The United Republic of Tanzania
Ministry of Water

Global Water Partnership

WRBWB
WAMI/RUVU BASIN
WATER BOARD

REPORT

Valuing Water in Tanzania: (Re)assessing the Contribution of Water to the National Economy

SDG 6
IWRM
SUPPORT
PROGRAMME

UN environment programme
DHI
UNEP-DHI CENTRE

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Abstract

Water plays a crucial role in our economies, yet we often fail to properly assess its value and contributions to the national economy. This study aims to shed light on the hidden economic added value of water in three of the most important sectors of the Tanzanian economy, namely agriculture, manufacturing, and mining. The study employs market price and proportional production costs functions as the two key valuation methods. The main sources of information used was pulled from the *National Agricultural Census Survey 2019-2020 and the Annual Survey of Industrial Production 2016*. Where nation-wide statistics were lacking, sub-national proxies, primarily from the Wami/Ruvu Basin, were used. The results reveal that the lower bound contribution of water to these three sectors is 4,816,560 million TZS (2,100 million USD), which is the equivalent to 3.31% Tanzania's GDP in 2020. This research serves to illuminate the shadow value added that water brings to each of these sectors, aiming to spark a multi-stakeholder dialogue on the re-evaluation and revaluation of water in Tanzania.

About the Ministry of Water, Tanzania

The Vision of the Ministry is to have a water secure country, where people have sustainable access to sufficient quantity and quality of water to meet human, environmental and economic needs. Our Mission is to ensure water resources are managed and developed sustainably for universal access to water and sanitation services and economic development. The Ministry is mandated to formulate and monitor implementation of policies on Water Resources Management and Development; Rural and Urban Water Provisions; Central Water Laboratory; River Basins Development; Water Quality and Pollution Control; Drilling, Rain Water Harvest and Dam Construction; Water Sources Protection; Sewage and Drainage Development; Performance Improvement and Development of Human Resources under the Ministry; and Extra-Ministerial Departments, Agencies, Programmes and Projects under this Ministry.

The Ministry is currently implementing the giant Water Sector Development Programme Phase Three (WSDP III) which spans from July 2022 to June 2026. The overall Programme Development Objective (PDO) is strengthening sector institutions for integrated water resources management and improving access to water supply and sanitation services through interventions which are in five components namely; Water Resources Management and Development; Water Quality Management; Water Supply; Sanitation and Hygiene; and Programme Coordination and Delivery Support. Water Sector Stakeholders participation is crucial in sustaining and driving the socio economy of our country.

About Wami/Ruvu Basin Water Board

Tanzania mainland is comprised of nine hydrologic basins. Wami/Ruvu Basin is the third smallest basin that embraces about 7% of the area of the country. The Wami/Ruvu Basin is comprised of the Wami and Ruvu Rivers. The basin is located in eastern Tanzania, stretching west to east. The Wami flows from its source in the semi-arid Dodoma region and from the Eastern Arc Mountain ranges of Tanzania to the humid inland swamps in the Morogoro region to Saadani Village in the coastal Bagamoyo district. The Ruvu sub-basin extends from Morogoro to the west of Dar es Salaam through the Coast and Dar es Salaam regions. Waters that run from precipitation eventually flow into the Indian Ocean. The Basin is a main source of water to the capital and commercial cities of Tanzania, Dodoma and Dar es Salaam respectively; and Morogoro City and the whole of the Coastal Region including the historical town of Bagamoyo. The basin serves a population of approximately 11.2 million people.

The Wami/Ruvu Basin Water Board is responsible for protecting, maintaining and conserving water and environmental resources within the boundaries of the Wami and Ruvu River Basin systems in collaboration with various stakeholders in accordance with the Water Resources Management Act No. 11 of 2009 and its Amendments No. 8 of 2022.

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.

About the SDG 6 IWRM Support Programme

The SDG 6 IWRM (Integrated Water Resources Management) Support Programme assists governments in designing and implementing country-led responses to SDG indicator 6.5.1, the degree of implementation of IWRM, as an entry point to accelerate progress towards the achievement of water-related SDGs and other development goals, in line with their national priorities. This is in direct support of the official SDG monitoring and reporting processes, and leads to measurable progress on the relevant SDG targets.

Under the guidance of the UN Environment Programme (UNEP) and coordinated by Global Water Partnership (GWP) in collaboration with UNEP-DHI Centre and UNDP Cap-Net, the Support Programme brings together a unique blend of partners in each country, representing governments, civil society, academia, and the private sector, in the spirit of SDG 17 on Partnerships for the Goals.

Contents

Preface from the Global Water Partnership

Water is one of the most essential elements for all life and activity on Earth. All major civilisations over the centuries have prospered due to their proximity to water bodies that have provided them with plentiful supplies of clean water, enabling vast economic growth, while the absence of water in sufficient quality and quantity has been linked to the collapse of several major civilisations around the world, from the Akkadian Empire in the Middle East to the Mayans in Mexico and Central America and the Tang Dynasty in ancient China.

Despite modern technological advances, water is still as irreplaceable today as it has ever been. It is also a finite resource, and the growing demand for water from all sectors of society is a common threat facing every nation on earth. For those reasons, it is not impossible to imagine that our current civilisations could suffer the same fate as those of our ancestors. The Stockholm Resilience Centre, in its 2022 report on the planetary boundaries framework, found that we have already gone beyond the planetary boundary for green water, and warned that this situation might threaten the relative stability that Earth has experienced over the last few thousand years.

Why is it that our modern society is using and polluting ever greater quantities of water without stopping to consider the limits of that consumption? Many renowned academics and institutions contend that our society is not appropriately valuing water as the finite and irreplaceable element that it is. That undervaluation is both in economic terms, related to the low price often paid for water compared to the significant benefit it generates in productive uses, but also in political terms, where the availability of water in quality and quantity is not factored into decision making around our wellbeing. Nor are the spiritual, cultural and recreational values of water captured in economic or political terms. This situation has led to increased water stress, poor water quality, increased prevalence of floods and droughts, and all of the other water-related manifestations which *do* have major economic impacts.

It is the Global Water Partnership's vision that we can achieve a water secure world, in a way that equitably maximises economic and social welfare, without compromising the sustainability of vital ecosystems. To do that, we must start to value water as the limited resource that it is. The unit by which our modern society measures most things is economic, so while we strongly believe that water should be valued in both economic and non-economic senses, we also recognise that the economic translation of the value of water is perhaps the easiest one for all sectors of society to grasp.

That is why we are delighted to have collaborated, on behalf of the SDG 6 IWRM Support Programme, with our partners at the United Nations Environment Programme, UNEP-DHI Centre on Water and Environment, and UNDP Cap-Net, with the Ministry of Water in Tanzania, in quantifying the economic valuation of water in Tanzania. This study highlights the value of water as an input for three economic sectors, namely agriculture, manufacturing and mining. Despite the fact that few similar studies have been conducted, and the required data were scarce, the results of this methodologically sound study are clear, demonstrating the significant importance of water in Tanzania's current economic activity, at the same time as they suggest that the lack of water would threaten that economic productivity.

It is our sincere hope that this study, by helping to highlight the economic value of water, will contribute to increasing the valuing of water in political and other contexts, in Tanzania, in Africa, and around the world. By doing so, we hope to boost efforts to achieve the Sustainable Development Goals, the Paris Climate Agreement, the Kunming-Montreal Global Biodiversity Framework, and other frameworks which will not be achieved unless water is valued and managed appropriately, as a connector across all sectors.

Alan AtKisson
CEO and Executive Secretary
Global Water Partnership

Foreword from the Permanent Secretary of the Ministry of Water, Tanzania

Sustainable Development Goal number 6 highlights the need to ensure access to water and sanitation for all and is interlinked with most of the other 17 goals. The interlinkage highlights how water is influencing and or is being influenced by other sectors. One of the notable features of water is its influence in supporting both productive and social sectors across the world. This is more evident in Tanzania where the performance of almost all the key productive sectors e.g agriculture, mining, tourism etc is linked to availability of adequate freshwater supplies. In this regard, the economic growth of the country is tied to availability of water.

Although Tanzania is not considered as a water scarce country, it needs to sustainably utilize and manage its water for the benefit of current and future generations while ensuring water security for all in the country. Thus the approaches for addressing the challenges of water resources management and water supply must be comprehensive and integrated. It is in this context that the Water Sector Development Programme (WSDP) was developed as a national framework for addressing challenges and providing mitigations on water resources management, water supply, health and sanitation, institutional and environmental management. This report addresses one of the inherent challenges in water resources management and hence is a contribution towards implementation of WSDP.

In 2020, Tanzania was categorized as a lower-middle economy with agriculture, tourism and mining contributing averagely 26%, 17% and 10% respectively to the national economy. The national aspiration is to scale to the next economic status of middle economy, which will require a sustained growth and expansion of economic activities both in urban and rural areas. As Tanzania grows into middle economic development stature, so do the demands for improved availability of adequate water supply for all productive sectors. Intuitively, one of the primary drivers, and hence contributors to the economic growth of Tanzania is water. However, there has never been a sound study to quantify the contribution of water in the national economy.

The need to quantify the actual contribution of water in the Tanzanian economy gained momentum in 2022 when the Ministry of Water requested technical support from Global Water Partnership Tanzania in undertaking the exercise. The Ministry of Water and Global Water Partnership Tanzania (GWPTZ) have an active Memorandum of Understanding (MoU) covering various areas including capacity building and resource mobilization. Through GWPTZ, we managed to access more expertise at the SDG 6 IWRM Support Programme, facilitated by the Global Water Partnership Organisation in Sweden, and together we successfully accomplished the study, the outcome of which has been shared with partners, including during the UN Water Conference in 2023. We acknowledge support from the Valuing Water Initiative who are leading the global agenda of showcasing the implementation of the UN Valuing Water Principles to bring a solid change in the way water is appreciated and valued in all fronts including policy, practice and financing.

We acknowledge that this was a maiden pilot study on economic valuation of water that targeted three productive sectors i.e. agriculture, mining and manufacturing. Water is a cornerstone resource for many other economic activities. In this regard, we welcome more partners to join us in undertaking the valuation studies for other economic sectors so that we can comprehensively define and state the contribution of water in the national economy. The outcome of the study is expected to bring about informed investment and policy decision in water resources management and development, based on how water significantly contributes to the national economy. Thus, it is my sincere appreciation to the President of United Republic of Tanzania, Minister of Water and all our leaders in Tanzania for their continued support in enabling and nurturing social, economic, and industrial development through sustainable investment and utilization of our valuable water resources.

I once again wish to thank Global Water Partnership and the Valuing Water Initiative for the financial and technical support as well as congratulate development partners, NGO's, private sector, academic and research institutions, the National Bureau of Statistics, all other sectors, individual experts and the Ministry's staff who collectively contributed to the success of the study as well as drafting of this valuable report. I welcome all stakeholders to read and use the report for the sustainable development of Tanzania.

Eng. Mwajuma J. Waziri
Permanent Secretary
Ministry of Water, United Republic of Tanzania

Message from the Director of Water Resources

Water is fundamental to life, sustains the environment and plays a central role in the socio-economic development of Tanzania. The country's water resources form the basis for a diversity of uses including domestic, agriculture, industrial, hydroelectric power, mining, navigation, fishing, tourism and the sustenance of terrestrial and aquatic ecosystem functions. The government is striding ahead with the implementation of an industrialization agenda, food security and energy security plans which will require an increase in water use to meet current and future needs. For example, out of the potential irrigation area of 29.4 million hectares, the government has set a target of reaching coverage of 1.24 million hectares in the year 2025 from the current coverage of 694,715 hectares. Proceeds, services and products from the expanded irrigated area are projected to significantly contribute to the national economy which will have been enabled and facilitated through provision of water resources for irrigation.

