revised Irrigation Master Plan 2018 (NIMP2018). Benefits per hectare were also derived from NIMP2018. Using these data, the EIRR would be more than 25% (MoW, 2020d: 118-119). This clearly shows a high economic viability for irrigation development. In terms of benefits, investments in irrigation are justified based on:

- Socially benefits of irrigation are high as well because most of the rural population is employed in agriculture, 67% in 2014 according to the Ministry of Agriculture.

- Irrigation will increase production significantly and protect against variation in weather patterns thereby guaranteeing a good income for 9 out of 10 years.
- Environmental sustainability is achieved by only developing those irrigation schemes that would allow sufficient flows to remain in the river to cater for domestic water requirements and to maintain a healthy ecosystem.
- Additional area might be developed after the storage capacity has been increased through flood protection and multipurpose dams such as Dambalo, Hombolo and Kidunda dams.
- Kidunda Dam will also provide a regular environmental flow downstream, additional water abstraction potential for the Mkulazi Irrigation System and, 20MW of installed hydropower capacity.

6.4.3.3 Cost benefits of Investing in Flood and Drought Management

In the case of the Wami/Ruvu Basin, the IWRMDP interventions to cope with droughts are imbedded in proposals related to water storage. The most important are:

- Mindu dam raising, to supply drinking water for Morogoro, has an estimated cost of USD $158. According to the feasibility study, its financial internal rate of return is not positive, but the economic internal rate of return would be positive.
- Kidunda Dam, a multipurpose storage facility, has an estimated cost of USD $127. The economic internal rate of return would be 10.4%. It is mainly designed to improve the water supply; however, it will also provide power generation of 20 MW, control of floods, improvement of irrigation, fishing, and other human requirements. However, these other benefits have not be valued.
- There are also other to dams planned for rehabilitation and height raising such as Dabalo and Hombolo, located in the midstream of Kinyasungwe River and utilized for domestic water supply and small-scale farming. These dams do not have a cost benefit analyses available but would have a direct impact on water storage for irrigation.

Flood management investments planned are mainly grey infrastructure (USD $1 million), such as flood retention dams in the upper reaches of Kinyasungwe catchment and small dams in other catchments to retain water as well as embankments and spurs for bank protection. However, as argued in the IWRMDP, combination of grey infrastructure and nature-based solutions would have a greater impact on catchment management related to flood mitigation (MoW, 2020d: 120). The IWRMDP proposes interventions such as improvement and conservation of riparian vegetation and flood buffer areas (USD $0.55 million) and improving catchment conditions and better catchment management through management plans (USD $0.65 million). It is argued that social, environmental, and economic benefits can be very significant (in thousands of USD) in terms of avoided damages or related to developing business initiatives to commercialize nature-based products. However, these benefits have not measured.

At basin level, some instruments such as water funds might be an interesting option. In general, this mechanism helps downstream water users work with upstream communities to safeguard water supplies at their source by investing in natural protection (e.g., conserving and restoring native plants, reducing agricultural runoff). In such way, water funds contribute to improve water quality and quantity at a fraction of the cost of traditional built solutions such as aqueducts and treatment facilities (TNC, 2021a). They are also a proven adaptation measure which make it relevant for both flooding and droughts management (Gonzalez, 2021).

Water funds are taking off in Africa with well-developed examples such as Nairobi (Kenya – TNC, 2015) and Greater Cape Town (South Africa – TNC, 2022). The latter is a pertinent example for the Wami/Ruvu Basin as it estimated the positive return on investment of natured-based solutions[40]. It is also worth reviewing the experience of Tanga water fund (TNC, 2021b) which could be replicated in some catchments that serve urban centres such as Dar es Salaam, Morogoro, among others.

6.4.3.4 Cost Benefits of Investing in Hydropower

As mentioned before, WSDP has prioritized investments for building multipurpose dams and designing and implementing dam safety plans for the existing ones to cope with water scarcity and flood management. In the case of the Wami/Ruvu Basin, investments in hydropower generation consist of building six run-of-the-river hydropower plants (four in the Wami Catchment and two in the Upper Ruvu Catchment) valued at USD $69 million, with a capacity between 1 and 10 MW. The financial internal rate of return of plants is approximately 6% and their economic internal rate of return would amount to almost 15%. As mentioned in the IWRMDP, the benefits of these hydropower generation plants are:

- The social impact is better availability of power in the remote areas near the run-of-the-river plants at an affordable price.
- No resettlement is required.
- The environmental impact is negligible since the water will only be diverted over a short distance and the diverted volumes are only a fraction of the river flow

Another prioritized project for hydropower generation is Mandera Dam (Wami Catchment), estimated at USD $420 million. Its financial internal rate of return is approximately 7.5% and economic internal rate of return would amount to almost 16.9%. It does not required resettlement since the area that will be submerged is in dense forested land, however, requiring further studies to assess its environmental impact.

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[40] For a rapid assessment of return on investment from a portfolio of nature-based solutions for catchment protection and conservation, it is possible to use *WaterProof*. This free-access digital tool is intended to engage stakeholders interested in exploring solutions to local water challenges. Available at: https://water-proof.org/

6.5 Key reflections and takeaways

6.5.1 On the availability of information and the need for harmonized water information system

The Production Function methodology is appropriate for developing valuations based on nationwide studies such as national agricultural / industrial production surveys because they use proxy market data and production process features that could allow consolidation of Production Functions. This would enable the value of water in specific sectors to be periodically quantified.

If Tanzania undergoes periodic water environmental valuation calculations, the country should build specific production functions with information that the NBS periodically collects. To do so, it is proposed that this institution together with the MoW include additional variables in the crops and livestock components of the following National Agricultural Survey, such as water consumption and labour costs, and other essential production costs such as food and veterinary expenses. They should also include additional variables in the following Annual Survey of Industrial Production such as volumetric water consumption

The information requirements of valuation methodologies may appear unrealistic when they are intended to be implemented nationwide, especially in developing countries. The latter means that instead of focusing on gathering information to implement further water valuations, it is advised that the country focuses on consolidating the information that already has available and identifying missing information to improve water management. A clear example of this is the need to record water consumption for different economic sectors.

6.5.2 On Consolidation of Water Valuation System

The first step in consolidating a water valuation system for Tanzania is to promote a national high-level discussion on the purpose of this system and its main features. This initial step would allow stakeholders to build a common understanding of the task, appropriate the idea to the Tanzanian context, define how it can improve water resources management, and increase political will. It would also contribute to understand what it can be achieved in the near future and determine what needs to be done in terms of data collection, processing, and diffusion of results.

The consolidation of the water valuation system should be proposed as a modular effort that renders results once every module is completed. Consolidating this system will require the joint effort of the MoW and the NBS. This collaborative effort could allow recording, analysing, and reporting data and identifying improvement areas as part of the process. The goal would be that the effort is continuous through time; In such way, methodological processes are constantly developed, decreasing eventual discrepancies among valuations made in different years, making possible to compare results to reach robust conclusions.

The authors suggest that the NBS and the MoW review the SEEA and determine which parts might implement in the short, medium, and long term. If this framework were to be implemented, Tanzania should begin by initially constructing the stocks and flows accounts and then continues with the monetary flows assigned to maintain them.

6.5.3 On Water Investments

The GoT needs to go from plans to action. The water sector has numerous diagnostics and third-party recommendations on water resources management compiled in public policy documents (sectoral strategies and implementation plans) without showing enough tangible results in the last two decades to protect and potentialize its water endowment. In other words, Tanzania is not investing enough resources in its water endowment, thus endangering its economic performance, and having a direct negative effect on the well-being of its population and protection and conservation of nature in the future.

The evaluation of WSDP Phase I and Phase II regarding Water Resources Management reiterates that underfunding of BWBs and the MoW due to national budget restrictions and prioritization of investments in urban and rural water access and sanitation over water resources management has derived in understaffing of these institutions and, consequently, in a low capacity to execute urgent investments to face water insecurity in the long-term.

Investments in irrigation for agriculture should have a high priority for Tanzania's government. Its economic and social return (e.g., employment creation; participation of vulnerable groups, such as women and youth; food security) is not arguable, as the calculation of cost-benefit analysis demonstrates. However, they need to be carried out together with investments in monitoring and assessing water resources to deal with scarcity when extreme climate events, such as droughts and floods, impact the country. Consequently, water allocation management, based on reliable hydrological data, becomes an urgent issue to be tackled to avoid water conflicts in future.

Not only are investments in information essential but also in water infrastructure to hedge against water scarcity and the impact of climate change. As cost-benefit analyses show for the Wami/Ruvu basin, the construction of strategic multipurpose dams, modernisation of irrigation schemes, and catchment protection (with emphasis on natured-based solutions) and conservation programs to cope with water security are socially and financially feasible.

Even though the valuation of water resources might be relevant in the context of a worldwide urgency to increase investments in WRM, it is not a pre-condition to embark on investments that already have been judiciously recommended and grounded in detailed socio-economic studies. In the case of the Wami/Ruvu basin, there is enough information to make decisions to invest in its water endowment; it requires political will, technical discipline, and long-term persistence to achieve the desired impacts of water security.

6.5.4 On Prospects for Future Water Economic Valuation Studies

Valuing water for a whole economy, at country or regional level, might oversimplifies results. It is possible to make calculations such as *"if X (input) water is available, the economy might produce Y (output). Therefore, under a scenario of water stress (drought) / water excess (floods), the economy will produce Z% of Y"*. In such way, we might end up focusing on infrastructure solutions to secure water availability or to manage water surpluses. However, water valuation is usually carried out at basin level using techniques from ecosystem valuations. This approach helps to value water not only as an economic input but also as part of an ecosystem and its co-benefits for people and nature. In the case of this study, we adopted the first approach. However, a next step should be choosing strategic basins and value the ecosystem services derived from water and their contribution to the economy, people, and nature. This approach was adopted in Tanzania two decades ago at Pangani basin (IUCN, 2005). If it were applied systematically, it would require a strong political commitment from governments to invest in equipment and staff and the application of robust methodologies by water authorities to collect hydrologic and economic data. The result would be reliable statistics, periodically available, to make decisions on water security, as argued in this study.

The recommendation above does not mean the approach adopted in this study is not useful. It could be argued that using the *Production Function Approach* for manufacturing and mining limits results and recommendations. However, it was chosen as there are indications these industries underpay abstraction fees. Therefore, it is a first attempt to understand the challenges that water valuation poses and opportunities for future studies. For example, in terms of other methods that could be applied to get closer to capturing the full value of water in the three sectors that were selected for this study, it is possible to use a *Next Best Alternative Approach* for agriculture, saying that if surface irrigation were to disappear (say not enough rain), then the next best alternative would be groundwater (using costs of pumps, drilling, etc). Other alternative could be desalination with much higher costs (see discussion of using sea water to supply potable water to Arizona in United States to solve water scarcity at the Colorado river basin[41]) . In the end, it could be argued that the economic value of irrigation (and protecting the sources that feed it) is at least equal to the cost that people would incur if they would go to the next best alternative. Moreover, other method that could be used is the *Marginal Opportunity Cost Approach* by which it is possible to calculate what it would happen to agriculture production, if irrigation would simply disappear, and translating results into monetary value (Reinhard et al., 2022).