One of the critical inputs in all productive sectors that drive the economy is water resources. However, the contribution of water in the productive sectors and the economy at large has never been established as reported in this study. In this regard, as a Directorate of Water Resources, we are proud to have pioneered this work and we look forward to fully maximize the whole package of valuing water principles in Tanzania.

Limited knowledge on the economic significance of water resources has contributed to minimal attention from decision makers, and hence many fundamental challenges have not been adequately addressed over time. It is acknowledged that there are inherent challenges in computing the actual value of water because different stakeholders have varied perceptions and comprehensions on the attributes that describe or inform the value of water. Often, water is perceived to be a social good, always underpriced, and tagged with human right elements. All stakeholders have a genuine claim on water and its use. However we all need to understand and take a bold step to seek the requisite information and new knowledge that will help narrow our difference in opinion and perceptions on this scarce and precious resource while recognizing the fact that water has an economic value in all its competing uses.

It is through our desire and commitments, alongside our partners, that the value of water comes into sharper focus through this study. Preparation of this report went through a number of consultative meetings where sectors, institutions, stakeholders and individuals, had the chance to provide their invaluable contribution which is one of the key principles of valuing water. This report provides new evidence and benchmarks the understanding of value of water and its contribution to the three economic sectors of agriculture, mining and manufacturing industry. This report seeks to bring these initial findings to investment and policy decision makers, as well as other relevant stakeholders, on how water contributes to the national economy, issues of water risks, the costs of its mismanagement and the need for increased investment in water resources management and development.

I urge all to acknowledge the value that water holds in our social life, cultural values and environmental perspectives as well as in economic aspects, in Tanzania and across the globe.

Dr. George V. Lugomela
Director of Water Resources
Ministry of Water, United Republic of Tanzania

Acknowledgements

As part of the *Value Water Initiative*[1] and the technical assistance given to the Ministry of Water in Tanzania, the SDG 6 IWRM Support Programme 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. That was the essence of this study – to establish the contribution of water in the national economy.

A special mention goes to Dr. George Lugomela, the Director of Department of Water Resources in the Ministry of Water for his close guidance as well as Ms. Pamella C. Temu, Assistant Director of Water Resources Planning, Monitoring and Assessment and Eng. Elibariki J. Mmassy, the Basin Water Director of Wami/Ruvu Basin Water Board for their material support, advice and continued oversight during the implementation of this study. Special thanks goes to Dr. Victor Kongo, the Executive Director of GWP Tanzania, who provided invaluable support to understand the local context of the water sector in Tanzania.

Much appreciation goes to the reference team that the Ministry of Water established to guide the study. The reference team comprised of Prof. Henry Mahoo (National Irrigation Commission), Dr. Victor Kongo (Global Water Partnership Tanzania), Dr. Subira Munishi (University of Dar es Salaam, Dr. Hussein Nassoro (Institute of Finance Management), Eng. Hubert Kashililah (Shahidi wa Maji), Eng. Willie Mwaruvanda (Independent Consultant) and Dr. Sekela Twisa, Senior Environmental Officer from the Ministry of Water. Their valuable contribution, wisdom and insight made it possible to steer the study to its conclusion. We also wish to thank Jacques Rey for his technical support. We are grateful to all sectors, institutions, individuals, Ministries' staff and all Basin Water Boards who assisted in ensuring that the study was successfully conducted. Many thanks go to all those who provided valuable data and information to this study.

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1 See https://valuingwaterinitiative.org/.

List of abbreviations

BWB: Basin Water Board

GDP: Gross Domestic Product

GoT: Government of Tanzania

GWP: Global Water Partnership

IUCN: International Union for Conservation of Nature

IWRM: Integrated Water Resources Management

JICA: Japanese International Cooperation Agency

MCM: Million Cubic Meters

MoW: Tanzania Ministry of Water

MW: Megawatt (one million watts)

NBS: Tanzania National Bureau of Statistics

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

VWI: Valuing Water Initiative

WEI: Water Exploitation Index

Key quantitative assumptions

The 2020 GDP of Tanzania was 145,429,645 million TZS[2].

The consumer price index of 2020 for Tanzania was 3.2%[3].

The exchange rate to convert TZS to USD is as follows:

- For 2020: 2,293.49 (TZS/USD)[4] (2020 current prices)
- For 2021: 2,297.84 (TZS/USD)[5] (2021 current prices)
- For 2022: 2,308.89 (TZS/USD)[6] (2022 current prices).

2 MoF (2023). The Economic Survey 2022. Available at: https://www.mof.go.tz/uploads/documents/en-1691583449-THE%20ECONOMIC%20SURVEY%20_2022.pdf

3 Average from January to December reported for Tanzania: https://www.nbs.go.tz/index.php/en/consumer-price-index-cpi/587-annual-headline-inflation-rates-for-some-neighbouring-countries-december-2020.

4 Average daily mean rate reported by the Bank of Tanzania: https://www.bot.go.tz/ExchangeRate/previous_rates.

5 Idem.

6 Idem.

Executive Summary

Key messages

1 Production function approach

2 Replacement or damage cost avoidance

3 Contingent valuation

4 Hedonic pricing

5 Travel cost method

6 Next best alternative method

Water plays a crucial role in our economies, yet we often fail to properly assess its value and contributions to the national economy. Valuation methods and shadow pricing techniques can help reveal the economic value added that water resources bring to economic sectors. Each valuation method has its strengths and limitations, and the choice of method depends on the context, data availability and the objectives of the valuation exercise.

Anticipated return on bean irrigation investment

$1 USD = 11.47 kg output rise

Our quantitative analysis shows that for every 1 USD allocated to bean irrigation during the short rainy season, an estimated output rise of 11.47 kg is projected. Considering the 2020 price of beans at 0.83 USD per kilogram, the anticipated return ratio for bean irrigation stands at approximately 955%. Using productive function as a valuation tool can help reveal where and when the business case for investing in irrigation is the greatest.

0.05%
of total production costs are for water supply and treatment

Water-related expenditures represent a negligible proportion of total production costs in the manufacturing sector in Tanzania. Both supply and water treatment costs account for an average of 0.05% of total production costs in the manufacturing sector. Even in the most water-intensive manufacturing processes, water costs remain proportionally low; for instance, water costs for manufacturing food and beverages represent only 0.104% and 0.914% of their total production costs, respectively.

Contribution of water to agriculture, mining and manufacturing in Tanzania

$2,100 million USD = 3.31% of Tanzania's GDP

The results of this study reveal that a conservative estimate of the contribution of water to agriculture, mining and manufacturing in Tanzania is 4,816,560 million TZS (2,100 million USD), which is the equivalent of 3.31% of Tanzania's Gross Domestic Product (GDP) in 2020. Out of the three sectors considered, the added value of water was found to be highest in the agricultural sector with an estimated 4,614,037 million TZS (2,012 million USD), representing 95% of the total estimated value of water in the three sectors.

Volumetric value of water used

Cattle	Goats	Sheep
$2.34 USD/m^3	$0.95 USD/m^3	$0.49 USD/m^3

The volumetric value of water used for different livestock was estimated at 5,356 TZS/m^3 (2.34 USD/m^3) for cattle, 2,169 TZS/m^3 (0.95 USD/m^3) for goats, and 1,114 TZS/m^3 (0.49 USD/m^3) for sheep. Such volumetric water pricing findings can help inform water allocation decisions, especially in times of water scarcity and drought where water demand restrictions between and within sectors may be needed.

manufacturing

99.7%
of water-related costs are from water treatment

mining

Water treatment costs dominate water-related expenditures in the manufacturing and mining sectors in Tanzania. The analysis of total water-related costs in these two sectors indicates that 99.7% of these costs are attributed to water treatment. This suggests that water supply services, abstraction fees and licensing fees are relatively minimal, particularly when compared to other production costs.

Assessing the overall contribution of water to society should incorporate the economic and non-economic values. As such, the total value of water identified in this study is likely to be a lower limit, as it does not incorporate broader non-economic value to Tanzanian society. Integrating multiple shadow pricing methods and sectoral perspectives can provide a more comprehensive understanding of the true value of water. The Valuing Water Principles and approach are powerful tools to understand and embrace the non-economic value of water.

The need for valuing water

From helping us grow our food, to supporting the transport of goods and services and giving us electricity to power our industries and manufactures, the economic role of water is undoubtedly of vital importance. Many economic activities would not be possible without water, yet water is often under-valued and under-priced. Water-intensive sectors such as agriculture, manufacturing, and mining typically overlook economic externalities and end up paying directly only a fraction of the total costs of water. The economic impacts of systematically underinvesting in water and mismanaging water-related challenges is however becoming increasingly visible. As evidenced through the Global Commission on the Economics of Water, there is now a growing momentum towards revaluing water and rethinking its position within our economic systems, at all levels.

In Tanzania the economic role and contribution of water has also been traditionally underestimated. Based on figures from the *National Economic Survey* (NES), the Ministry of Finance evaluated the economic value of the water sector in Tanzania at 635,959 million TZS in 2020 (277.29 million USD), accounting for about 0.44% of the national GDP[1]. The *National Economic Survey* evaluated the water sector value based on the direct revenues and investments made in water supply, sewage and wastewater treatment. This water sector figure did not consider, however, the added value that is derived from the use of water in other economic sectors, meaning that its full economic value was not captured by such estimates. By focusing on the (often overlooked) added value that water brings to other key economic sectors, this study breaks away from assessing the economic contribution of water through the limited lens of "water sector investments".

Methodological considerations for assessing the economic contribution of water in Tanzania

The objective of this study was to shed light on the unaccounted contribution of water to the Tanzanian national economy, by:

1. Evaluating the economic contribution of water, providing a low-bound economic valuation of the value of water in the agricultural, manufacturing and mining sectors in Tanzania,
2. Offering a methodological reflection on the process and challenges of evaluating the economic contribution of water at the national level, and
3. Suggesting entry points to spark multi-stakeholder discussion and engagement processes towards revaluing water in Tanzania.

While the true economic value of water is not commonly assessed, methodologies exist which facilitate this understanding, even in areas where high quality data are not abundant, such as in Tanzania. After studying these methodologies, our methodological framework followed an iterative process, commencing with the identification of a preliminary set of shadow pricing methodologies suitable for implementation. Subsequently, we delineated the requisite information for each potential shadow pricing technique and proceeded to an extensive data collection phase spanning six months. Based on the data made available, we concluded that "revealed preference" approaches were the most appropriate methodological choice for this study. Leveraging primarily the data from the *National Agricultural Census Survey 2019-2020* (NBS, 2020) and the *Annual Survey of Industrial Production 2016* (NBS, 2018), our calculations were derived employing scale-down methodologies based on production functions and market price valuations. Where nation-wide statistics weren't available, estimations were extrapolated from figures based on the Wami-Ruvu Basin.

1 MoF. (2023). The United Republic of Tanzania: The Economic Survey 2022. Note: the MoF estimates the value of the water sector to 746,403 million TZS in 2021 and to 893,174 million TZS in 2022.

Key results and implications

The analysis reveals that the contribution of water to Tanzania's economy, using estimates limited to the agricultural, manufacturing and mining sectors, is 4,816,960 million TZS (2,100 million USD), which is equivalent to 3.31% of Tanzania's GDP (based on 2020 current prices). Out of the three sectors, the value of water for agriculture had the highest economic contribution. It must be noted that these sectoral valuation estimates are based on production functions that derive the value added based on the proportion that water-related costs represent in terms of total production costs. Since we worked on a proportional costs basis, and that we know that some of those water costs may be affected by market price distortions, we conclude that this figure thus represents the lower bound economic contribution of water in these three sectors.