An important discussion is about other sectors where water valuation could be applied and the kind of methods that could be used. For tourism, stated preferences could be carried out (e.g., the value of natural lakes is high but that could only be obtained if it would be possible to find how much tourists spend - or say they are willing to spend - to go and see beautiful lakes such as Manyara and Natron). For WASH, a well-known approach is to calculate losses to labour

[41] https://www.nytimes.com/2023/06/10/climate/arizona-desalination-water-climate.html?smid=nytcore-android-share

productivity, if population do not have access to water and sanitation. For example, diarrheal diseases kill X% of the children, who otherwise would have become economically productive adults. Then, it is possible to calculate the average GDP/person and multiply that by the number of children dying of diarrheal diseases, saying that the value of access to safe water and sanitation is at least equal to that amount that would have been otherwise generate.

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Annex 1: Economic and Social Statistics

Table A1 - 1: Gross Domestic Product by Kind of Economic Activity – Current Prices – in TZS. Million

	2015	2016	2017	2018	2019	2020	2021
Agriculture, forestry, and fishing	***25,234,560***	***29,739,111***	***34,154,594***	***35,962,728***	***37,192,537***	***39,965,584***	***42,233,161***
Crops	13,279,392	16,474,729	19,703,004	21,003,720	20,686,963	22,867,540	23,513,172
Livestock	7,158,457	8,205,007	8,857,939	9,240,100	10,345,069	10,609,888	11,256,597
Forestry	2,920,425	3,094,767	3,310,076	3,459,581	3,738,360	3,947,993	4,578,311
Fishing	1,843,401	1,929,747	2,245,558	2,218,731	2,379,172	2,494,162	2,836,934
Agriculture support services	32,886	34,861	38,017	40,596	42,973	46,001	48,146
Industry and Construction	***23,103,647***	***26,937,139***	***29,735,584***	***34,851,874***	***39,944,212***	***44,950,342***	***47,844,421***
Mining and quarrying	4,055,619	5,299,362	5,206,217	6,573,059	7,213,403	9,947,971	11,587,501
Manufacturing	7,411,672	8,467,126	9,102,282	10,418,776	11,860,403	12,531,009	12,635,164
Electricity supply	798,801	472,868	413,351	348,527	369,917	398,084	380,057
Water supply, sewerage, waste management	390,758	433,132	519,909	566,562	628,187	745,222	876,939
Construction	10,446,797	12,264,650	14,493,826	16,944,950	19,872,302	21,328,055	22,364,760
Services	***38,146,529***	***42,747,407***	***45,066,596***	***48,059,561***	***51,417,505***	***55,219,451***	***59,019,313***
Wholesale and retail trade; repairs	8,747,862	9,861,678	10,843,499	11,793,201	12,264,511	12,935,145	14,056,161
Transport and storage	6,929,895	7,549,484	7,897,993	8,381,276	9,622,792	11,172,778	11,527,736
Accommodation and Food Services	1,421,916	1,523,035	1,602,543	1,653,792	1,764,898	1,506,711	1,715,764
Information and communication	1,681,098	1,739,556	1,829,360	1,948,180	2,052,242	2,196,758	2,375,162
Financial and insurance activities	4,189,021	5,268,866	4,789,632	4,947,301	4,927,613	5,259,757	5,414,784
Real estate	2,949,598	3,162,290	3,334,171	3,553,630	3,834,061	4,253,172	4,524,204
Professional, scientific, and technical activities	518,123	617,914	726,707	817,442	903,234	986,133	1,088,002
Administrative and support service activities	2,183,917	2,661,978	3,027,384	3,306,554	3,640,720	3,992,260	4,408,969
Public administration and defence	4,548,604	4,846,491	4,986,287	5,131,630	5,354,893	5,530,738	5,876,655
Education	2,413,306	2,673,289	2,864,290	3,081,718	3,322,028	3,440,525	3,649,794
Human health and social work activities	1,419,090	1,540,484	1,681,353	1,816,738	1,920,963	2,060,600	2,213,814
Arts, entertainment, and recreation	248,510	285,626	322,353	374,924	427,887	416,049	513,448
Other service activities	717,898	831,216	959,152	1,037,612	1,140,417	1,217,190	1,358,754
Activities of households as employers;	177,691	185,501	201,872	215,564	241,246	251,635	296,065
All economic activities	***86,484,736***	***99,423,658***	***108,956,774***	***118,874,163***	***128,554,255***	***140,135,377***	***149,096,895***
Taxes on products	7,864,579	8,938,667	9,787,724	10,169,738	11,087,600	11,031,006	12,428,863
GDP at Market Prices	**94,349,316**	**108,362,324**	**118,744,498**	**129,043,901**	**139,641,854**	**151,166,383**	**161,525,759**

Source: NBS, 2022a.

Annex 2: Crops Statistics

Table A2-1: Smallholders crops production by subcategory and season Wami/Ruvu and Mainland Tanzania

Crop	Wami Ruvu Short Rainy Season Quantity Harvested (Tons)	Wami Ruvu Long Rainy Season Quantity Harvested (Tons)	Wami Ruvu Short Rainy Season + Long Rainy Season Quantity Harvested (Tons)	Mainland Tanzania Short Rainy Season + Long Rainy Season Quantity Harvested (Tons)	% Production Wami/Ruvu / Mainland Tanzania
CEREALS					
Maize	674,228	1,006,540	1,680,768	6,500,773	25.85%
Paddy	157,287	613,090	770,377	3,330,293	23.13%
Sorghum	6,017	264,388	270,405	601,390	44.96%
Bulrush Millet	176	109,439	109,615	148,011	74.06%
Finger Millet	1,009	6,168	7,177	32,950	21.78%
Wheat	18	84,997	85,015	93,184	91.23%
Barley	-	-	-	355	0.00%
ROOTS & TUBERS					
Cassava	291,085	45,232	486,969	1,177,683	41.35%
Sweet potatoes	8,601	15,152	23,753	466,122	5.10%
Irish potatoes	135,795	17,868	153,663	319,314	48.12%
Yams	124	508	632	4,463	14.16%
Cocoyams	1,193	556	1,749	7,400	23.64%
PULSES			-		
Beans	94,013	59,462	153,475	659,473	23.27%
Cowpeas	24,244	23,274	47,518	139,207	34.13%
Green gram	830	2,065	2,895	31,372	9.23%
Pigeon pea	8,017	7,682	15,699	38,293	41.00%
Chickpeas	-	2,955	2,955	28,093	10.52%
Bambaranuts	38	7,910	7,948	27,351	29.06%
Field peas	153	256	409	16,725	2.45%
Fiwi	353	3,281	3,634	6,326	57.45%
Upupu	-	-	-	408	0.00%
OIL SEEDS & NUTS			-		
Sunflower	49,478	239,010	288,488	503,032	57.35%
Sesame/Simsim	8,516	29,342	37,858	128,588	29.44%
Groundnut	17,117	190,645	207,762	620,975	33.46%
Soyabeans	573	80	653	19,710	3.31%
FRUITS & VEGETABLES					
Onion	14,128	13,274	27,402	63,954	42.85%

Crop	Wami Ruvu Short Rainy Season Quantity Harvested (Tons)	Wami Ruvu Long Rainy Season Quantity Harvested (Tons)	Wami Ruvu Short Rainy Season + Long Rainy Season Quantity Harvested (Tons)	Mainland Tanzania Short Rainy Season + Long Rainy Season Quantity Harvested (Tons)	% Production Wami/Ruvu / Mainland Tanzania
Ginger	3,245	420	3,665	11,548	31.74%
Garlic	-	172	172	811	21.21%
Strawberry			-	8	0.00%
Roselle	-	359	359	359	100.00%
Cabbage	10,211	1,586	11,797	35,154	33.56%
Spinach	5,904	1,564	7,468	15,289	48.85%
Carrot	584	1,505	2,089	32,040	6.52%
Chilies	3,371	655	4,026	5,854	68.77%
Amaranths	12,240	13,221	25,461	35,208	72.32%
Pumpkins	5,565	3,846	9,411	16,381	57.45%
Cucumber	1,284	146	1,430	3,193	44.79%
Egg Plant	375	1,076	1,451	4,862	29.84%
Water mellon	18,924	10,703	29,627	57,573	51.46%
Cauliflower	-	-	-	492	0.00%
Okra	17,896	11,533	29,429	33,238	88.54%
Coriander	-	-	-	77	0.00%
Tomatoes	59,431	58,024	117,455	318,431	36.89%
Bitter tomato	1,220	2,633	3,853	16,339	23.58%
Sweet/bell pepper	434	181	615	2,078	29.60%
Squash	-	93	93	105	88.57%
Sweet potato leaves	15,135	2,775	17,910	18,241	98.19%
Mnavu/Mnafu	608	48	656	1,096	59.85%
Figiri sukuma wiki	39	-	39	886	4.40%
Brocol	-	-	-	299	0.00%
Pumpkin leaves	-	40	40	599	6.68%
Majani ya kunde	-	14	14	14	100.00%
CASH CROPS					
Cotton	-	-	-	330,845	0.00%
Seaweed	16	-	16	16	100.00%
Tobacco	-	190	190	58,104	0.33%
Pyrethrum	-	-	-	1,698	0.00%
Jute			-	39	0.00%
Olive	16	110	126	126	100.00%
Lemon grass	-	5	5	51	9.80%
OTHER CROP	**69**	**-**	**69**	**6,043**	**1.14%**

Source: Elaborated by authors based on data retrieved from NBS, 2023.

Table A2-2: Smallholders Permanent Crops production Wami/Ruvu and Mainland Tanzania

Crop	Wami/Ruvu Permanent Crops Quantity Harvested (Tons)
Cassava	150,652
Pigeon pea	1,675
Palm Tree	1,499
Coconut	62,707
Caster seed	21
Malay apple	-
Ambarella	89
Bread fruit	110
Pomelo	-
Jack fruit	6,082
Passion Fruit	398
Banana	288,177
Avocado	2,531
Mango	143,191
Pawpaw	33,277
Pineapple	93,878
Orange	137,359
Grapefruit	61
Grapes	661
Mandarin	6,051
Guava	422
Plums	48
Apples	1,560
Pears	123
Peaches	3,115
Durian	-
Mbilimbi	495
Rambutan	-
Custard apple	1
God fruit	-
Mitobo	-
Zambarau	9
Pomegranate	75
Dates	-
Vanilla	-
Lime	1,515
Lemon	1,425
Black Pepper	1,310
Cashew nut	43,186
Sisal	33,165
Coffee	1,928
Tea	9,475
Cocoa	269
Rubber	-
Sugar cane	45,351
Cardamom	561
Tamarind	-
Cinnamon	382
Nutmeg	-
Clove	926

Source: Developed by authors based on data retrieved from NBS, 2023.

Annex 3: Livestock Statistics

Data for Livestock is retrieved from National Bureau of Statistics – Agriculture Census 2019-2020 – Table Retrieval System. Available at: http://data.nbs.go.tz:81/kilimo/index.php/ded/viewDashboard.