This analysis has shown that water brings many tangible (and yet often underrepresented) contributions to the national economy in Tanzania. Applying production functions and market-based approaches as well as other shadow pricing methods could be used to raise awareness on the hidden value that water brings to other important sectors such as tourism, construction and the service industry, as well as the economic value of domestic water supply and sanitation (WASH). The more sectors for which such economic valuation exercises are conducted, the closer we would get to estimating the total value of water in the country.

Yet, such valuation exercises should aim to go beyond monetary terms and consider non-economic values of water, such as spiritual, cultural, health, or environmental benefits (VWI, 2020). Since water knows no sectoral or political boundaries, a final implication of this study is, therefore, that reassessing water in Tanzania needs to be guided by a multi-stakeholder engagement process. We hope that this study contributes to sparking renewed cross sectoral engagements and societal dialogues for a greater valuing of water in Tanzania and other countries.

Consolidated results of water valuation for mainland Tanzania (Current 2020 prices).

Sector	Value Added Proportion Derived from Water	National Value of water (Millions TZS/year)	National Value of water (Millions USD/year)	% of GDP
Crops	17.66%	3,871,103	1,687.9	2.66%
Livestock	6.99%	742,934	323.9	0.51%
Subtotal Agriculture	-	4,614,037	2,011.8	3.17%
Manufacturing	0.24%	27,173	11.8	0.02%
Mining and Quarrying	1.78%	175,749	76.6	0.12%
Total Value of Water	**-**	**4,816,960**	**2,100**	**3.31%**
Tanzania’s GDP (2020)	-	145,429,645,000,000	63,409,757,618	-

Note: GDP figures obtained from MoF (2023). Source: Elaborated by authors.

List of tables

List of figures

List of equations

1. Introduction

1.1 Background and rationale

> *"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"*
>
> (Mazzucato *et al., 2023, 20)*

From helping us grow our food, to supporting the transport of goods and services and giving us electricity to power our industries and manufactures, the economic role of water is undoubtedly important. Many economic activities would not be possible without water, yet water is often under-valued and under-priced (Barbier, 2022). Water intensive sectors such as agriculture, manufacturing, and mining typically oversee economic externalities and end up paying only a fraction of the total costs of water (D'Odorico et al., 2020; Das et al., 2023; Ossa-Moreno et al., 2018). The economic impacts of underinvesting in water and mismanaging water related challenges is however becoming increasingly visible. As seen with the Global Commission on the Economics of Water, there is now a growing momentum towards revaluing of water and rethinking its position within our economic systems (Mazzucato, et al., 2023).

In Tanzania the economic role and contribution of water has been traditionally underestimated. Based on figures of the *National Economic Survey*, the Ministry of Finance evaluates the economic value of the water sector in Tanzania to 635,959 million TZS in 2020 (277.29 million USD), accounting for about 0.44% of the national GDP (Figure 1)[7] (MoF, 2023). Official statistical accounts evaluated the water sector economic activities based on revenue and investments made in water supply, sewage, and wastewater treatment, i.a., income from the urban water and sanitation supply services, expenditures towards urban and rural water supply (e.g., borehole drilling, the construction of rainwater harvesting infrastructure, sewage network construction) (MoF, 2023). This water sector figure does not consider however investments made in water resources management nor the added value that is derived from the use of water in other economic sectors, meaning that its full economic value is only merely captured by such estimates. By focusing on the (often overlooked) added value that water brings to other key economic sectors, this study breaks away from assessing the economic contribution of water as through the limited lens of "water sector investments" (as expressed in Figure 1).

7 The 2021 annual accounts estimated the water sector to 746,403 million TZS and 893,174 million TZS in 2022. See details in Annex 1.

1.2 Research objective

This study aims to shed additional light on the unaccounted contribution of water to the Tanzanian national economy by quantifying its lower bound value to three of the most important economic sectors, namely agriculture, manufacturing, and mining. To achieve this aim, a methodology based on production function and market prices valuation was employed, combined with scale-down approaches. The specific objectives of this study are to:

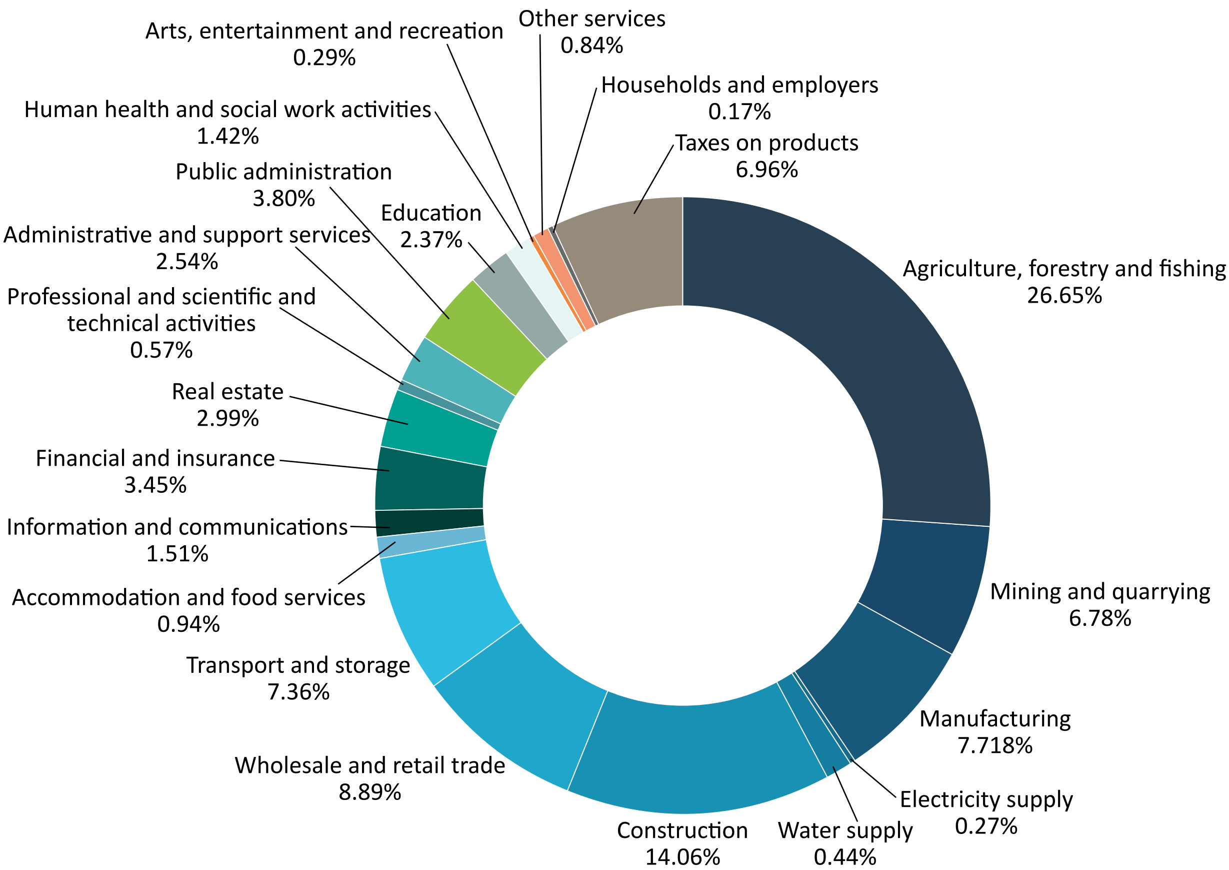
1. Revaluate the economic contribution of water by providing a low-bound economic valuation of the monetary value of water in the agricultural, manufacturing and mining industries in Tanzania,

2. Offer a methodological reflection on the process and challenges of evaluating the economic contribution of water at the national level, and

3. Suggest entry points to spark a multi-stakeholder discussion and engagement process towards revaluing water in Tanzania.

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.

Figure 1. The share of economic activities to GDP in Tanzania in 2020.



Source: MoF (2023).

1.3 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 and Bos, 2004). The overall approach consisted of identifying an initial group of shadow pricing methodologies that could be implemented, determining information requirements, and then collecting the available information. After a data collection period of 6 months, from August 2022 to January 2023, we determined that revealed preference approaches were the best methodological fit for this study. The available information, mainly from the *National Agricultural Census Survey 2019-2020* (NBS, 2020) and the *Annual Survey of Industrial Production 2016* (NBS, 2018), allowed the authors to develop the final calculations based on scale-down approaches of the production function and market prices valuation methodologies.

1.4 Key results

The valuation results reveal that the contribution of water to Tanzania's economy, using estimates limited to the agricultural, manufacturing and mining sectors, is 4,816,960 million TZS (2,100 million USD), which is equivalent to 3.31% of Tanzania's GDP (based on 2020 current prices). Out of the three sectors, the value of water in the agricultural sector is the most significant with the equivalent of 4,614,037 million TZS (2011.80 million USD), followed by the value of water in the mining sector at 175,749 million TZS (76.63 million USD) and finally the value of water in the manufacturing sector 27,173 million TZS (11.85 million USD). These sectoral valuation estimates are based on calculating the water related costs as a total of total production costs and using this proportion to extrapolate its value based on total production value, hence we deem this as the lower bound economic contribution of water.

In addition to those results, this research has derived other key findings, including:

- **The anticipated return ratio for bean irrigation stands at approximately 955%.** A partial quantitative analysis suggests that for each Tanzanian Shilling invested in irrigating bean crops during the short rainy season, there's an expected output increase of 0.005 kg. Translating these findings into 2020 USD values, it indicates that for every 1 USD allocated to bean irrigation during the short rainy season, an estimated output rise of 11.47 kg is projected. Considering the 2020 price of beans at 0.83 USD per kilogram, the expected return ratio for bean irrigation amounts to about 955%.
- **The volumetric value of water used for different livestock was estimated:**
  - 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).
- These findings illustrate that water allocated for cattle consumption yields the highest volumetric value, followed by goat consumption, which generates nearly double the value compared to water consumed by sheep. This underscores the importance of considering such factors in public policy, particularly in scenarios of water scarcity and drought, where decisions regarding water allocation per animal may be influenced by the generated volumetric value.
- **Water-related expenditures are negligible for the manufacturing sector:** Both supply and water treatment costs account for an average of 0.05% of total expenses in the manufacturing sector. Even in the most water-intensive manufacturing processes, water costs remain proportionally low; for instance, water costs for manufacturing food products and beverages represent only 0.104% and 0.914% of their total production costs, respectively.
- **Water treatment costs dominate water-related expenditures:** Analysis of total water-related costs in the manufacturing and mining sectors indicates that 99.7% of these costs are attributed to water treatment. This suggests that water supply services, abstraction fees, and licensing fees are relatively minimal, particularly when compared to other production costs.

1.5 Limitations and interpretation

Water resources information is not centralised in a single source (e.g., Ministry of Water Resources or the National Bureau of Statistics). General information on the water sector is compiled in various government reports, which have been commissioned in different years and presented in a diversity of formats. As such, no data is collected systematically and periodically, which is essential to implement any valuation methodology and manage water resources appropriately and successfully (Pandeya et al., 2016). 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 point of reference when basin-level calculations and estimates were needed.

It must however be noted that these results do not include the valuation of water in other important economic sectors such as construction, trade, tourism, and services, nor do they other essential use values such as self-consumption for households and non-use values that are essential for communities and individuals. Additionally, these estimates do not consider non-economic values of water, such as spiritual, cultural, health or recreational purposes (VWI, 2020). This means that if further efforts were to be made to refine and expand this quantitative exercise, the estimated added value of water would only increase. This allows the authors to conclude that water plays a much more important role in the economy than what is otherwise reflected in official accounts.

1.6 Structure of the document

Chapter 2 explains in detail the overall methodological approach employed by this study, including the limitations faced with respect to available data and information. Chapters 3, 4, and 5 detail the valuation equations and results for the estimated value of water in agriculture, manufacturing, and mining. Chapter 6 provides a conclusion and discussion on the implications of this study and suggests recommendations for future water valuation research in Tanzania.

2. Methodology

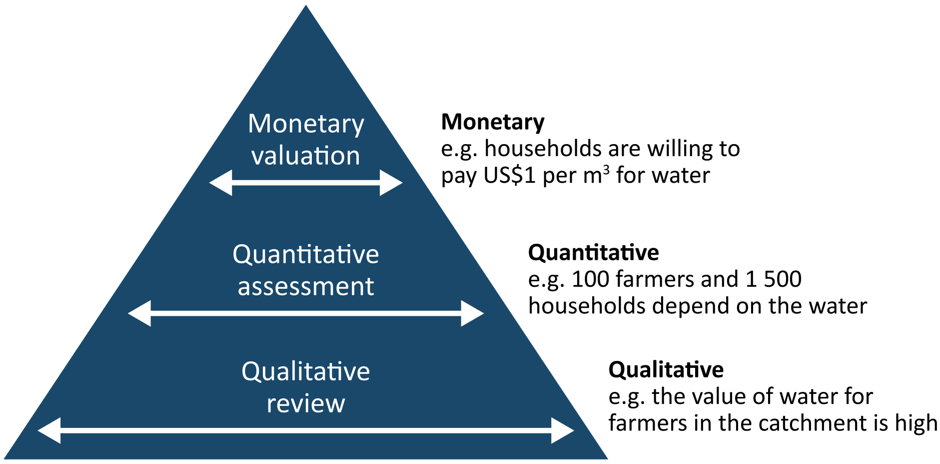
2.1 Methodological approach

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 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, Preface).

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 scale-down approaches. This methodology uses information from solid national sources and interprets them as market signals.

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 should 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 (Figure 2).

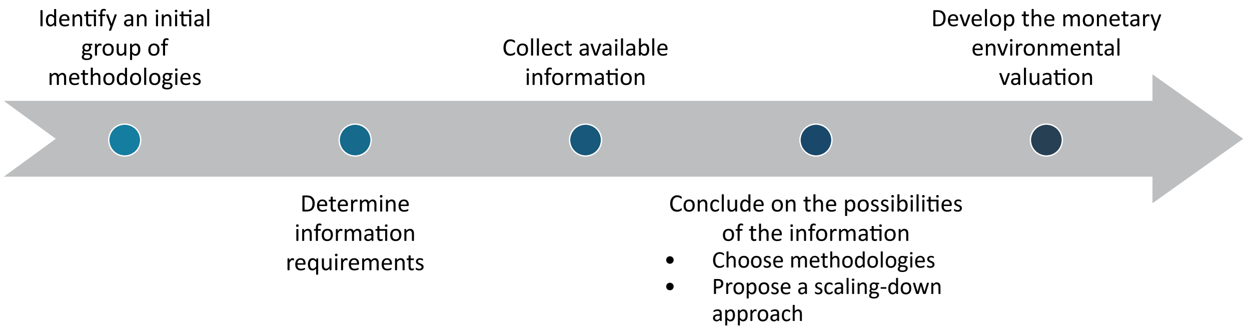
Figure 2. Methodological framework to carry out a water valuation.



Source: United Nations (2021).

It was agreed with the Ministry of Water that the value of water would be determined for three sectors - industry, agriculture, and mining - which represent an important share of Tanzanian economy (Figure 1). 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 3).

Figure 3. Process to choose the water valuation techniques for each economic sector.

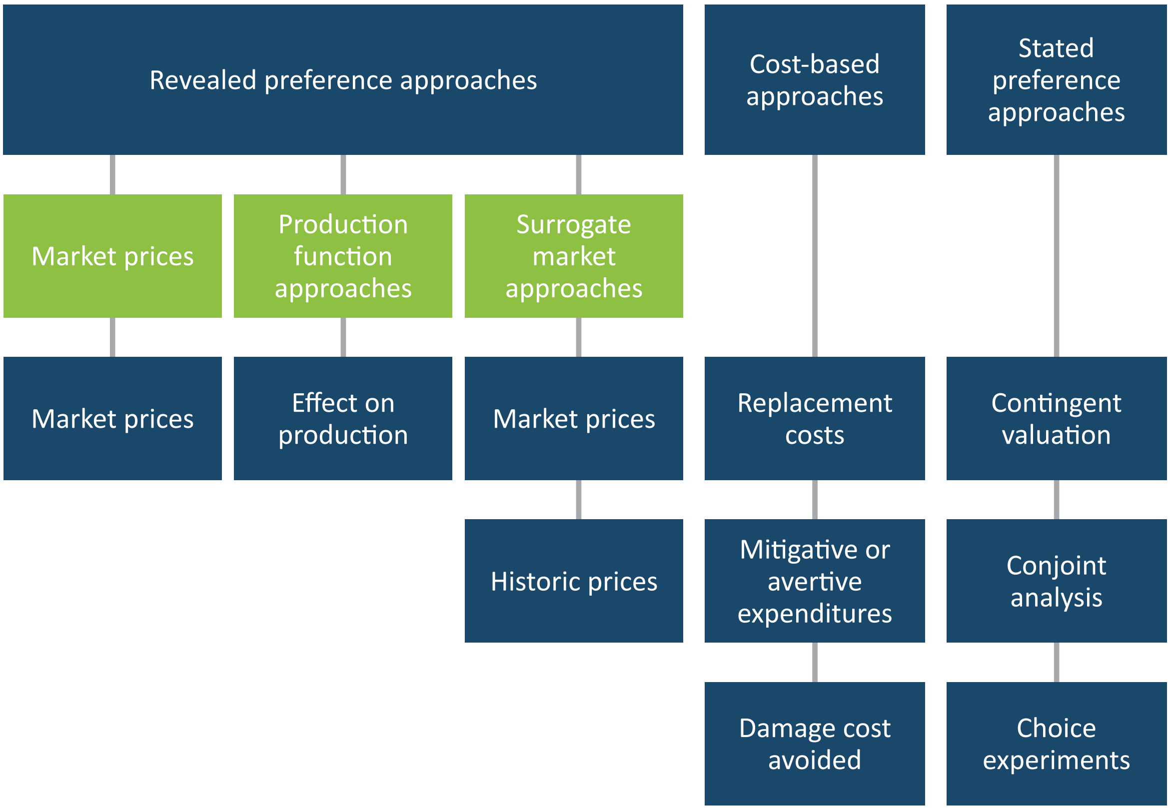


Source: Elaborated by authors.

2.2 Identification of an initial group of methodologies

To identify the initial group of methodologies, it is 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 document *Value, Counting Ecosystems as Water Infrastructure* (Emerton and Bos, 2004) which identifies a group of relevant methodologies (Figure 4).

Figure 4. Environmental techniques for water valuation.



Source: Emerton and Bos (2004).

The selection of the valuation methodologies is also based on a maximisation rationale to obtain the best possible outcome with the available information. Thus, due to time and budget constraints, water valuations rely entirely on secondary information. Consequently, the initial group of valuation methodologies do not include any stated preference techniques as they 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 are:

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

2.3 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 water usage; and specific information for manufacturing, agriculture, and mining sectors. 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.

2.4 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), presents 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.
- *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].

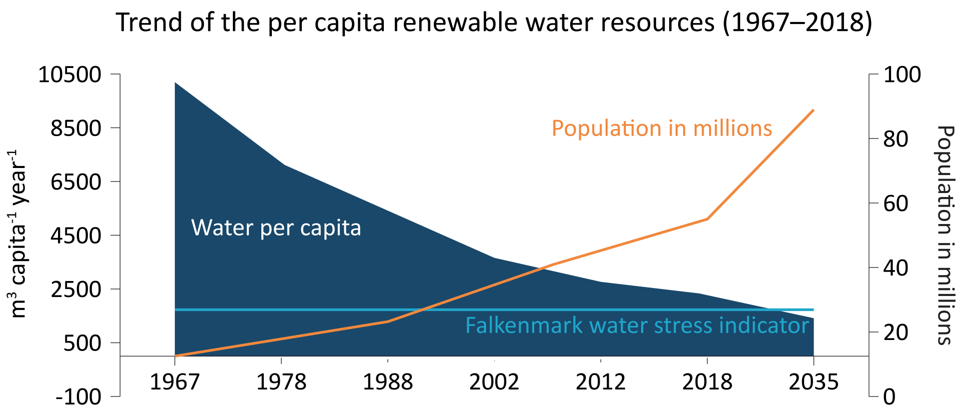
Official documentation and statistics related to water resources are, however, not harmonised which limits the range of valuation methods that can be employed. One of the major limitations with current water-related datasets is that they use different baseline years, sources of information, and methodologies to calculate water indicators (e.g., water stress, water balance, etc.). For example, the *Water Sector Status Report 2015-2020*, 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 m^3/cap/yr, which is above the Falkenmark Water Stress Indicator of 1700 m^3 /cap/yr (Figure 5).

In contrast, the *Water Resources Factsheets*, also developed by the MoW, show the same amount of annual renewable water resources for 2015 but an average of 2,250 m^3/cap/yr, implying a population decrease or an increase in annual renewable water resources in 2018. Moreover, the *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 m^3 /cap/yr, using information from FAO statistics (USAID, 2020, 9).

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.

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

Figure 5. Tanzania per capital annual renewable water resources trend as population increases from 1967 to 2018.



Source: MoW (2020b, 33).

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 (BWB).

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 1).

Table 1. 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, 2020, 10).

2.5 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 which can be used to derive water valuations in the three sectors of interest:

- **Agriculture:** The sector that has the best information is agriculture, mainly contained in the *National Agricultural Census 2019 – 2020* (NBS, 2021). Final reports are publicly accessible through the National Bureau of Statistics' website. In addition, there is public access to the survey's anonymised 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, 2018) is an important source of consolidated data. Nonetheless, there is no access to anonymised 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.