Smallholders – Cattle

Table A3-1: Total Number of Agricultural Households Raising Cattle by Region During 2019/20 Agricultural Year,

Category	Wami Ruvu	Tanzania Mainland	Participation %
Households rearing cattle	459,354	1,971,550	23.30%
Households not rearing cattle	1,719,865	5,865,855	29.32%
Total Agriculture Households	**2,179,219**	**7,837,405**	**27.81%**

Table A3-2: Total Number of Cattle by Type and Region as of 1st August 2020

Category	Wami Ruvu	Tanzania Mainland	Participation %
Indigenous	7,597,919	32,378,139	23.47%
Improved Beef	125,789	300,521	41.86%
Improved Dairy	274,262	836,056	32.80%
Total	**7,997,970**	**33,514,716**	**23.86%**

Table A3-3: Number of Agricultural Households Rearing Cattle, Herd of Cattle and Average Cattle per Household by Herd size as 1st August 2020, Mainland Tanzania

	Cattle rearing households		Herd of Cattle		
Herd Size	**Number**	**%**	**Number**	**%**	**Average Cattle per household**
1 - 5	856,298	45.1	3,150,934	9.4	4.0
6 - 10	412,601	21.7	4,185,725	12.5	10.0
11 - 15	227,370	12	3,930,164	11.7	17.0
16 - 20	129,764	6.8	3,095,119	9.2	24.0
21 - 30	119,857	6.3	4,072,202	12.2	34.0
31 - 40	57,413	3.0	2,794,793	8.3	49.0
41 - 50	27,557	1.5	1,762,738	5.3	64.0
51 - 60	19,122	1.0	1,464,081	4.4	77.0
61 - 100	27,834	1.5	3,184,230	9.5	114.0
101 - 150	8,499	0.4	1,731,561	5.2	204.0
151+	11,416	0.6	4,143,169	12.4	363.0
Total	**1,897,731**	**100**	**33,514,716**	**100**	**18.0**

Table A3-4: Number of Cattle Intake by Category of Cattle and Region During 2019/20 Agricultural Year

Category	Wami Ruvu	Tanzania Mainland	Participation %
Number Purchased	265,567	964,059	27.55%
Number given/obtained	158,170	695,314	22.75%
Number born	2,176,169	8,142,063	26.73%
Total Intake of Cattle	**2,599,906**	**9,801,436**	**26.53%**

Table A3-5: Total Number of Cattle Offtake Sold/traded and Average Price per Head by Type and Region During 2019/20 Agricultural Year

Category	Wami Ruvu	Tanzania Mainland	Participation %
Number sold/traded	815,103	3,019,867	**26.99%**
Number consumed by hh	86,511	358,297	**24.15%**
Number given away	218,317	1,059,346	**20.61%**
Number stolen	86,474	269,232	**32.12%**
Number died	348,060	1,785,203	**19.50%**
Total Offtake of Cattle	**1,554,465**	**6,491,945**	**23.94%**

Table A3-6: Milk Production by Season and Breed, During 2019/20 Agricultural Year

Season	Type of Breed	Variable	Wami Ruvu	Tanzania Mainland
Wet Season	Improved	Number of milked cows	194,843	1,094,202
		Average milk production per cow per day (Lts)	9	8
		Average number of days cows milked	120	116
		Quantity of milk produced (Lts)	112,692,388	520,748,994
	Indigenous	Number of milked cows	1,034,039	3,927,890
		Average milk production per cow per day (Lts)	3	3
		Average number of days cows milked	110	112
		Quantity of milk produced (Lts)	367,641,954	1,392,934,994
		Consumed by Household (Lts)	91,522,843	389,174,364
		Sold (Lts)	722,920,781	1,668,038,215
		Average price (TZS/Ltr)	1,059	1,056
Dry Season	Improved	Number of milked cows	170,170	564,500
		Average milk production per cow per day (Lts)	8	8
		Average number of days cows milked	113	114
		Quantity of milk produced (Lts)	79,763,718	229,017,536
	Indigenous	Number of milked cows	777,374	2,819,739
		Average milk production per cow per day (Lts)	3	3
		Average number of days cows milked	105	105
		Quantity of milk produced (Lts)	256,676,363	933,787,847
		Consumed by Household (Lts)	42,955,702	183,536,580
		Sold (Lts)	125,495,463	420,958,030
		Average price (TZS/Ltr)	1,144	1,095

Table A3-7: Cattle Offtake by Category of Cattle and Region During 2019/20 Agricultural Year

	Castrated Bulls (Oxen)		Uncastred Bulls		Cows		Steers	
Region	Number sold/traded	Average price per head	Number sold/traded	Average price per head	Number sold/traded	Average price per head	Number sold/traded	Average price per head
Dodoma	66,831	574,558	60,623	484,767	74,135	411,720	12,417	284,375
Tanga	10,236	900,000	80,833	663,769	62,125	553,719	4,589	534,375
Morogoro	13,100	749,063	38,704	612,491	29,177	484,728	7,145	496,069
Pwani	35,185	600,517	50,011	699,338	27,882	528,667	30,759	342,593
Dar Es Salaam	-	-	212	600,000	424	1,000,000	1,694	500,000
Manyara	9,621	584,091	51,470	588,971	19,963	401,822	1,203	666,667
Wami Ruvu	**134,973**	**568,038**	**281,853**	**608,223**	**213,706**	**563,443**	**57,807**	**470,680**
Mainland Tanzania	**647,003**	**606,835**	**810,666**	**558,930**	**890,644**	**487,611**	**188,390**	**506,252**

	Heifers		Male Calves		Female Calves	
Region	Number sold/traded	Average price per head	Number sold/traded	Average price per head	Number sold/traded	Average price per head
Dodoma	28,120	317,043	1,826	205,068	2,556	223,485
Tanga	19,414	473,256	13,060	256,000	2,118	285,000
Morogoro	4,168	365,616	4,168	239,474	1,786	250,000
Pwani	24,342	439,727	5,753	264,634	2,434	161,111
Dar Es Salaam	-	-	212	300,000	212	350,000
Manyara	9,380	324,834	5,532	236,919	1,684	241,803
Wami Ruvu	**85,424**	**320,079**	**30,551**	**250,349**	**10,790**	**251,900**
Mainland Tanzania	**291,042**	**331,572**	**122,721**	**217,903**	**69,402**	**255,832**

Table A3-8: Number of Cattle Intake Purchased and Average Price per Head by Type and Region During 2019/20 Agricultural Year

	Castrated Bulls (Oxen)		Uncastred Bulls		Cows		Steers	
Region	**Number Purchased**	**Average price per head**	**Number Purchased**	**Average price per head**	**Number Purchased**	**Average price per head**	**Number Purchased**	**Average price per head**
Dodoma	7,669	351,834	25,929	354,689	13,512	460,487	5,478	711,290
Tanga	9,883	385,217	23,650	464,848	20,826	505,599	-	-
Morogoro	20,245	576,479	2,382	469,687	5,955	406,628	-	-
Pwani	3,983	622,121	3,541	953,390	3,762	425,472	26,555	300,000
Dar Es Salaam	-	-	-	-	212	450,000	-	-
Manyara	241	350,000	7,215	629,708	1,924	328,167	241	300,000
Wami/Ruvu	**42,021**	**457,130**	**62,717**	**574,464**	**46,191**	**429,392**	**32,274**	**437,097**
Mainland Tanzania	**163,789**	**339,293**	**173,801**	**442,204**	**210,071**	**428,457**	**83,978**	**282,980**

	Heifers		Male Calves		Female Calves	
Region	**Number Purchased**	**Average price per head**	**Number Purchased**	**Average price per head**	**Number Purchased**	**Average price per head**
Dodoma	12,417	239,706	2,191	216,374	5,843	297,736
Tanga	11,648	338,879	2,118	227,704	8,119	210,890
Morogoro	5,359	357,143	1,191	250,000	7,145	227,188
Pwani	9,073	260,000	5,532	200,000	664	242,857
Dar Es Salaam	-	-	-	-	-	-
Manyara	9,380	413,928	722	376,762	962	341,321
Wami/Ruvu	**47,877**	**321,931**	**11,754**	**254,168**	**22,733**	**263,998**
Mainland Tanzania	**190,711**	**288,153**	**71,151**	**192,950**	**70,558**	**220,381**

Table A3-9: Number of Cattle Intake by Category of Cattle and Region During 2019/20 Agricultural Year

Region	Castrated Bulls (Oxen)	Uncastred Bulls	Cows	Steers	Heifers	Male Calves	Female Calves	Total
Dodoma	19,356	38,711	38,346	7,304	26,294	269,152	315,532	714,695
Tanga	9,883	25,062	30,356	1,765	18,708	220,613	275,325	581,712
Morogoro	23,223	4,168	7,145	-	5,359	147,672	192,331	379,898
Pwani	4,647	4,426	7,303	26,555	9,737	94,269	75,459	222,396
Dar Es Salaam	-	-	212	-	-	9,318	12,706	22,236
Manyara	9,621	8,177	6,013	1,443	11,064	305,211	337,440	678,969
Wami Ruvu	**66,730**	**80,544**	**89,375**	**37,067**	**71,162**	**1,046,235**	**1,208,793**	**2,599,906**
Mainland Tanzania	**282,953**	**273,076**	**404,184**	**110,888**	**307,587**	**4,039,547**	**4,383,204**	**9,801,439**

Table A3-10: Cattle Offtake by Category and Region During 2019/20 Agricultural Year

Region	Castrated Bulls (Oxen)	Uncastred Bulls	Cows	Steers	Heifers	Male Calves	Female Calves	Total
Dodoma	81,805	85,091	122,707	15,338	48,937	11,686	13,878	379,442
Tanga	20,473	124,249	105,541	7,060	42,711	61,066	42,358	403,458
Morogoro	32,750	58,354	68,477	8,336	13,695	31,559	24,413	237,584
Pwani	44,700	68,378	52,224	41,160	50,011	25,227	22,129	303,829
Dar Es Salaam	424	1,906	6,777	1,906	1,482	1,694	1,906	16,095
Manyara	14,431	92,117	64,458	1,443	13,469	18,038	10,102	214,058
Wami Ruvu	**194,583**	**430,095**	**420,184**	**75,243**	**170,305**	**149,270**	**114,786**	**1,554,466**
Mainland Tanzania	**1,088,103**	**1,303,468**	**1,921,196**	**367,998**	**646,990**	**592,261**	**571,929**	**6,491,945**

Large Farms - Cattle

A3-11: Number of Large-Scale Farms Raising Cattle by Region During 2019/20 Agricultural Year

Category	Wami Ruvu	Tanzania Mainland	Participation %
Farms Raising Cattle	96	275	34.91%
Farms Not Raising Cattle	378	640	59.06%

Table A3-12: Number of Cattle by Type and Region as of 1st October 2019

Category	Wami Ruvu	Tanzania Mainland	Participation %
Indigenous Cattle	8,006	68,640	11.66%
Improved Beef	23,793	52,913	44.97%
Improved Dairy	6,364	21,124	30.13%
Total	**38,163**	**142,677**	**26.75%**

Smallholders - Goat

Table A3-13: Number of Agricultural Households Raising Goats by Category and Region During 2019/20 Agricultural Year

Category	Wami Ruvu	Tanzania Mainland	Participation %
Raising Goats	421,839	1,796,741	23.48%
Not Raising Goats	1,757,385	5,860,446	29.99%
Total	**2,179,224**	**7,657,187**	**28.46%**

Table A3-14: Total Number of Goats by Goat Type and Region as of 1st August 2020

Category	Wami Ruvu	Tanzania Mainland	Participation %
Indigenous	6,935,818	24,122,946	28.75%
Improved Meat	35,017	109,957	31.85%
Improved Dairy	69,107	190,218	36.33%
Total	**7,039,942**	**24,423,121**	**28.82%**

Table A3-14: Number of Agricultural Households Rearing Goats and Heads of Goats by Herd size as 1st August 2020