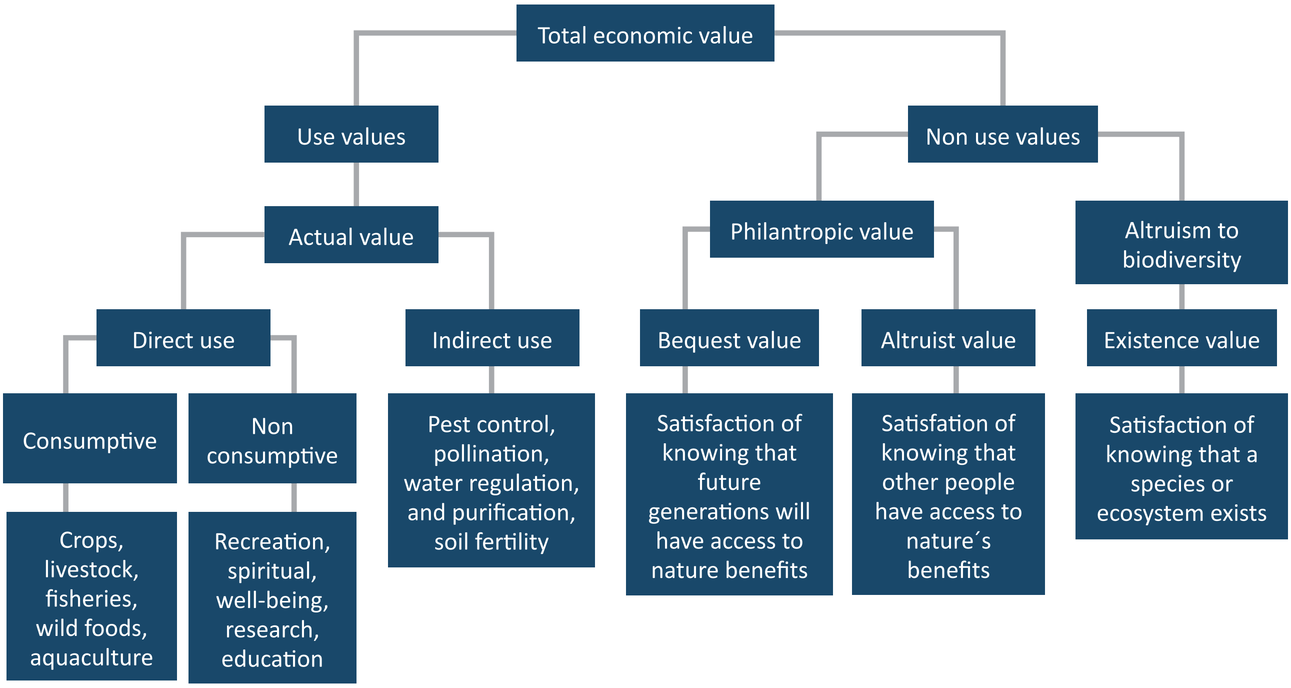
Based on these considerations, a specific methodological approach for developing the environmental valuation of water for each sector is carried out. This includes explaining technical assumptions to select the initial methodology, modifications made to the methodology in line with the available information, and the technical arguments supporting these decisions. The present valuation exercise is understood as a starting point for Tanzania to continue developing a broader study. Thus, documenting this process in detail will allow building on the results achieved.

2.6 Methodological 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 Total Economic Value Framework is a commonly used conceptual model that helps differentiate between the different values and develop economic valuation of the environment (Pearce and Pretty, 1993). Figure 6 demonstrates two main groups of values: use value and non-use value, distinguishing between ecosystem services an individual makes use of and those which are not dependent on any type of use (Freeman III et al., 2014). Consider the direct consumptive use of irrigated crops and the existence value of a delta ecosystem.

For informed decision-making recognising the impact of water uses on economic and social prosperity, total economic value, regardless of how it is divided between use and non-use values, is important (Freeman III et al., 2014). It is important 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.

Figure 6. Total Economic Value Framework.



Source: TEEB (2010).

The authors used the methodological framework proposed by (Emerton and Bos, 2004) to choose the best possible valuation methodologies to quantify the contribution, but 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.

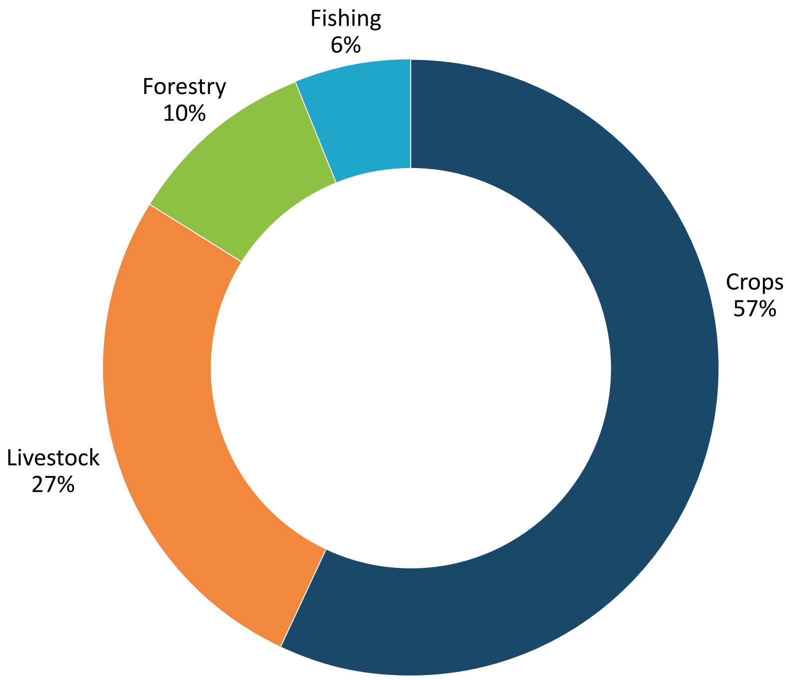
The latter means that the quantitative results of this study will be the lowest quantifiable bound of the value of water in Tanzania, and this means that if further efforts were to be made to refine this quantitative exercise, the value of water would only increase.

3. Valuation of Water in Agriculture

3.1 Introduction

Agriculture is the main economic activity engaging about 65% of the population and contributing 26.7% of the GDP in 2020 (see Annex 1). This sector is divided into crops, livestock, forestry, and fishing (Figure 7). Crop and livestock subsectors represent 84% 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 authors chose to cover as much as possible with the best available information.

Figure 7. Agriculture subsectors 2020.



Source: MoF (2023).

Based on the available information from the crop component of the *Agricultural Census Survey 2019-2020*, the production function methodology was implemented, concluding that its initial results required a scaling-down approach. Another scale-down approach inspired by the production function methodology was used for the valuation of the livestock subsector as it did not have the same information as the crop subsector.

The water valuation of these two subsectors estimated to 4,614,037 million TZS (2,011.80 million USD) or 3.17% of the GDP of Tanzania in 2020. The results of implementing these two calculations showed that water in the crop subsector contributed nearly 3,871,103 million TZS (1,687.87 million USD) and 742,934 million TZS (323.93 million USD) for the livestock subsector (in 2020 current prices).

A partial result that the authors obtained from the only production function they considered quantitatively acceptable was that for every TZS that was spent on irrigation for beans crop in the short rainy season, an increase of output of 0.005 Kg would be achieved. In 2020 USD figures, this meant that for every 1 USD spent on beans crop irrigation during the short rainy season, the output would increase by 11.47 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 4) because it used statistical data of a marketed good and the inputs that it required (Tinch et al., 2019). 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 is taken from the *National Agricultural Census Survey 2019-2020*, specifically from anonymised microdata available online at the National Bureau of Statistics website (NBS, 2020). 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 enquiries about infrastructure product processing, 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 are 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.

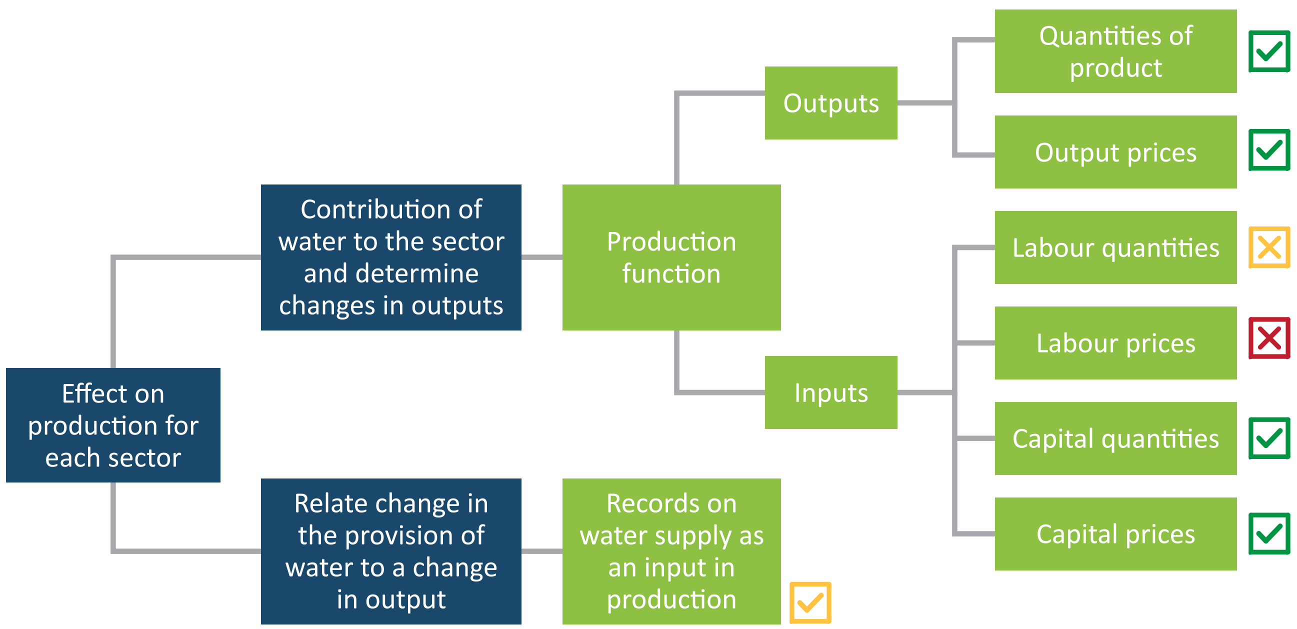
The information on crops (NBS, 2020) is presented seasonally as follows:

- **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 is selected based on information from the *National Agricultural Census Survey 2019-2020*. Figure 8 shows the information requirements of this methodology; on the right side, it is concluded whether each requirement is met.

Figure 8. Analysis of information requirements for production function methodology.



Source: Elaborated by authors based on Emerton & Bos (2004).

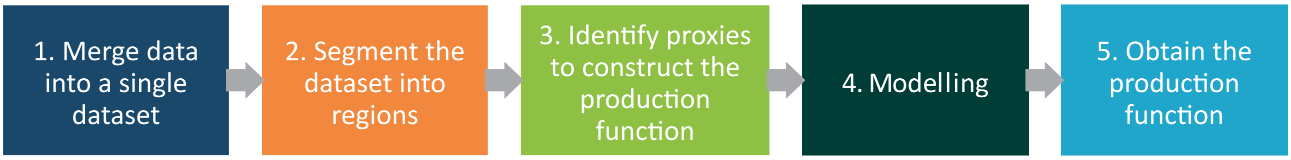
In terms of outputs, the census contains information on quantities and sale prices for each crop. Regarding water as a production input, the survey enquires about the cost of irrigation but not about average water consumption. Even though the survey does not detail specific labour costs[10], some variables make it possible to conclude whether household members work in growing crops. Finally, the authors observed that the survey contained information on capital costs associated with other production inputs (e.g., preparation, agrochemicals).

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, 30). Therefore, this methodology is the best possible option from a technical perspective to the extent that it will 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 9).

Figure 9. 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[11] 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.

Therefore, it was proposed that the best alternative was to assume the entire area of the regions that make up the basin (Dodoma, Morogoro, Pwani, Tanga Dar Es Salaam, and Manyara) as representative. 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 to. 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 (see Equation 1):

Equation 1. Functional form of the production function.

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

Where:

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

10 The labour costs mentioned here refer to the ones that take place during planting, preparation, weeding control, cultivation, transportation, irrigation and harvesting.

11 Statistical Package for the Social Sciences. Software from IBM.

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)[12].
- 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 reported the cost of irrigation per season but did not specify the amount of water given to the farmer. The irrigation cost was reported in TZS per season, but neither the survey nor the final report of the Census defined what the cost entailed.
- 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 kilogrammes: 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, and 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 kilogrammes.
- **Independent variables:**
  - > **Capital:** Continuous variable in 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. This was done 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 was also worth noting that the census reported 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 3).

Table 2. Crops chosen to calculate the value of water in the crop subsector.

Option 1: Main crops identified for smallholders.	Option 2: Group all crops present in the census according to subcategories.[13]
• Maize	• Cereals
• Paddy	• Legumes
• Beans	• Fruits
• Sunflower	• Vegetables
• Pigeon Pea	• Permanent cash crops
	• Permanent crops

Source: Elaborated by authors.

12 The definition of the used variables can be obtained from https://www.nbs.go.tz/tnada/index.php/catalog/31 using the variable codes indicated.

13 Categories mentioned in National Sample Census for Agriculture 2019- 2020, smallholders' questionnaire.

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[14].
- The significance[15] of the variables, especially the irrigation cost.

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

- Not all crops had the same information. For example, some registries did 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 led to the conclusion 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 considered it necessary to show the production function for beans crop results as some important conclusions could be drawn. Thus, Table 3 indicated that the function was acceptable quantitatively because its adjusted R^2 was close to 1, and the irrigation cost variable was significant within the model.

Table 3. Summary of the model for beans.

Model	R	R^2	Adjusted R^2	Standard Error	
Beans	0.993a	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.

14 "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 R^2 lies between these values" (IBM, 2023a).

15 "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).

Thus, the production function presented in Table 3 for the beans crop would have the following quantitative representation (see Equation 2):

Equation 2. Production function for beans.

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

Where:

- ***Q***: Quantitative variable indicating 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 represented how much money the household expended on irrigation (operation and equipment) for that crop during the short rainy season.

Results from this production function revealed that for every TZS spent on irrigation for beans crop in the short rainy season, an output increase of 0.005 Kg would be achieved. In 2020 USD figures, this meant that for every 1 USD spent on beans crop irrigation during the short rainy season, an increased output of 11.47Kg was estimated. Based on the price of beans in 2020 of 0.83 USD/Kg[16], the expected return ratio of beans irrigation was about 955%. The results of this analysis for beans suggested that investments in irrigation could improve physical and economic crop productivity.

3.3 Valuing water for crops through a scaling-down methodology and analysis

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 for a broader valuation of water in the entire crop subsector. A scale-down approach is a simplification of a well-defined methodology adapted to the available information, which however aims to keep the structure and logic of the original methodology in place so that a broader interpretation can still be derived (Möller Gulland et al., 2020).

This scaling-down approach employed is based on the principles of the production function methodology and uses National Agricultural Census microdata to produce an alternative simplified model of the value of water in crop production. Two main simplifications are performed in our valuation of water the crop subsector: (1) we rely on data from small farmers as representation of the crop subsector, and (2) the proportion of income related to water is calculated for specific indicative crops and applied to the larger crop categories they belong to. Our scaling-down 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 if 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 their crop. The latter is consistent with what is considered in (Perman et al., 2003) that in some cases, production function approaches can be implemented following principles of avertive 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.
- Considering that the *National Agricultural Census 2019 – 2020* contains no variables that report neither water quantity or quality consumed by the farmers, using the data from the Census is still 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 a 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.

16 The United Republic of Tanzania Ministry of Agriculture Agricultural Marketing Section Monthly Market Bulletin August, 2020. Available at: https://www.kilimo.go.tz/uploads/dasip/Monthly_Market_Bulletin__Aug_2020_FINAL.pdf.

- 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.

3.3.2 Steps and analysis using the scaling-down methodology

The quantitative representation of the scaling-down process is (see Equation 3):

Equation 3. Value of water per crop.

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

Where:

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

The proportion of income related to water is calculated as follows (see Equation 4):

Equation 4. Proportion of income related to water.

$$\mathrm{Wp}_{Cn} = \frac{IC_{Cn}}{IC_{Cn} + C1_{Cn} + \ldots + CN_{Cn}} \times 100$$

Where:

- $\boldsymbol{Wp_{Cn}}$**:** Proportion of income related to water in %
- $\boldsymbol{IC_{Cn}}$**:** Irrigation cost per hectare of crop *n* incurred by the farmer during a harvesting season in TZS/ha
- $\boldsymbol{C1_{Cn}}$**:** First cost per hectare of crop *n* incurred by the farmer during a harvesting season in TZS/ha
- $\boldsymbol{CN_{Cn}}$**:** Cost N 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 anonymised microdata for the same group of regions used to calculate the production functions.

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 a bucket (in terms of registries, 51.0% short rainy season, 45.7% long rainy season, 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.

The authors did not analyse all crops, only those with the most significant planted area (80% of the area planted), which is why Table 4 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 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 4 are considered a representative sample of the region's reality. This approach requires retrieving information from anonymised microdata, the census sample. Consequently, the results are a sample of the reality of the geographical area analysed.

Table 4. Planted area by crop type and season.

Short Rainy Season			Long Rainy Season			Permanent Crops		
Crop	Area (ha)	Aggregated %	Crop	Area (ha)	Aggregated %	Crop	Area (ha)	Aggregated %
Maize	14,581	58.7%	Maize	19,075	38.3%	Cashew nut	1,630	32.3%
Paddy	2,015	66.8%	Paddy	9,250	56.9%	Cassava	702	46.2%
Beans	1,886	74.4%	Sunflower	3,860	64.7%	Orange	435	54.8%
Cassava	1,547	80.6%	Sorghum	3,557	71.8%	Banana	429	63.3%
			Beans	2,325	76.5%	Coconut	395	71.1%
			Groundnut	2,253	81.0%	Sugarcane	236	75.8%
						Mango	231	80.3%

Source: Elaborated by authors based on anonymized microdata from NBS (2021b).

Table 4 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 4 suggests that for the two rainy seasons, the two main crops are maize and paddy, and the third crop is different for both. Permanent crops are more heterogeneous and have in main place cashew nut and cassava.

Cost information for all crops recorded in Table 4 was collected from the anonymised dataset, finding out that there was no cost information for some of them, namely:

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

For the following crops only unit cost information was reported, requiring unit analysis:

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

Moreover, it is worth mentioning that unit costs were reported by season, short rainy and long rainy seasons. 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 reported 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. The information in Table 5 shows a consolidated amount of area reported by the anonymised 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 5. 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 anonymised microdata from NBS (2021b).

The weighted average of costs was then calculated based on the following logic (see Equation 5):

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 6 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, labour, taxes, and storage, as well as some others are not included. This fact must be considered when interpreting results. Nonetheless, the validity of the calculation maintains as the proportion of water costs incorporates data from a national information source with high credibility. Table 6 shows the average costs per hectare for each crop and adds them to calculate later the proportion of income related to water based on the Equation 4.

Table 6. 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 6 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, (see Annex 1), this proportion is equivalent to an average ranging from 11.5% to 24.5%. Considering previous findings, the following group of assumptions will allow the information on these three crops to be extrapolated to the entire crop subsector:

- The grouping of crops used in *National Sample Census for Agriculture 2019-2020*, that is, cereals, tubers and roots, pulses, oil seeds and nuts, fruits and vegetables, cash crops, and other crops (see Annex 2) 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, roots and tubers use average results for maize and paddy (12.1%).
- Pulses, oil seeds and nuts, fruits and vegetables use results for beans (24.5%).
- Cash crops and permanent crops use the average results from the previous groups (cereals, tubers and roots, cash crops, and permanent crops) (18.3%).

Consequently, it 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 7 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 rainy and long rainy seasons, as well as for permanent crops.
- **Amount harvested:** The amount of each crop harvested 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, as well as permanent crops (see Annex 2). 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 anonymised 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 as 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 as of 2020.

Table 7 shows that the annual value of water in analysis for the crop subsector is about 948,146 million TZS. This amount is equivalent to 17.66% of the income generated by those crops in the period analysed.

Table 7. Calculation of value[17] 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

17 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)
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
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 7, specifically the income with statistics from the Gross Domestic Product for 2020 (Table 8). The calculations developed by the authors conclude that income derived from crops in the study area corresponds to about 5,368,178 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 (21,920,177 million TZS), corresponding to 15.1% of the GDP in 2020.

This calculation was made for what was produced in 6 regions (Dodoma, Morogoro, Pwani, Tanga Dar Es Salaam, and Manyara) in the crop 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 8. GDP by kind of economic activity (Current prices 2020).

ECONOMIC ACTIVITIES	2020 (TZS Million)	2020 (USD Million)
Agriculture, forestry, and fishing	*38,760,377*	*16,900*
Crops	21,920,177	9,558
Livestock	10,622,499	4,632
Forestry	3,720,575	1,622
Fishing	2,497,126	1,089
Industry and Construction	*42,549,256*	*18,552*
Mining and quarrying	9,867,293	4,302
Manufacturing	11,207,276	4,887
Electricity supply	398,084	174
Water supply; sewerage, waste management	635,959	277
Construction	20,440,644	8,912
Services	*53,994,408*	*23,542*
Wholesale and retail trade; repairs	12,931,133	5,638
Transport and storage	10,701,520	4,666
Accommodation and Food Services	1,371,161	598
Information and communication	2,196,753	958
Financial and insurance activities	5,013,181	2,186
Real estate	4,348,618	1,896
Professional, scientific, and technical activities	822,440	359
Administrative and support service activities	3,692,864	1,610
Public administration and defence	5,530,738	2,411
Education	3,440,525	1,500
Human health and social work activities	2,060,600	898
Arts, entertainment, and recreation	416,049	181
Other service activities	1,217,190	531
Activities of households as employers;	251,635	110
All economic activities	**135,304,041**	**58,995**
Taxes on products	10,125,604	4,415
GDP at Market Prices	**145,429,645**	**63,410**

Source: MoF (2023).

We assumed 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 Equation 6):

Equation 6. National value of water for the crop subsector.

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

Where:

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

By substituting the values in Equation 6, the following result was obtained:

$$NA_{Cwv} = 21,920,177 * 17.66\%$$

$$NA_{Cwv} = 3,871,103,258,200\ TZS\ (1,687,865,767\ USD)$$

Applying this value to the GDP, the value of water for the crop subsector corresponds to 2.66% of the GDP in 2020.

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 4) 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.

Because this scale-down approach was done on a volumetric basis, an additional finding was realized regarding the unit value of water, meaning that each cubic meter of water consumed by the livestock generated 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 generated the most income per volume of water, followed by goats, which generated 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 based on the income that it generates.

The following section details calculations made to estimate the value of water for the livestock subsector, including the data used and the methodology employed.

3.4.1 Data sources

The *Smallholder National Agricultural Census Survey 2019-2020* has a robust livestock[18] 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 does not include the following:

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

18 Survey includes information on other types 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.

3.4.2 Rationale for applying market prices methodology for valuing water for livestock

After analysing the information available for this subsector, the first conclusion was that it was 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 4, 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.
- 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 were 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) presented 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 because using it as a reference allowed the authors to use what had been done in Tanzania regarding water valuation.

The approach proposed by IUCN (2005) looked 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 gave a volumetric economic valuation of consumed water per animal.

Based on this rationale, the authors from the IUCN (2005) study interpreted water value as the income it generated for the livestock subsector. This interpretation is consistent with the market prices methodology presented in the methodological framework that this consultancy adopted (Figure 1).

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 was essential to make the following considerations:

- *The National Agricultural Census Survey 2019-2020* quantified all the livestock in Tanzania and recorded 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.
- Some data was not available at national level, e.g., average sale price per head, in which case we used estimates from the Wami/Ruvu basin, which comprised the regions of Dodoma, Morogoro, Pwani, Tanga, Dar Es Salaam, and Manyara (see Annex 3).
- Most of the income from the livestock subsector was derived from milk production, the rest of the income was generated by animals that are sold off in a year, i.e., a subset of the herd.
- Only a portion of the entire herd generated income for the farmers (e.g., not all livestock could be milked, and not all was bought or sold).
- The scale-down approach proposed by the authors was made on a volumetric basis of water consumed by the animals. So, it was essential to note that the water required to generate income equated to the water that the entire herd consumed.
- Not all livestock in Tanzania generated income, but regardless of this, it consumed water.