	Goat rearing households		Heads of Goats		
Herd size	Number	%	Number	%	Average Goats per households
1 - 4	749,143	41.8	3,376,808	13.8	5
5 - 9	519,220	29	5,265,000	21.6	10
10 - 14	227,583	12.7	3,879,443	15.9	17
15 - 19	107,191	6.0	2,428,691	9.9	23
20 - 24	61,392	3.4	1,755,520	7.2	29
25 - 29	31,616	1.8	1,032,573	4.2	33
30 - 34	22,673	1.3	850,506	3.5	38
35 - 39	11,332	0.6	548,921	2.2	48
40+	60,887	3.4	5,285,660	21.6	87
Total	**1,791,037**	**100**	**24,423,122**	**100**	**14**

A3-15: Number of Goat Intake by Category and Region During 2019/20 Agricultural Year

Category	Wami Ruvu	Tanzania Mainland	Participation %
Number Purchased	140,575	740,124	18.99%
Number given/obtained	58,099	293,766	19.78%
Number born	2,061,092	6,862,945	30.03%
Total Goat Intake	**2,259,766**	**7,896,835**	**28.62%**

Table A3-16: Number of Goats Offtake by Category and Region During 2019/20 Agricultural Year

Category	Wami Ruvu	Mainland Tanzania	Participation %
Number sold/traded	893,552	3,390,831	26.35%
Number consumed by household	385,541	1,350,013	28.56%
Number given away	414,636	1,410,818	29.39%
Number given stolen	188,511	512,202	36.80%
Number died	771,638	2,450,511	31.49%
Total Goat Offtake	**2,653,878**	**9,114,375**	**29.12%**

Table A3-17: Number of Households Reported Goat's Milk Production by Region During 2019/20 Agricultural Year

Region	Produced Milk	Did not produce Milk	Total
Dodoma	-	144,117	144,117
Tanga	1,474	87,753	89,227
Morogoro	411	25,656	26,067
Pwani	119	13,592	13,711
Dar Es Salaam	1,981	24,597	26,578
Manyara	2,034	120,103	122,137
Wami Ruvu	**6,019**	**271,701**	**277,720**
Mainland Tanzania	**38,804**	**1,757,935**	**1,796,739**

Table A3-18: Number of Milked Goats, Production, Lactation Length and Price (Tzs/Litre) per Season by Category and Region During 2019/20 Agricultural Year

	Number of milked goats		Average milk production per goat per day		Average number of days for goats on milked		
Region	**Wet Season**	**Dry Season**	**Wet Season**	**Dry Season**	**Wet Season**	**Dry Season**	**Total milk production (Litres)**
Dodoma	-	-	-	-	-	-	-
Tanga	9,147	5,546	3	2	54	53	2,069,690
Morogoro	3,946	3,208	3	3	36	30	714,888
Pwani	322	322	3	3	58	54	108,192
Dar Es Salaam	248	248	2	2	42	51	46,128
Manyara	10,111	18,346	3	2	51	48	3,308,199
Wami Ruvu	**23,774**	**27,670**	**14**	**12**	**241**	**236**	**6,247,097**
Mainland Tanzania	**111,435**	**65,325**	**33**	**27**	**608**	**459**	**25,565,561**

Table A3-19: Goats Intake Purchased and Average Price per Head by Type and Region During 2019/20 Agricultural Year

	Billy Goat		Castrated Goat		She Goat		Male Kid		She Kid	
Region	**Number Purchased**	**Average Price (TZS)**	**Number Purchased**	**Average Price (TZS)**	**Number Purchased**	**Average Price (TZS)**	**Number Purchased**	**Average Price (TZS)**	**Number Purchased**	**Average Price (TZS)**
Dodoma	5,546	45,492	2,204	43,357	20,241	51,818	854	35,956	1,026	35,643
Tanga	8,576	51,772	249	60,000	34,262	51,878	250	30,000	5,813	27,793
Morogoro	3,135	44,769	-	-	9,652	54,918	3,531	50,000	-	-
Pwani	6,893	79,149	-	-	14,852	57,345	1,708	10,000	1,544	21,704
Dar Es Salaam	101	60,000	-	-	247	80,000	-	-	228	35,000
Manyara	9,949	52,119	1,974	50,000	6,221	43,777	928	40,000	591	35,000
Wami Ruvu	**34,200**	**55,550**	**4,427**	**25,560**	**85,475**	**56,623**	**7,271**	**27,659**	**9,202**	**25,857**
Mainland Tanzania	**148,969**	**46,791**	**20,397**	**63,000**	**490,844**	**60,131**	**45,480**	**28,976**	**38,970**	**28,787**

Smallholders - Sheep

Table A3-20: Number of Households Raising or Managing Sheep by Region During the 2019/20 Agricultural Year

Category	Wami Ruvu	Tanzania Mainland	Participation %
Raising Sheep	196,832	677,080	29.07%
Not Raising Sheep	1,982,388	6,980,105	28.40%
Total	**2,179,220**	**7,657,185**	**28.46%**

Table A3-21: Number of Sheep by Type and Region as of 1st August 2020

Category	Wami Ruvu	Tanzania Mainland	Participation %
Indigenous	2,072,064	8,438,573	24.55%
Improved	21,708	53,471	40.60%
Total	**2,093,772**	**8,492,044**	**24.66%**

Table A3-21: Number of Households Rearing Sheep and Heads of Sheep by Flock Size as of 1st August 2020

Herd size	Number	%	Number	%	Average per households
1 - 4	284,310	42.1	1,006,756	11.9	4
5 - 9	192,389	28.5	1,705,119	20.1	9
10 - 14	81,292	12.0	1,198,591	14.1	15
15 - 19	40,262	6.0	763,692	9.0	19
20 - 24	24,566	3.6	670,929	7.9	27
25 - 29	8,942	1.3	237,689	2.8	27
30 - 34	6,858	1.0	248,555	2.9	36
35 - 39	5,778	0.9	187,226	2.2	32
40+	30,240	4.5	2,473,488	29.1	82
Total	**674,637**	**100.0**	**8,492,045**	**100.0**	

Table A3-22: Number of Sheep Intake by Category and Region During 2019/20 Agricultural Year

Category	Wami Ruvu	Tanzania Mainland	Participation %
Number Purchased	47,199	209,216	22.56%
Number given/obtained	16,041	91,942	17.45%
Number born	634,571	2,384,457	26.61%
Total Intake of Sheep	**697,811**	**2,685,615**	**25.98%**

Table A3-23: Number of Sheep Offtake by Category and Region During 2019/20 Agricultural Year

Category	Wami Ruvu	Mainland Tanzania	Participation %
Number sold/traded	191,567	829,132	23.10%
Number consumed by hh	78,783	415,103	18.98%
Number given away	47,538	216,597	21.95%
Number given stolen	78,554	126,128	62.28%
Number died	175,231	835,019	20.99%
Total Offtakeber	**571,673**	**2,421,979**	**23.60%**

Table A3-24: Total Number of Sheep Intake Purchased and Average Price per Head by Type and Region During 2019/20 Agricultural Year

Region	Ram		Castrated Sheep		She Sheep		Male Lamb		She Lamb	
	Number Purchased	Average price per head	Number Purchased	Average price per head	Number Purchased	Average price per head	Number Purchased	Average price per head	Number Purchased	Average price per head
Dodoma	1,690	40,924	-	-	4,872	39,659	-	-	-	-
Tanga	3,550	37,637	3,831	50,000	9,941	46,209	-	-	1,225	38,836
Morogoro	1,766	150,000	-	-	2,396	54,885	630	10,000	-	-
Pwani	1,035	65,000	690	75,000	5,304	43,356	-	-	-	-
Dar Es Salaam	265	60,000	-	-	-	-	-	-	-	-
Manyara	4,406	39,538	219	50,000	5,153	31,335	-	-	226	20,000
Wami Ruvu	**12,712**	**NA**	**4,740**	**NA**	**27,666**	**NA**	**630**	**NA**	**1,451**	**NA**
Mainland Tanzania	**45,326**	**51,780**	**9,053**	**57,987**	**132,991**	**46,087**	**6,134**	**24,153**	**15,712**	**30,808**

Annex 4: State of Water Resources in Tanzania

Table A4-1: Water Demands by Basin - Tanzania, 2015

MCM Year	Wami Ruvu	Ruvuma SC	Rufiji	Pangani	L Victoria	L Tanganyika	L Rukwa	L Nyasa	IDB	Tanzania
Domestic	345.0	148.0	70.0	157.0	466.0	215.0	54.0	34.0	200.0	1,686.0
Irrigation	682.0	254.0	4,886.0	2.659,0	222.0	269.0	532.0	310.0	687.0	10,500.0
Hydropower	2.0	-	6,322.0	3,780.0	-	0.3	-	2,958.0	-	13,062.0
Livestock & Aquaculture	34.0	31.0	19.0	12.0	130.0	24.0	13.0	11.0	99.0	395.0
Industries & Mining	78.0		130.0	36.0	33.0	64.0	5.0	11.0	101.0	445.0
Ecosystem & Wildlife	298.0	4,801.0	21,850.0	1,622.0	4,400.0	4,287.0	4,676.0	4,168.0	4,547.0	50,627.0
Total	**1,439.0**	**5,234.0**	**33,277.0**	**8,266.0**	**5,251.0**	**4,859.3**	**5,280.0**	**7,492.0**	**5,634.0**	**76,715.0**
Consumptive	1,139.0	433.0	5,105.0	2,864.0	851.0	572.0	604.0	366.0	1,087.0	13,026.0
Non-Consumptive	2.0	-	6,322.0	3,780.0	-	0.3	-	2,958.0	-	13,062.0
Ecosystem & Wildlife	298.0	4,801.0	21,850.0	1,622.0	4,400.0	4,287.0	4,676.0	4,168.0	4,547.0	50,627.0
Total	**1,439.0**	**5,234.0**	**33,277.0**	**8,266.0**	**5,251.0**	**4,859.3**	**5,280.0**	**7,492.0**	**5,634.0**	**76,715.0**

Source: adapted by the authors from Water Resources Fact Sheets, Ministry of Water, 2015.

Figure A4-1. Water Demands by sector, Wami/Ruvu 2015

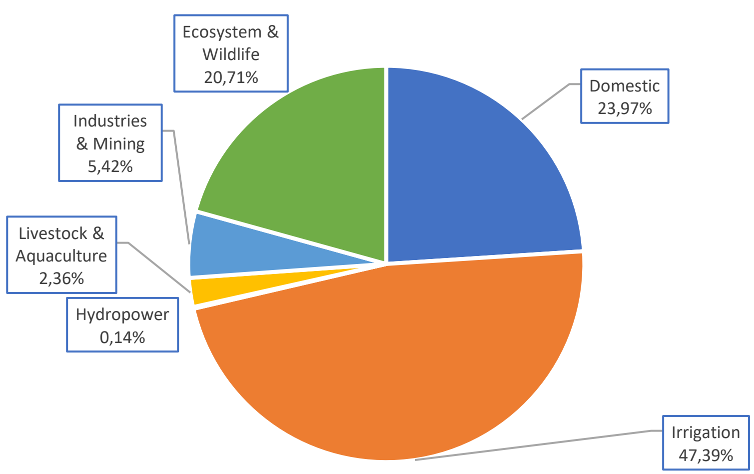
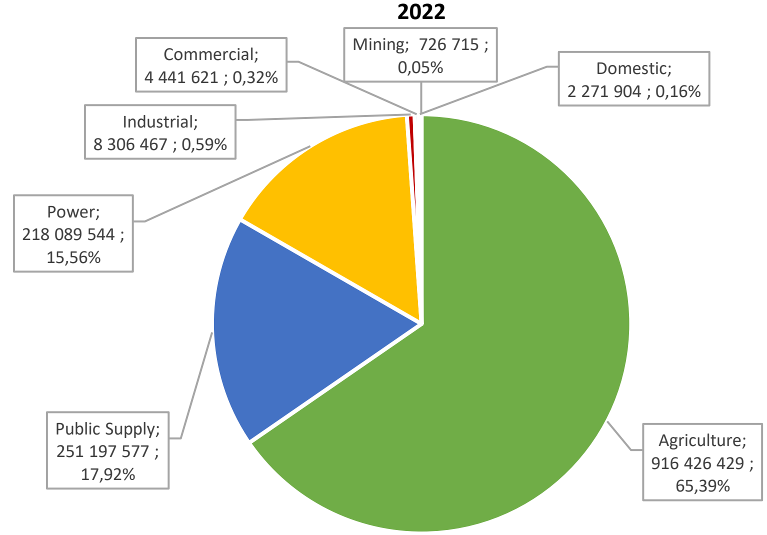


Figure A4-2: Water Use by Permits Allocated by Wami/Ruvu Basin Water Board 2022



Source: Adapted by the authors from Water Resources Factsheets, MoW, n.a

Source: Elaborated by the authors with information provided by MoW,2022.

Table A4-2: Summary of Annual Water Resource and Water Demand by Basin for years 2015, 2025, and 2035

Year = 2015		Water Resources (MCM/yr)			Water Demand (MCM/yr)									
Basin	Code	Surface Water	Groundwater (sustainable yield)	Groundwater (recharge)	Environmental Flow (MCM/yr)	Domestic & Institute	Industry & Mining	Irrigation	Livestock	Wildlife	Tourism	Fisheries & Aquaculture	Total	Annual WEI %
Pangani	PG	6,963	587	1,466	1,622	157	36	2,657	12	0	0	0	2,862	34%
Wami Ruvu	WR	4,865	1,139	4,273	298	345	61	656	15	0	0	0	1,076	12%
Rufiji	RF	41,049	9,021	22,533	21,85	69	131	4,905	19	0	0	0	5,124	8%
Ruvuma & S. Coast	RV	11,7	3,238	8,307	4,801	50	0	254	7	25	0	0	335	2%
Lake Nyasa	LN	12,188	107	1,07	4,161	34	11	309	11	0	0	0	365	3%
Lake Rukwa	LR	12,982	2,136	5,341	4,674	54	2	532	13	0	0	0	600	3%
Lake Tanganyika	LT	10,641	2,755	5,511	4,271	215	63	273	25	16	1	0	592	4%
Lake Victoria	LV	8,439	1,327	4,424	4,4	206	15	163	73	0	0	0	456	4%
Internal Drainage	ID	5,985	884	4,421	1,599	176	89	561	87	4	0	0	917	9%
Total		**114,812**	**21,195**	**57,345**	**47,676**	**1,306**	**407**	**10,309**	**261**	**45**	**1**	**1**	**12,329**	**7%**

Year = 2025		Water Resources (MCM/yr)			Water Demand (MCM/yr)									
Basin	Code	Surface Water	Groundwater (sustainable yield)	Groundwater (recharge)	Environmental Flow (MCM/yr)	Domestic & Institute	Industry & Mining	Irrigation	Livestock	Wildlife	Tourism	Fisheries & Aquaculture	Total	Annual WEI %
Pangani	PG	5,881	587	1,466	1,655	204	56	2,959	14	1	0	0	3,234	44%
Wami Ruvu	WR	4,865	1,139	4,273	298	441	142	993	19	0	0	0	1,595	17%
Rufiji	RF	41,049	9,021	22,533	21,85	110	245	5,504	33	0	0	0	5,891	9%
Ruvuma & S. Coast	RV	11,755	3,238	8,307	4,801	61	0	568	8	36	0	0	673	3%
Lake Nyasa	LN	12,041	102	1,07	4,545	39	11	606	11	0	0	0	668	5%
Lake Rukwa	LR	12,982	2,136	5,341	4,674	83	3	832	16	0	0	0	934	5%
Lake Tanganyika	LT	10,75	2,755	5,511	4,271	318	67	578	30	29	13	0	1,037	6%
Lake Victoria	LV	8,439	1,327	4,424	4,466	322	23	430	84	0	0	6	865	7%
Internal Drainage	ID	5,654	884	4,421	1,599	206	95	869	107	4	0	0	1,282	13%
Total		**113,417**	**21,189**	**57,345**	**48,159**	**1,784**	**642**	**13,338**	**323**	**70**	**13**	**7**	**16,179**	**9%**

Year = 2035		Water Resources (MCM/yr)			Water Demand (MCM/yr)									
Basin	**Code**	**Surface Water**	**Groundwater (sustainable yield)**	**Groundwater (recharge)**	**Environmental Flow (MCM/yr)**	**Domestic & Institute**	**Industry & Mining**	**Irrigation**	**Livestock**	**Wildlife**	**Tourism**	**Fisheries & Aquaculture**	**Total**	**Annual WEI %**
Pangani	PG	5,099	587	1,466	1,667	294	155	3,11	16	1	0	0	3,577	54%
Wami Ruvu	WR	4,865	1,139	4,273	298	552	355	1,268	25	0	0	0	2,201	24%
Rufiji	RF	41,049	9,021	22,533	21,85	149	363	7,619	58	0	0	0	8,188	13%
Ruvuma & S. Coast	RV	11,794	3,238	8,307	4,801	76	0	1,056	12	47	0	0	1,191	6%
Lake Nyasa	LN	11,959	96	1,07	5,019	50	12	938	12	0	0	0	1,012	8%
Lake Rukwa	LR	12,982	2,136	5,341	4,674	110	4	1,164	21	0	0	0	1,298	7%
Lake Tanganyika	LT	10,474	2,755	5,511	4,271	520	75	986	37	52	27	0	1,699	11%
Lake Victoria	LV	8,439	1,327	4,424	3,514	335	24	772	96	0	0	17	1,245	10%
Internal Drainage	ID	4,981	884	4,421	1,599	229	102	1,177	131	4	0	0	1,644	17%
Total		**111,641**	**21,184**	**57,345**	**47,693**	**2,315**	**1,09**	**18,091**	**408**	**104**	**27**	**18**	**22,056**	**13%**

Source: JICA ,2018. Prepared by the JICA Project Team based on the IWRMDP and LVBC study reports. For detailed information, see "Chapter 3 - Present Conditions of Water Sector".

Table A4-2: Water use by permits allocated by Wami/Ruvu Basin Water Board, 2022

General Use	Specific Use	No. Permits	M^3 Year
Agriculture		**242**	**916,426,429**
	Agriculture Mixed	18	66,445,565
	Fishing	16	4,581,152
	Irrigation	203	845,375,988
	Livestock	4	16,425
	Other	1	7,300
Commercial		**675**	**4,441,621**
	Commercial	426	2,954,276
	Construction	73	668,607
	Hotel	166	777,310
	Other	10	41,428
Domestic		**1,053**	**2,271,904**
	Domestic	1,053	2,271,904
Industrial		**359**	**8,306,467**
	Bottling	11	229,827
	Industrial	345	7,623,642
	Industrial Mixed	3	452,997
Mining		**4**	**726,715**
	Mining	4	726,715
Power		**4**	**218,089,544**
	Hydropower	4	218,089,544
Public Supply		**229**	**251,197,577**
	Institutional	31	296,111
	Public Supply	198	250,901,466
Total		**2,566**	**1,401,460,256**

Source: Elaborated by the authors with information provided by MoW,2022.

Table A4-3: Water Infrastructure Profile by Basin - Tanzania, 2015

Water Infrastructure	Wami Ruvu	Rufiji	Ruvuma SC	Pangani	L Victoria	L Tanganyka	L Rukwa	L Nyasa	IDB	Tanzania
Water Points:										
No. of Water Points	*8,012*	*12,372*	*6,868*	*13,025*	*17,090*	*9,374*	*3,873*	*7,666*	*11,957*	***131,316 ****
No. of Taps	*11,905*	*15,610*	*8,121*	*15,583*	*21,044*	*12,214*	*5,094*	*9,725*	*16,285*	***115,581***
No. of Monitoring Stations:										
Weather	*11*	*19*	*21*	*15*	*17*	*15*	*8*	*7*	*5*	***118***
Rainfall	*46*	*34*	*10*	*39*	*33*	*14*	*9*	*55*	*57*	***297***
Hydrological	*43*	*58*	*28*	*72*	*27*	*32*	*25*	*31*	*46*	***362***
Hydrogeological	*26*	*12*	*6*	*10*		*1*	*NA*	*NA*	*31*	***86***
Water storage:										
No. of Dams and Reservoirs	*167*	*37*	*75*	*156*	*154*	*60*	*4*	*5*	*119*	***776***
Reservoirs Capacity (MCM)	*52.5*	*3.935*	*21.6*	*1,191.70*	*85.6*	*55.7*	*NA*	*1.1*	*119.2*	***5,462***
Irrigation Schemes:										
No.	*208*	*404*	*126*	*960*	*234*	*117*	*91*	*88*	*315*	***2,919 ****
Area (Ha)	*29,920*	*209,500*	*12,950*	*84,473*	*30,543*	*6,501*	*28,944*	*5,580*	*51,872*	***460,300***
Irrigation Efficiency	*25% - 30%*	*NA*	*0*	*30%*	*30%*	*25%*	*NA*	*25%*	*30%*	***25%-30%***
Main Crops (irrigated)	*Maize, legume, Cotton, Coconut*	*Maize, legume, Cotton, Tea, Banana, Coffee*	*Maize, legume, Cashew, Coconut*	*Coffee, Cotton, Maize, Rice, Sorghum, Bananas*	*Maize, Legume, Sorghum, Cotton, Coffee, Banana, Sugarcane, Rice*	*Maize, Sorghum, Wheat, Beans*	*Maize, Cotton, Coffee, Sorghum*	*Maize, Cotton, Rice, Sorghum*	*Maize, Sorghum, Wheat, Beans*	***Paddy, Maize, Sugarcane, vegetable***

Notes: (*) Totals for each basin after summed up differ from total for Tanzania as reported in national factsheet.

Source: Adapted by the authors, Water Resources Factsheets, MoW, n.a..