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

Equation 7. Value of water for the livestock subsector.

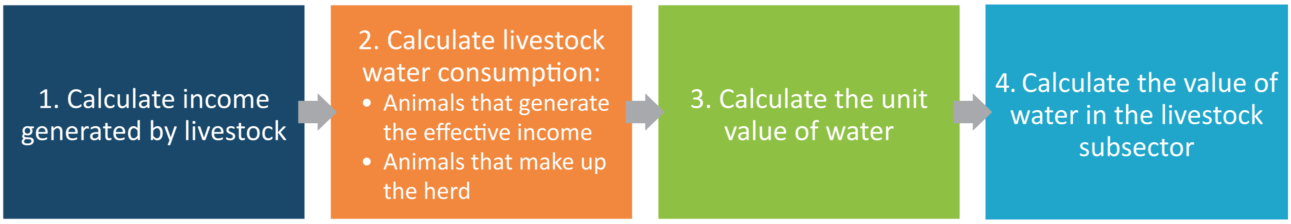
$$VWA_L = U_{WL} * CW_{Ei}$$

Where:

- ***VWA**$_L$*: Value of water for the livestock subsector
- ***CW**$_{Ei}$*: Consumption of animals that generate income (m^3/year)
- ***U**$_{WL}$*: Unit value of water (TZS/m^3)

The authors proposed the following steps (Figure 10) to develop the scale-down approach embodied in Equation 7:

Figure 10. Process followed to calculate the value of water in the livestock subsector.



Source: Elaborated by authors.

- **Calculate income generated by livestock:** In this first step, the authors calculated the income generated by the livestock subsector. This calculation considered the income resulting from selling milk and buying and selling livestock.
- **Calculate livestock water consumption:** In the second step, the authors calculated the water consumption that is composed of the following two groups of livestock:
  a. Animals that generate the effective income
  b. Animals that make up the herd.
- **Calculate the unit value of water:** In this third step, the authors calculated the unit value of water by taking the total income generated by the livestock subsector and dividing it by the total water consumption of the herd.
- **Calculate the value of water in the livestock subsector:** In the fourth step, the authors calculated 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 generated the effective income. This is to say that the economic value of the water consumed by the livestock only monetises 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 (see Equation 8):

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:** 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**: 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/herder 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):

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 9 shows the result of this calculation.

Table 9. Calculation of effective income in TZS (Current prices 2020).

	Cattle	Goat	Sheep
($O_S - I_P$) (Animal /year)	549,536	752,977	144,368
P_A (TZS/Animal)	433,245	38,250	41,271
E_i (TZS/year)	238,083,488,805	28,801,219,655	5,958,258,888

Source: Elaborated by authors using data retrieved from NBS (2023).

A smallholder farmers' 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 9 shows the result of this calculation.

Table 10. Milk income calculation in TZS (Current prices 2020).

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

Source: Elaborated by authors using data retrieved from NBS (2023)19.

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 type 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 (Table 10) and the livestock named effective income (Table 9). This can be further explained by the figures presented in Table 11 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 11. Livestock figures for the WRB according to the National Agricultural Census 2019 – 2020.

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

Source: Elaborated by authors using data retrieved from NBS (2023).

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 by grouping the results of Table 9 and Table 10 (Table 12).

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

Table 12. *Calculation of livestock income (Li) in TSZ.*

	Cattle	Goat	Sheep	Total
E_i (TZS/year)	238,083,488,805	28,801,219,655	5,958,258,888	272,842,967,347
(Mi) (TZS/year)	934,530,492,766	10,204,903,715	-	944,735,396,481
Livestock Income (Li) (TZS/year):	**1,172,613,981,571**	**39,006,123,370**	**5,958,258,888**	**1,217,578,363,828**

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 they have a herd. Their 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 (CW_{Ei})**: Total water consumed by animals that generate effective income, that is, ($O_S - I_P$) (Table 13). 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 (CW_C)**: Total water the herd consumes 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 13, and is done by multiplying the water consumption per animal by the number of animals that comprise each of the two water consumption groups mentioned above.

Table 13. *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 in one year by the amount of water that the livestock herd would consume in one year. The quantitative exposure of this calculation is as follows (see Equation 10):

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

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

The calculation indicated in Equation 10 was made for cattle, goats, and sheep and is presented in Table 14.

Table 14. Calculation of the unit value of water for the livestock subsector (Current prices 2020).

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

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 (CW_{EI}) (Table 13) is representative of both of the income streams for livestock (buying and selling livestock and selling milk). Thus, Table 15 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 15 shows the result of applying Equation 7 to Cattle, Goats, and Sheep. The value of water of the total livestock subsector is estimated at 85,152,483,765 TZS/year (37,129,875 USD).

Table 15. Value of water for the livestock subsector.

Item	Cattle	Goat	Sheep	Total
Consumption of animals that generate effective income. CW_{Ei} (m³/year)	15,043,548	1,923,856	368,860	
Unit Value of Water (U_{WL}) *(TZS/m³)*	5,356	2,169	1,114	
Value of Water for the Livestock Subsector (VWA_L) (TZS/year)	**80,573,243,088**	**4,172,843,664**	**410,910,040**	**85,156,996,792**

Source: Elaborated by authors using data retrieved from NBS (2023).

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

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 on a proportional basis (VWA_L/Li). 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 in 2020.

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

Where:

- $\boldsymbol{NA_{Lwv}}$: National value of water for livestock subsector in Tanzania 2020
- $\boldsymbol{L_{GDP}}$: Value of Tanzania's GDP for the livestock subsector in 2020
- $\boldsymbol{P_{Lwv}}$: Proportion of value of water for livestock subsector in 2020

By substituting the values in Equation 11, the authors obtained the following result:

$$NA_{Cwv} = 10{,}622{,}499{,}000{,}000 * 6.99\%$$

$$NA_{Cwv} = 742{,}933{,}793{,}947\ TZS\ (323{,}931{,}560\ USD)$$

When comparing this value to the GDP, it is concluded that the value of livestock water corresponds to 0.51% for 2020.

3.5 Conclusion

The value of water in the agricultural sector was calculated using different methodological approaches, which for 2020 equated to approximately 4,614,037 million TZS (2011.80 million USD). The crop subsector used a scale-down approach of the production function methodology, obtaining a value of 3,871,103 million TZS (1,678.87 million USD) in a year for Tanzania. The livestock subsector used an approach inspired by the market price methodology, obtaining a value of 742,934 million TZS (323.93 million USD). Both results equated to 3.17% of Tanzania's 2020 GDP. These results were the lowest quantifiable bound of the value of water in the agricultural sector in Tanzania, and this meant 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 incurred for irrigation, and no information on water consumption was used. Conversely, the livestock water valuation used volumetric proxies and did not use any information regarding the cost of water. The result from the crops subsector was then derived from how much the cost of water for irrigation represented from the overall costs of each crop, and the result from the livestock subsector was determined based on the amount of income generated by each unit of water.

Both results expressed in economic terms, have different backgrounds, and their interpretation can bring different considerations for public policy. The results from the crop subsector allow policymakers to understand how a modification to the current water price (e.g., increasing water tariffs or subsides on irrigation technologies) could affect farmers' cost structure and production. 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. Such comparison can be used to identify the water allocation regimes based on a comparative use efficiency of different sectors. Therefore, these two results can become essential tools to inform national and basin-level policy discussions on the value of water and how this value is translated into the price of the resource.

In terms of the methodological implications of these results, it must be noted that 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. However, neither of these documents reports water consumption. We believe 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

Water is a vital resource in manufacturing, playing a crucial role in essential production processes, equipment cooling, and maintenance, thereby ensuring operational efficiency (Dupont & Renzetti, 2001). Beyond direct use, water is integral to various industrial applications like material processing, cleaning, and energy generation. The importance of water to manufacturing extends to supply chain management as it impacts production schedules, transport, and overall productivity as well.

The manufacturing sector holds significant economic importance in Tanzania, accounting for 7.71% of the GDP in 2020 (MoF, 2023). Manufacturing is the fourth most important economic subsector in Tanzania after the “Crops”, “Construction” and the “Wholesale and retail trade” (see Annex 1). By providing employment opportunities for a large portion of the population, including both skilled and unskilled workers, manufacturing helps to alleviate unemployment and contributes to economic diversification. Moreover, it reduces dependency on imports by expanding the range of goods produced domestically, promoting self-sufficiency and economic resilience. Manufacturing activities also add value to raw materials, leading to higher export potential and increased income generation. Additionally, the sector facilitates technology transfer and skill development, fostering productivity growth and competitiveness in the global market. Overall, the manufacturing sector plays a crucial role in Tanzania’s economic development, driving industrialization, attracting investment, and stimulating sustained economic growth (Lugina, et al., 2022).

The Tanzania 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 encompasses a wide range of economic activities and services, including, for example:

- Food production
- Beverages
- Textiles
- Clothing
- Paper production.

To calculate the value of water in manufacturing, we primarily relied on statistics from the *Annual Survey of Industrial Production 2016* (NBS, 2018). The value of this water was calculated using a production function combined with a scale-down approach. One of the data limitations faced related to the way in which water related costs were represented in this *Annual Survey*. The methodology component of the *Annual Survey of Industrial Production 2016* (specifically, 3.5.4) outlined a set of production costs, and it mentioned “water as an input” and “water treatment” as the two only water-related costs. Available documentation did not provide any additional information about what the “water as an input” variable entailed. In this study, we assumed that “water as input” costs covered abstraction fees and licenses as well as pumping and filtration costs, which we would refer to more simply as “water supply” costs. Similarly, “water treatment” costs were assumed to include costs related to pollution charges, treatment and discharging costs.

According to the calculations, the manufacturing sector’s water value was 27,173 million TZS (11.85 million USD), corresponding to a mere 0.02% of GDP in 2020. The monetary value of water was derived from cost proportion estimates that were extrapolated and applied against the value added by the manufacturing sector. It was found that water costs (calculated by adding up the cost of water supply and water treatment) represented an average of 0.05% of the total production costs of the manufacturing sector. Another finding is that 99.7% of the water costs were water treatment costs and that only 0.3% related to water supply. Water supply costs corresponded to only 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 costs 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, 2018), which is 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 yields metrics that could be proxies of the income generated by each subsector.
- The production costs contain prices of water and water treatment costs, these being potential proxies to calculate the value of water.
- Labour and production costs allow for an accurate mapping of the total costs of each subsector.

4.2.2 Rationale for using production function for valuing water for manufacturing

The Annual Survey of Industrial Production 2016 (NBS, 2018) presents variables that allow quantitative relationships between income and the main production factors such as labour, capital, and water, which are necessary datapoints for developing production functions (Tinch et al., 2019).

As discussed in the crop subsector valuation, the production function is very reliable and fits the study's objective, meaning evaluating the contribution of water to the economy, making it the best possible methodological option from Figure 4 because it uses market data from public sources of Tanzania and allows to understand the cost of water in a broader cost structure.

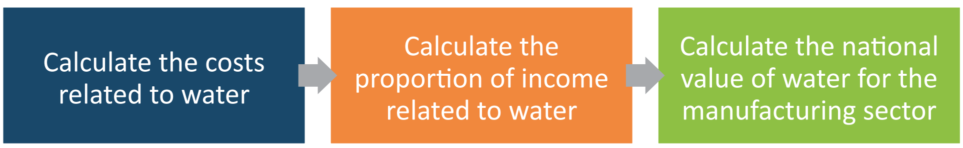
Given the information available, the authors decided to implement the same principle of the scale- down approach that was used to value water for the crop subsector (See section 3.3) but with the consolidated results from the results of the survey. The main idea was to understand how the cost of water related to the value added generated by the subsector.