Annex 5: Summary of findings reports on climate change impacts on Tanzania's water resources

Variable		National Climate Change Response Strategy 2021-2026 (2021) - URT	Climate Risk Profile: Tanzania (n.a.) - GIZ	Climate Risk Profile Tanzania (2018) - USAID
Impact on Hydrological Variables	**Temperature**	− The climate models project warming in the range of 0.8 to 1.8°C by the 2040s. − Regional temperature projections to 2050: ▪ A warming of less than 1.76ºC in the ▪ northern coast regions and north-eastern highlands. ▪ A warming in excess of 1.77ºC in the Lake Victoria and central zone ▪ A warming in excess of 1.39ºC in the southern coast	− Air temperature over Tanzania is projected to rise approximately 1.4 °C in 2030, 1.7 °C in 2050 under the low emissions and medium / high emissions scenarios. − The annual number of very hot days (days with daily maximum temperature above 35 °C) is projected to rise substantially and with high certainty, in particular over eastern Tanzania.	− Increased average annual temperature of 1.4 to 2.3°C; greatest warming in the west/southwest. − Increased duration of heat waves (by 7–22 days) and dry spells (by up to 7 days).
	Precipitation	− Rainfall will decrease during dry seasons and increase during wet seasons, which translates to higher risks for drought and flooding. Changes in annual rainfall across Tanzania show increases in the north/northeast (around 3 to 4%) and decreases in the south (-1 to -2%) by 2040 − Regional rainfall projections to 2050: ▪ An increase of about 10-12% in Lake Victoria ▪ An increase of up to 13.4 in North-eastern Highlands. ▪ an increase of up to 9.9% in The Southwestern Highlands and Western Zones ▪ An increase of about 1.8% in The North Coast Zone ▪ An increase of up to 9.9% in the Central Zone ▪ a decrease of up to 7% in the Southern Coast Zone	− Future projections of precipitation are less certain due to high natural year-to-year variability (no convergence in climate change models). − Climate models project a slight increase in the number of days with heavy precipitation, from 8 days per year in 2000 to 9 days per year in 2080.	− Likely increase in average annual rainfall (range of -3 to +9 percent), with greatest increase in the northeast; likely rainfall decline July–September. − Increased heavy rainfall event frequency (7–40 percent) and intensity (2–11 percent).
	Sea level rise	(There is not a specific analysis of the impact of climate change related to sea level rise at national or regional levels)	− Until 2050, similar sea levels are projected under low and medium/high emissions scenarios. The median climate model projects a sea level rise by 11 cm in 2030, 21 cm in 2050 and 41 cm in 2080 compared to 2000. − This threatens Tanzania's coastal communities and may cause saline intrusion in coastal waterways and groundwater reservoirs, rendering water unusable for domestic use and harming biodiversity.	− Rise in sea levels of 16 to 42 cm. − Sea level rise is putting coastal infrastructure, coastal populations (about 25 percent of the total population), and coastal ecosystems at risk of inundation, salinization, and storm surge.

Variable		National Climate Change Response Strategy 2021-2026 (2021) - URT	Climate Risk Profile: Tanzania (n.a.) - GIZ	Climate Risk Profile Tanzania (2018) - USAID
Impact on Selected Sectors	**Water Resources**	– Severe and recurrent droughts in the past decade triggered a decrease in water flows in rivers, hence shrinkage of receiving lakes, declines of water levels in satellite lakes and hydropower dams. Furthermore, some of the perennial rivers have changed to seasonal rivers and some wetlands have dried up. – With increasing evapotranspiration due to increased temperature and changed rainfall regime, wetland water characteristics will change with adverse consequences for the biodiversity within. – Following unusual heavy rainfall coupled with flooding in 2019/2020 has led to highest increase of water levels of main water basins in the country. For instance, Lake Tanganyika has recorded highest water levels by almost 3 meters and Lake Victoria by 0.53 m. – Although, projected river flows will be highly influenced by non-climate factors such as changes in land use, climate projections indicate increased runoff for the Pangani and Rufiji basins, which will increase risk of flooding and sedimentation; and decreased runoff for Wami/Ruvu basin, which will increase water stress in Dar es Salaam, Morogoro, Kibaha and Dodoma (with a combined population of more than 6 million). – Water availability will also depend on the development of rivers upstream by neighbouring countries, as 13 percent of Tanzania's renewable water resources are transboundary. – Generally, all water basins are faced with water demand stress from different uses, such as irrigation, hydroelectric power, domestic, industry, tourism, etc. Such stress creates a drastic impact to the downstream users especially the national hydropower plants (Nyumba ya Mungu, Old Pangani, New Pangani and Julius Nyerere (under construction). Prolonged drought, floods, coupled with human water demanding activities will further worsen the already precarious situation.	– When accounting for population growth, per capita water availability for Tanzania is projected to decline by 76 % under low and medium/high level emissions models by 2080 relative to the year 2000. – Projections of future water availability from precipitation vary depending on the region and scenario. Under a low emissions model, water availability will decrease by up to 25 % in northern and south-eastern Tanzania. Under a medium/high emissions model, there is no conclusive evidence of high decreases. – Several studies show that climatic changes in Tanzania have resulted in a decrease in total precipitation, a shift of the onset of the rainy season and an increase in the frequency and duration of droughts. These changes have materialised, for example, in the extreme decrease of water levels of Lake Victoria and Lake Tanganyika, and the 7-km recession of Lake Rukwa over the past 50 years. – Unreliable precipitation in the highland areas has been the main driver for shifting agricultural production towards lower wetland areas, which offer comparatively fertile soils and year-round water availability. However, the conversion of wetlands in favour of agricultural production has negative trade-off effects on affected ecosystems.	– Increased temperatures, longer dry spells and heavy rainfall events threaten Tanzania's nine major river basins and the continent's three largest lakes (Victoria, Tanganyika and Nyasa). – While future river flows will be highly influenced by nonclimate factors such as changes in land use, climate projections indicate increased runoff for the Pangani and Rufiji basins, which will increase risk of flooding and sedimentation, and decreased runoff for Wami/Ruvu basin, which will increase water stress in Dar es Salaam, Morogoro, Kibaha and Dodoma (with a combined population of more than 6 million). – Water availability will also depend on the development of rivers upstream by neighbouring countries, as 13 percent of Tanzania's renewable water resources are transboundary. – Mainland urban areas rely primarily on surface water sources that are increasingly polluted and further threatened by heavy rainfall events that wash mining, commercial and domestic pollution into rivers, lakes, and wetlands. – With reduced surface water quantity and quality, coastal cities will increasingly rely on groundwater, which is already at risk of saltwater intrusion.

Variable		National Climate Change Response Strategy 2021-2026 (2021) - URT	Climate Risk Profile: Tanzania (n.a.) - GIZ	Climate Risk Profile Tanzania (2018) - USAID
		This calls for harmonized and inclusive Strategy that will lead to water resilience.		
	Agriculture	**Crops** − Dependency on rain-fed agriculture makes it acutely vulnerable to weather changes. Changing climate has already resulted in a general decline in agricultural productivity, including changes in agro-diversity and hence jeopardizing food security and nutrition. − Unreliable rainfall in terms of intensity and distribution is the most likely and damaging production risk. Shortening and/or change of the growing season, a trend that has already been observed, is seen as a direct consequence of the warming up and changes in rainfall. − Drought is also known to severely affect agriculture. Between 2015 and 2019 drought was most frequently reported in the northern regions (Arusha, Tanga, Manyara, Kilimanjaro, Simiyu and Mara), central regions (Dodoma and Morogoro), and south-eastern regions (Mtwara and Lindi). − Evidence of the impacts of climate variability on agriculture sector in Tanzania include: ▪ shifting in agro-ecological zones ▪ prolonged dry episodes ▪ unpredictability in rainfall ▪ uncertainty in cropping patterns ▪ increased weed competition with crops for (moisture, nutrients, and light) ▪ ecological changes for pests and diseases. **Livestock** − Livestock sub-sector is affected by various impacts of climate change, drought being the most serious effect. Changes in the mean temperature and rainfall, and the increased variability of rainfall have resulted into the prolonged length of dry seasons and increased severity	− Since crops are predominantly rainfed, they depend on water availability from precipitation and are prone to drought. However, the length and intensity of the rainy season is becoming increasingly unpredictable, and the use of irrigation remains limited. The high uncertainty of projections regarding water availability translates into high uncertainty of drought projections. − the national crop land area exposed to at least one drought per year will increase by a factor of five in response to global warming. − Regional climate variability will likely cause crop yields to increase in some areas, while simultaneously decreasing in others. − In terms of yield projections, millet, sorghum, rice, groundnuts, and cassava are projected to gain from climate change. There are no conclusive results on maize, − Overall, adaptation strategies such as switching to high-yielding improved varieties in climate change sensitive crops should be considered, yet carefully weighed against adverse outcomes, such as a resulting decline of agro-biodiversity and a loss of local crop types.	− Increasing temperatures, longer dry spells and more frequent and intense rains put crop and livestock production in Tanzania at risk. − While increasing temperatures may benefit rainfed maize in the highlands, national production is projected to decrease 8–13 percent by 2050 due to increased heat stress, drying, erosion and flood damage. − Bean, sorghum, and rice yield projections follow similar trends, with decreases of 5 –9 percent by 2050. − Increasing heat stress and expansion of the coffee berry borer beetle are expected to decrease coffee productivity from 225 kg/ha currently to less than 100 kg/ha in 2060. − Along the coast, cassava and rice crops are subject to salinization, waterlogging and inundation from sea level rise. − Livestock production is at risk from increasing heat extremes, flood losses, degraded pastureland, and disease outbreaks, including Rift Valley Fever.

Variable		National Climate Change Response Strategy 2021-2026 (2021) - URT	Climate Risk Profile: Tanzania (n.a.) - GIZ	Climate Risk Profile Tanzania (2018) - USAID
		of periodic droughts that reduce availability of water and pastures. – It is also expected that they shrink the rangelands that are important for livestock keeping communities in Tanzania. Shrinkage of rangelands, and pastoralists and agro-pastoralists migration are likely to exacerbate conflicts between livestock keepers, crop farmers and other resource users in many areas. – On the other hand, warming is predicted to increase disease vectors which will consequently increase the incidences of vector-borne diseases of livestock, such as Trypanosomiasis, East Coast Fever, and Rift Valley Fever. This is expected to severely affect survival and production of livestock – Although floods are usually less recurrent, their occurrences cause severe impacts while also affecting larger areas.		
	Industry	– The large dependence on agricultural raw materials means that the industrial sector is vulnerable to the impacts of climate change. – Despite the agro-based nature of most of these industries, power supply is mainly from hydro sources, which are vulnerable to climate change, particularly drought. Therefore, climate change adversely affects the sector and people's wellbeing at large. The effects include: ▪ Decrease in industrial production due to unstable power supply, water supply, low or inadequate supply of agricultural raw materials, damage of infrastructure, which mean limited inflow of foreign currency. ▪ Increase of industrial production costs due to imported materials and technology, which would mean more capital flight.	– Extreme weather events will have devastating effects on human settlements and economic production sites, especially in urban areas with high population densities such as Dar es Salaam or Mwanza. – The flooding-poverty nexus is particularly strong in Dar es Salaam, where many households experience floods on an annual basis and even during average precipitation events – Flooding and droughts will also affect hydropower generation: Tanzania is planning to increase its hydropower capacity from 0.5 gigawatts in 2015 to a planned volume of 3.4 gigawatts in 2030. – However, variability in precipitation and climatic conditions could severely affect river levels and disrupt hydropower generation. – The exposure of the GDP to heatwaves is projected to increase from around 2 % in 2000 to	– Tanzania is the most flood-affected country in East Africa. Intensifying heavy rainfall events are likely to increase flood impacts to infrastructure and associated energy, water, and transportation services. – Sea level rise is expected to cost about $200 million per year by 2050 in lost land and flood damage. In Dar es Salaam, infrastructure assets valuing $5.3 billion are increasingly at risk from flooding and sea level rise. – About 40 percent of Tanzania's limited electricity supply comes from hydropower vulnerable to increasing evaporation, siltation from heavy rainfall events and longer dry spells. – While future flows may increase in the Pangani and Rufiji basins, both important for hydropower, increasing evaporation and siltation will constrain Tanzania's inadequate electric

Variable		National Climate Change Response Strategy 2021-2026 (2021) - URT	Climate Risk Profile: Tanzania (n.a.) - GIZ	Climate Risk Profile Tanzania (2018) - USAID
		▪ Increased occupational health risk due to high temperatures and inadequate water for sanitary activities. ▪ Increase in unemployment rate due to decreased industrial investment and production. – Impacts of climate change in other sectors such as infrastructure, agriculture, and livestock will also affect supply of raw material for agro-industry.	6 % and 16 % by the end of the century. It is recommended that policy makers start identifying heat-sensitive economic production sites and activities and integrating climate adaptation strategies such as improved solar-powered cooling systems, “cool roof” isolation materials or switching the operating hours from day to night.	supply, which only reaches 16 to 18 percent of the population.

Source: GoT, 2021a; GIZ n.a.; USAID, 2018. Table elaborated by authors.

Annex 6: Evaluation of WSPD ii – Main Findings for Water Resources Management

Specific Interventions	Performance Targets	Results	Evaluation
Institutional strengthening and improvement of the operational capacity of Basin Water Boards	Operational capacity of BWBs strengthened through targeted training in areas of operational hydrology, financial management, human resources management, hydrogeology, establishment and strengthening of WUAs; assessments on climate change vulnerability conducted.	Construction of 8 BWB Headquarters: 3 completed, and 5 were close to completion.	Significant progress in meeting the target, however shortage of staff continued to constrain BWBs' performance.
	1,000 staff in various technical disciplines (hydrologists, hydrogeologists, environmental engineers, water resource engineers, economists, community development officers, chemists, etc.) recruited for deployment to MoW, basins, and water laboratories.	98 staff in various positions were recruited, 9.8 percent of the target	Acute shortage of staff to fully implement the program's WRM component. This underperformance in staff recruitment against the target derailed the implementation of the program—particularly limiting MoW's DWR, water quality laboratories and the BWBs' ability to offer consistent extension services and capacity-building support to community-level WUAs and perform routine duties in ensuring sustainable WRM in the country
	Water resources research centre established and functional	(No results reported)	(Not reported)
▪ Establishment and strengthening of Water User Associations (WUAs)	▪ 170 new WUAs established ▪ 90 existing WUAs strengthened and capacitated	▪ 44 new WUAs were established. ▪ 4 out of the planned 130 WUA offices were constructed or rehabilitated. ▪ 134 WUAs (44 new and 90 existing) were strengthened by adding support for transportation infrastructure (100 motorcycles and 100 bicycles).	▪ Lack of WUA offices has emerged as a bottleneck in their performance and limits their ability to be taken seriously and receive support from other organisations. ▪ Expressed satisfaction with the quality of support they have received from BWBs ▪ Several established committees and WUAs are still not fully operational or are not contributing as expected due to a lack of necessary resources and staff. ▪ The existence of non-functional WUAs and catchment committees indicates an inadequacy in the availability of the technical and financial support necessary to facilitate daily operations.
Gazettement of water catchment and sub-catchment areas, including establishment of catchment management committees	30 catchment areas gazette	No catchments were gazetted. The total gazetted catchments remained at 4 as it was in 2014–2015.	Inadequate funding for demarcation and gazettement of the catchments as the main reason behind the suboptimal performance on catchments gazettement.
	56 sub-catchment areas gazette	3 were gazetted	

Specific Interventions	Performance Targets	Results	Evaluation
	18 catchment committees established and functioning	▪ 27 catchment and sub-catchment committee offices have been built ▪ 11 of the planned 18 sub-basin water offices (sub-BWOs) have been rehabilitated/constructed.	The sub-catchment committees established are still not fully functional as they lack adequate resources and sufficient staff.
	36 sub-catchment committees established and functioning	6 sub-catchment committees were established—three in each of the two basins of Rufiji and Wami-Ruvu.	
Enhancing Transboundary WRM	(See USAID, 2021: 22-23)	(See USAID, 2021: 22-23)	(See USAID, 2021: 22-23)
Improving the systems for water resources conservation, monitoring, allocation, regulation, conflict resolution, and demand management	Functional Decision Support System database strengthened for all 9 BWBs and at DWR HQ	The AQUARIUS hydrological software was acquired through USAID/Tanzania's Water Resources Integration Development Initiative (WARIDI). It started with Rufiji and Wami-Ruvu basins but later extended to all nine basins. Each basin received at least three fast processing computers to facilitate data storage and processing. 50 MoW and BWBs staff received training on the use of AQUARIUS and issues related to quality assurance	(Not reported)
	National Water resources database established and operational	(No results reported)	(Not reported)
Investments in protection and pollution control of water resources		▪ 52 out of 161 catchments were demarcated with clear catchment boundaries and limits to enable the design and preparation of catchment conservation activities. ▪ BWBs made investments to assist communities in establishing income-generating activities such as beekeeping and tree planting around identified potential water sources, thereby ensuring water availability for multiple uses, and increasing income. ▪ The Government of Tanzania adopted several critical regulations as part of its efforts to improve water resources conservation, protection, and pollution control—and to disseminate information and raise stakeholder awareness.	▪ BWBs implemented activities at such a small scale that their overall contribution to reducing pollution in terms of reduced siltation into water sources has been minimal. ▪ Regulations, coupled with increased enforcement and expansion of protected areas and enforcement of permits, helps reinforce changes in farming and other practices to reduce their impact on catchment areas.

Specific Interventions	Performance Targets	Results	Evaluation
Construction of a mix of large, medium-sized, and small water reservoirs, and development of Dam Safety Management guidelines	3 multipurpose dams constructed 20 medium-sized dams rehabilitated in dry areas	CONSTRUCTION WORKS ▪ None of the strategic dams were built and the planned studies for multipurpose dams were carried out ▪ Studies for the Kidunda, Farkwa, Ndembera, and Lower Songwe dams were completed. ▪ Ongoing construction of the Julius Nyerere Hydroelectric Power Plant ▪ Only one of the planned 20 medium-sized dams (Leken-Monduli) was rehabilitated ▪ Feasibility studies for the remaining 19 dams were initiated and reported to be at different stages ▪ Surveys for 54 new dam sites were reported to be at different stages (feasibility study or detailed design phase)	CONSTRUCTION WORKS ▪ Failure to implement planned multipurpose dams was attributed to concerns raised by environmental activists about their environmental impacts. ▪ Awaiting allocation of funding to undertake construction activities.
		SAFETY GUIDELINES ▪ BWBs implemented pilot projects for flood management and early warning systems in the Pangani and Ruvuma basins. ▪ BWBs established 20 meteorological and 15 hydrological stations, registered four Tailing Storage Facility (TSF) dams, registered 28 Approved Professional Persons (APPs) authorized to deal with all aspects of dam safety, and issued 11 construction permits for ten TSFs. ▪ MoW conducted a flow forecasting study in the Lower Mara River and developed national dam safety guidelines. ▪ Development of strategic action plans for the construction of 225 charco dams in arid areas between 2021 and 2023 ▪ Completion of bathymetric surveys in five dams against the target of conducting bathymetric survey in all strategic dams.	SAFETY GUIDELINES Several planned activities were not implemented, including: ▪ conducting economic assessments of the existing large dams to ensure dam safety and advice on remedial or intervention measures ▪ procuring and installing dam monitoring instruments in large dams ▪ developing design manuals for small dams ▪ conducting research on dam failure assessment and maintenance for sustainable dam construction. These activities were not fully implemented due to limited funding allocation and capacity of MoW and BWB staff.
Drilling and rehabilitation of exploratory and monitoring wells	150 groundwater monitoring and exploratory wells drilled and/or rehabilitated	▪ 18 of the planned 150 observation or monitoring wells were drilled. The number of operational observation holes reached 82. ▪ 2 monitoring boreholes out of the 120 planned for rehabilitation were rehabilitated.	Inadequate allocation of funds to support the activity

Specific Interventions	Performance Targets	Results	Evaluation
Developing Integrated Water Resources Development Projects (IWRDPs) for the nine BWBs	Developed and disseminated 9 Integrated Water Resources Management and Development Plans (IWRMDPs) 30% of the IWRMDPs implemented	▪ 7 IWRMDPs for Lake Tanganyika, Nyasa, Rukwa, IDBs, Rufiji, Wami-Ruvu, and southern and coastal basins were prepared ▪ While IWRMDPs are in place, BWBs have not fully implemented them. ▪ Cross-sectoral coordination and collaboration forums reached 3,040 stakeholders (353 at the National Forum and 2,687 at the Basin and Catchment Forums).	▪ IWRMDPs are considered critical road maps for rationally managing and developing river and lake basins' water resources in the medium to long term for multi-sectoral needs while preserving ecosystem integrity. ▪ MoW and BWBs made significant efforts to ensure stakeholder engagement at the national and catchment levels through multi-stakeholder forums. ▪ The lag in implementing the developed basin IWRDMPs attributed to acute staff shortage. The effects of this staff shortage were further exacerbated by low funding for the WRM component. ▪ The delay in fully implementing the IWRMDPs is a critical missed opportunity that could jeopardize BWBs' and communities' ability to safeguard water security and ensure sustainable development.
Increasing the number of hydro-meteorological and hydro-geological monitoring stations from 410 to 600 Procuring operational equipment, chemicals, and necessary installations for WRM.	Hydro-meteorological and hydro-geological monitoring stations increased from 410 to 600	There has been no significant change in the number of hydrometric stations in Tanzania over the last decade. 794 monitoring stations were available and operational, including: ▪ 330 river gauging stations ▪ 189 rainfall stations ▪ 152 weather stations ▪ 95 groundwater stations ▪ 17 stations for lakes monitoring ▪ 11 stations for monitoring dams Most stations are found in three basins, with Wami-Ruvu having the highest number (139), followed by Rufiji (137) and Pangani (136).	The number of hydrometric stations in the basins decreased in 7 out of the 9 basins, except for the Wami-Ruvu and Ruvuma basins. 6 out of the 9 basins show a decline in the number of weather stations. The decline was attributed to poor maintenance of existing stations, acts of vandalism, and lack of new installations. Implementation of conservation, monitoring, allocation, and regulation are constrained by a lack of data and investment. KEY ACHIVEMENTS ▪ MoW published its first hydrological yearbook since 1980, containing data from 2010 to 2019 ▪ MoW published its first Water Resources Atlas. ▪ Issuance of 7,623 water-use permits (ground and surface water) across all basins, compared to the target of 6,000 by 2019
Implementing a Water Quality Management (WQM) and pollution control strategy	Capacity development plans (CDPs) for all Water quality laboratories implemented	▪ Water quality was monitored in 50 strategic water bodies, and a total of 1,540 water samples were collected and analysed.	▪ MoW has an elaborate mechanism to monitor the quality of water sources and implement pollution control measures that protect

Specific Interventions	Performance Targets	Results	Evaluation
		According to MoW, the analysis results indicated that water quality varies significantly between locations. These variations are caused by a variety of factors, including the state of natural rocks and human activity. In general, the ambient water quality of surface water is more susceptible to contamination by high levels of nitrogen, phosphorous, and turbidity, which can occur naturally or as a result of human activity. Groundwater quality is extremely vulnerable to high salinity, acidity, nitrate, and minerals such as fluoride, iron, manganese, and chloride. ▪ 19,339 water samples from Water Supply and Sanitation Authority (WSSAs) and rural supply systems were tested in compliance with the Potable Water Specialization; the compliance level of the samples from the WSSAs and from rural water supply was around 93.5 percent and 83.5 percent, respectively. Non-compliance was reported to mainly originate from the high levels of chemical and bacteriological parameters. ▪ 235 projects were supported to install simple water chlorination systems.	aquatic ecosystems and improve ambient water conditions countrywide. ▪ Several factors contributing to the underperformance against water quality targets, including inadequate funding and lack of recognition of water quality activities ▪ Main concern about the rural water supply is high levels of salinity, chloride, acidity, nitrate, manganese, and fluoride. ▪ The compliance level in urban WSSAs and rural areas is improving—implying an improvement in water quality supplied in general. This was attributed to the technical support provided to WSSAs and rural water supply schemes to establish efficiency of water treatment chemicals in relation to the quality of water sources.
	Comprehensive fluoride database and maps in fluoride belts Developed	▪ Dissemination of findings and raising of awareness about the use of bone char defluorination technology. According to reports, the GoT distributed 1,695 household defluorination units and constructed 15 Community Defluorination Plants in the Arusha and Manyara regions, which are particularly susceptible to fluoride contamination. According to MoW, the technology has benefited 14,975 citizens by providing them with clean, safe drinking water. ▪ A reconnaissance survey of fluoride levels was conducted by Rural Water Supply and Sanitation Agency in the regions of Arusha, Kilimanjaro, Singida, Shinyanga, Mwanza,	(Not reported)

Specific Interventions	Performance Targets	Results	Evaluation
		Manyara, Geita, and Mara where previous water testing had shown higher levels of fluoride as compared to other regions. The survey sampled 2,594 water sources and generated data that was used to develop the fluoride database and map.	
	Integrated mathematical Water-quality modelling tool to predict the future and analyse site-specific scenarios Developed	(No results reported)	(Not reported)
Rehabilitating existing water laboratory buildings and constructing new laboratories in regions that do not have them	9 existing laboratory buildings rehabilitated	1 laboratory rehabilitated and furnished	(Not reported)
	8 new water laboratories constructed and equipped	6 laboratories constructed, furnished, and equipped	(Not reported)
	5 water quality laboratories accredited	Southern African Development Community Accreditation Services (SADCAS) accredited 7 existing water laboratories	(Not reported)
Developing a water-quality data-management framework including a Laboratory Information Management System (LIMS) and water quality map	Laboratory Information Management System (LIMS) and Water quality map Developed	(No results reported)	(Not reported)
Developing and implementing a Climate Resilient Water Safety Plan	Implementation of climate change adaptation strategy action plan	(No results reported) Evaluated as Climate Change Adaptation and Mitigation Measure – Water Reservoirs and Dam Safety Management, see above	▪ Evaluated as Climate Change Adaptation and Mitigation Measure – Water Reservoirs and Dam Safety Management, see above. ▪ Degradation of the landscape and catchments, as well as water pollution caused primarily by human activities, have remained major threats to Tanzania's WRM. Most key informants expressed grave concern about the deteriorating state of water catchments and the increasing demand for water due to the growing population.
	Water safety plans implemented	▪ A template for a Water Safety Plan (WSP) was prepared and published by MoW as part of the (United Kingdom) Department for International Development (UKAID)-funded project on "Building adaptation to climate change in health in least developed countries through resilient water, sanitation, and hygiene (WASH)."	▪ Climate change continues to be a major threat to the long-term viability of water resources. Adaptation and mitigation efforts such as increasing capture and storage of flood water, increased groundwater recharge infrastructure, reducing production water footprint through various water-use efficiency measures are critical for the water sector

Specific Interventions	Performance Targets	Results	Evaluation
		▪ The MoW supported the development of three Water safety plans (WSPs) for the Dar es Salaam, Songea, and Kahama-Shinyanga water utilities. This included: − Training 104 staff from the regional water utilities on the use of the guidelines. − Pilot tests for urban utilities were carried out at Kigoma Water Supply and Sanitation Authority − Pilots for Community-Based Water Supply Organisation (CBWSOs) were carried out at Mbande CBWSO in Kongwa District and Mkambarani CBWSO in Morogoro District. Implementation of specific projects, such as Sustainable Land Management (SLM) and the Simiyu Climate Resilience projects, that allowed to train basin staff and practitioners on climate resilient WRM.	because they ensure the long-term sustainability of water resources. ▪ There appears to be no long-term strategy for continuing the activities beyond the projects' completion.

Source: Elaborated by authors based on USAID, 2021b.

Annex 7: Cost-Benefit Analysis of selected projects carried out in Wami/Ruvu basin - IWRMDP

Sectoral Projects	Investment	USD in Million	Cost-Benefit Analysis	Distribution of Costs and Benefits
Domestic Water Supply	Rural water supply	183	Monetary benefits of the drinking water projects could only be assessed based on willingness to pay data which were obtained from tertiary sources. Using these data all projects are highly beneficial with EIRRs that would be far above any standard value. This holds true for rural as well as for urban projects and when doing a sensitivity analysis on either costs or willingness to pay the benefits remain very high. Other benefits, that are externalities in the economic analysis, will be the increased opportunities for business including tourism.	▪ The social benefits of provision of drinking water do not need any justification. These benefits are equitable and there are no people excluded. ▪ Environmentally the provision of drinking water should not have any negative impact either. The quantities in the rural areas are limited and will not have any impact on the river flow, higher quantities for the urban areas of Dodoma and Morogoro can easily be supplied by a combination of well fields and the Farkwa dam for Dodoma and following the raising of the Mindi dam in Morogoro. ▪ Drinking water development for DAWASA will be accompanied by the construction of the Kidunda dam which will also a secure environmental flow. Socially the Kidunda dam might have a slight issue since 10 households need to be resettled, the raising of Mindu dam, however, will not result in any displacement.
	Small towns and district	330		
	Dar es Salaam	733		
Water storage	Mindu dam raising (only drinking water)	158.8	The FIRR is not positive according to the feasibility study, but the EIRR would be positive	▪ Review of the various feasibility reports for the raising of the Mindu Dam shows widely different estimates for costs and benefits, therefore there is no confidence in the basic rates available to do any estimates other than for the published feasibility studies for Mandera Dam, Mindu Dam raising, and Kidunda Dam.
	Kidunda Dam (multipurpose)	127	the EIRR would be 10.4%. Other benefits from hydropower, environmental flow, and more regular flow for irrigation abstractions have not been valued.	
Irrigation	76,000 ha (complying with social and environmental safeguards)	370	The costs for the irrigation development are based on the per hectare costs from the Revised Irrigation Master Plan 2018 (NIMP2018). Benefits per hectare were also derived from NIMP2018. Using these data, the EIRR would be more than 25%. This clearly shows a high economic viability for irrigation development.	▪ Socially benefits of irrigation are high as well because most of the rural population is employed in agriculture, 67% in 2014 according to the Ministry of Agriculture.

Sectoral Projects	Investment	USD in Million	Cost-Benefit Analysis	Distribution of Costs and Benefits
				▪ Irrigation will increase production significantly and protect against variation in weather patterns thereby guaranteeing a good income for 9 out of 10 years. ▪ Environmental sustainability is achieved by only developing those irrigation schemes that would allow sufficient flows to remain in the river to cater for domestic water requirements and to maintain a healthy ecosystem. ▪ Additional area might be developed after the storage capacity has been increased through flood protection and multipurpose dams such as Dabalo, Hombolo and Kidunda dams. ▪ Kidunda Dam will also provide a regular environmental flow downstream, additional water abstraction potential for the Mkulazi Irrigation System and, 20MW of installed hydropower capacity.
Hydropower	6 run-of-the-river hydropower plants: ▪ 4 in the Wami Catchment ▪ 2 in the Upper Ruvu Catchment.	69	The six run-of-the-river hydropower plants have a capacity between 1 and 10 MW. Assuming an efficiency of power generation of 80%, a price of 0.05 USD per kWh in line with the Kidunda dam feasibility report, and O&M costs of 2% of the investment annually, the FIRR of these run-of-the-river would amount to approximately 6%. For regional prices for electricity of around 0.10 USD/kWh the EIRR would amount to almost 15%.	▪ The social impact of the hydropower projects is better availability of power in the remote areas near the run-of-the-river plants at an affordable price. On a larger scale it is the availability of electricity at an affordable. No resettlement is required for the run-of-the river plants. ▪ The environmental impact of the run-of-the-river projects is negligible since the water will only be diverted over a short distance and the diverted volumes are only a fraction of the river flow.

Sectoral Projects	Investment	USD in Million	Cost-Benefit Analysis	Distribution of Costs and Benefits
	Mandera Dam	420	Assuming an efficiency of power generation of 80%, a price of 0.05 USD/kWh and O&M costs of 2% of the investment the FIRR would amount to 7.5%. For regional electricity prices of around 0.10 USD/kWh the EIRR would amount to almost 16.9%.	▪ No resettlement is required for the Mandera Dam since the area that will be submerged is in dense forested land only. ▪ The submergence of many trees for the Mandera Dam will need to be compensated. The dam is also located in an area that is indicated as environmentally sensitive for which reason additional environmental screening or possibly and EIA will be needed.
Flood management	▪ Flood retention dams in the upper reaches of Kinyasungwe Catchment ▪ Small dams in the catchments to retain water as well as embankments and spurs for bank protection	1	Flood protection is addressed by flood mitigation and flood early warning systems. Better estimates of costs and benefits will be defined during the mitigation planning. At present there are insufficient consistent data to estimate losses in monetary terms and relate these to river discharges and corresponding floods, even flood risks and inundation zones for specific water levels are not known. The anecdotic evidence indicates that damage is considerable, but it is lumped for all flood events jointly whether localized flash floods or large-scale inundations.	The benefits of better flood mitigation and preparedness will be high, financially, and particularly socially. Environmental consequences of better flood protection and management should be limited, particularly if an integrated combination of hard (grey) infrastructure and nature based (green) solutions will be adopted. The integrated approach of planning also puts particular emphasis on better catchment management, which will reduce water accumulation from sources areas and erosion and its related downstream siltation.
	Nature-based solutions such as improvement and conservation of riparian vegetation and flood buffer areas	0.55		
Catchment management	Improving catchment conditions and better catchment management (catchment management plans)	0.65	It is not possible to evaluate the benefits of the integrated package of measures that will form part of the management plans because: ▪ the current damages are not quantified. ▪ an exact plan with ensuing practical actions and costs will only be defined during the elaboration of the plans. ▪ the interventions will be localized and adapted to the specific catchment conditions.	Most of the budget is for the development of principles and the assessment of current conditions and recommendations and preparing guidelines for activities and sub-activities during the first planning horizon. After that, subsequent planning horizons focus will be on supporting community-based catchment planning and implementation.

Sectoral Projects	Investment	USD in Million	Cost-Benefit Analysis	Distribution of Costs and Benefits
			▪ no standard method exists yet to valuate ecosystem services. The benefits can be very significant though and run into the thousands of USD/. Benefits will be social, environmental, and economic. Economic benefits will be sub-divided into avoided damages and actual direct benefits, for example from nature-based products.	
Hydro-meteorological systems	Hardware of hydro-meteorological systems	0.65	Potential benefits are high and extend to all fields, economic development, social equity, and environmental sustainability. The total costs would amount approximately 4 million USD over the entire planning horizon of 15 years.	▪ The hydro-meteorological data form the core of any forecast and feasibility and impact assessments in the future as well as for the riparian management, for drought and flood mitigation and early warning systems. ▪ Even better cost recovery of the WRBWB is dependent on permitting fees which related to judicious decisions of water allocation, data of river flows are indispensable for such decisions. ▪ Related to flood management, the paucity of information, clearly shows the fundamental importance of upgrading and expanding the hydro-meteorological monitoring systems and the associated planning tools.
	Collecting, storage, processing and sharing of data, better computer connectivity, developing of planning tools and capacity building.	3.35		

Source: Elaborated by authors, MoW, 2020d.