4.2.3 Steps and analysis for implementing the production function methodology

Figure 11 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 in section 3.3 and, that is because it is a scale-down approach of the production function methodology based on the available information for this sector. Here are the key steps followed:

- **Step 1. Calculate the costs related to water:** The authors went thoroughly into the *Annual Survey of Industrial Production 2016* (NBS, 2018) 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, 2018) 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.

Figure 11. Process followed to implement the scale-down valuation approach to value water in the manufacturing sector.



Source: Elaborated by authors.

The costs considered for the calculation indicated in Equation 12 are:

- **Group Cost 1:** Electricity, water and fuels consumed by industrial activity. These include the following:
  - Electricity
  - Fuels for machines and vehicles
  - Gas
  - Other fuels
  - **Water**
  - Wool, coal, and peat.
- **Group Cost 2:** Total labour costs. These include:
  - 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. These consider:
  - Capital goods purchased / imports
  - Capital goods purchased / local
  - Raw materials / imports
  - Raw materials / local.
- **Group Cost 4:** Industrial services. These include:
  - 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.

The proportion of income related to water (Wp_M) was done on a simplified calculation based on available information related to costs. This calculation is represented by Equation 12:

Equation 12. Proportion of income related to water for the manufacturing sector.

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

Where:

- Wp_M: Proportion of income related to water in %
- PW_M: Yearly cost of water as an input for the manufacturing sector in TZS/year
- PWT_M: Yearly water treatment cost for the manufacturing sector TZS/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 quantitative representation of the scale-down approach is presented in Equation 13:

Equation 13. 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 13 differs from Equation 3 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, 2018, 6). 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[20]. This means the survey data explains more than 75% of GDP for the manufacturing subsector it reports.

4.2.4 Results and interpretation of the production cost analysis

Table 16 presents the implementation results, 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.

20 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.

Table 16. Calculation of the proportion of income related to water for the manufacturing sector (Thousand TZS/year – current prices 2016).

ISIC	Industrial Activity	Group Cost 1	Group Cost 2	Group Cost 3	Group Cost 4	Total cost	Water Abstraction 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%**

ISIC	Industrial Activity	Group Cost 1	Group Cost 2	Group Cost 3	Group Cost 4	Total cost	Water Abstraction Cost	Water Treatment cost	Total Water costs	Proportion of income related to water (%)
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%**
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 (2018).

Table 17. Calculation of the value of water for the manufacturing sector (Thousand 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 (2018).

Table 17 shows that the annual value of water in Tanzania for the manufacturing subsector in 2016 was 18,370,559 TZS[21]. 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 0.24%. This was the result of dividing the value of water by the added value generated by the manufacturing sector in 2016.

21 Current prices 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

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 is not expected to significantly change over time, at least based on observations from the available information. In other words, if it were projected until 2020 with inflation, the proportion would remain intact. By substituting the values in Equation 14, the following result below was obtained:

$$NA_{Cwv} = 11{,}207{,}276{,}000{,}000 * 0.24\%$$

$$NA_{Cwv} = 27{,}173{,}364{,}839\ TZS\ (11{,}848{,}042\ USD)$$

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 discussion 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 resources management, a higher budget allocation would therefore be 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 anonymised 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 27,173 million TZS (11.85 million USD), which represents less than 0.6%% of the value of water calculated for the agriculture sector. With respect to the broader economy, the value of water in manufacturing corresponded to a mere 0.02% of the GDP in 2020. 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 16 that show that water costs, both water supply 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 abstraction 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*.
- Sectoral-specific studies are conducted to analyse costs associated with water within the manufacturing sector, such as transporting and cooling.
- The evaluation of the contribution of water to the electricity sector is made because hydropower has traditionally contributed between 30-40% of the country's electricity (MoF, 2023).

5. Valuation of Water in Mining

5.1 Introduction

Water is a cornerstone resource with critical implications for mining industry. Water plays a pivotal role across mining operations from ore processing to dust suppression, and the overall mineral extraction process. Adequate water supply is also essential for equipment cooling and the transportation of minerals, contributing significantly to the sector's productivity (Scheiber et al., 2018).

Tanzania's mining sector is a vital component of its economy, making substantial contributions to GDP and government revenue. Based on 2020 accounts, the mining sector represents 6.7% of the national economy (MoF, 2023). Renowned for gold production, it significantly bolsters export earnings, encompassing diverse minerals like diamonds, gemstones, nickel, copper, and coal. The sector attracts foreign direct investment, fostering capital inflow and technological advancements. Revenue generated through taxes and royalties aids in funding public services and infrastructure development. Beyond economic benefits, mining provides extensive employment, spanning operations and related industries. The sector's growth necessitates substantial infrastructure, enhancing overall economic development and connectivity. Economically speaking, the mining sector in Tanzania covers the following activities and services:

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

In this chapter, we attempted to estimate the value of water in Tanzania's mining sector. We rely on data from the "Mining and Quarrying" component in the *Annual Survey of Industrial Production 2016* (NBS, 2018). A scale-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 sector for 2020 was 175,749 million TZS (76.63 million USD). This value is nearly six times larger than the value of water for the manufacturing sector but represent only a fraction of the value of water in agriculture.

5.2 Production function methodology and analysis

5.2.1 Data sources

The main source of data was the *Annual Survey of Industrial Production 2016* (NBS, 2018). Second hand data and statistics provided by the Ministry of Water Resources such as the *Water Resources Factsheets* were also consulted.

The "Mining and Quarrying" component covers activities related to the:

> *"…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, 2018, 2).*

The review of these sources of information for the mining sector yielded consolidated data on quantities, prices, and income for the main minerals that are exploited. Table 18 shows the value added reported in the *Annual Industrial Production Survey 2016* for mining and quarrying subsector.

Table 18. 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 (2018).

When comparing the total value presented in Table 18 with the value shown for mining and quarrying in the GDP of 2016 (See Annex 1), it can be observed that the results of the survey explain more than 49% of the GDP of this sector, which means that the survey is indicative but does not fully cover the GDP generated by the mining subsector. Furthermore, detailed information related to the following data points was found to be missing from the statistical documentation available:

- Main extraction methods and their associated costs
- Water consumption disaggregated by mining activity
- Costs of acquiring and treating water.

Another data limitation related to the lack of detailed information about what were the specific costs covered by "water as input" and "water treatment", i.e., the two water-related costs outlined in the *Annual Survey of Industrial Production 2016*. In this study, we assume that "water as input" costs cover abstraction fees and licenses as well as pumping and filtration costs, which we will refer to more simply as "water supply" costs. Similarly, "water treatment" costs are assumed to include costs related to pollution charges, treatment, and discharging costs.

5.2.2 Rationale for using production function for valuing water for mining

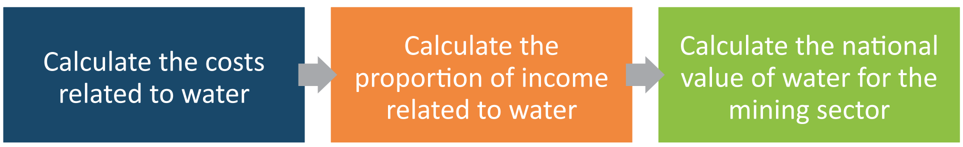
Given the available data, the production function methodology was identified to be the best methodological approach to estimate value of water in Tanzania's mining and quarrying sector. It is important to note that the production function valuation methodology quantifies the value of an environmental 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 (Tinch et al., 2019). 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 anonymised 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 costs in the overall cost structure and the value added the sector generates.

5.2.3 Steps and analysis for implementing the production function methodology

A three-step procedure was developed to estimate the value of water in the mining sector in Tanzania (Figure 12):

- **Step 1. Calculate the costs related to water:** The authors went thoroughly into the *Annual Survey of Industrial Production 2016* (NBS, 2018) to quantify the water costs reported in the survey.
- **Step 2. Calculate the proportion of income related to water:** The authors surveyed in detail the *Annual Survey of Industrial Production 2016* (NBS, 2018) to determine the overall production costs and add them up towards quantifying 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.

Figure 12. Process followed to implement the scale-down valuation approach to value water in the mining sector.



Source: Elaborated by authors.

The following costs were considered for in the valuation calculation:

- **Group Cost 1:** Electricity, water and fuels consumed by industrial activity. These include:
  - > Electricity
  - > Fuels for machines and vehicles
  - > Gas
  - > Other fuels
  - > **Water**
  - > Wool, coal, and peat.
- **Group Cost 2:** Total labour costs. These include:
  - > 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. These consider:
  - > Capital goods purchased / imports
  - > Capital goods purchased / local
  - > Raw materials / imports
  - > Raw materials / local.
- **Group Cost 4:** Industrial services. These include:
  - > 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.

Once these costs were calculated, the proportion of income related to water could be calculated using the following quantitative representation (See Equation 15):

Equation 15. Proportion of income related to water.

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

Where:

- Wp_G: Proportion of income related to water in %
- PW_G: Yearly cost of water as input for the mining sector in TZS/year
- PWT_G:Yearly water treatment cost for the mining sector TZS/year
- $C1_G$: First cost per year incurred by the establishment in TZS/year
- CN_G: Cost N per year incurred by the establishment in TZS/year

Using the estimates on proportion of income related to water, the value of water for the mining sector could then be derived through the following calculation expressed by Equation 16:

Equation 16. 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 %

5.2.4 Results and interpretation of the production function

Results reveal that the water costs are estimated at 15,057,583,000 TZS/year. Table 19 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 19. Calculation of the proportion of income related to water for the mining sector (Current prices 2016 - Thousand TZS/year).

ISIC	Industrial Activity	Group Cost 1	Group Cost 2	Group Cost 3	Group Cost 4	Total Cost	Water Supply Cost	Water Treatment Cost	Total Water costs	Proportion of income related to water (%)
5	Mining of coal and lignite [22]	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 (2018).

Once the proportion of income related to water was calculated, it was then applied to obtain the value of water in the Tanzanian mining industry. Table 20 shows that the annual value of water in Tanzania for the mining sector in 2016 is TZS 46,178,963,000 (current prices 2016).

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

Table 20. Calculation of the value of water in the mining sector (Current prices 2016 - Thousand 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 (2018).

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:

- NA_{GWV}: National value of water for the mining sector of Tanzania in 2020
- G_{GDP}: GDP value of the mining sector of Tanzania in 2020
- P_{Gwv}: Proportion value of water for the mining sector in 2016

Using the same rationale as in the manufacturing subsector (see discussion in section 4.2.4), the proportion value of water for the mining sector in 2016 (P_{Gwv}) can be applied to the GDP values in 2020, insofar as there are no reasons to believe that these proportions have changed significantly over this time period. By substituting the values in Equation 17, the following result was obtained:

$$NA_{Gwv} = 9{,}867{,}293{,}000{,}000 * 1.78\%$$

$$NA_{Gwv} = 175{,}749{,}179{,}260\ TZS\ (76{,}629{,}582\ USD)$$

5.3 Conclusion

The value of the water in the mining sector in Tanzania is estimated at 175,749 million TZS (76.63 million USD)[23] in 2020 current prices. As for 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 mining sector towards water goes into treatment.

The obtained value of water for the mining sector is more than six times larger than the value obtained for water in the manufacturing sector. Both sectors contribute is relatively equal terms to the GDP, 7.7% for manufacturing and 6.8% for mining. Thus, the attributed difference in the value that water has to the added value to these sectors is due to the fact that the mining sector has a much larger average expenditure ratio related to water (mostly treatment) costs. These results invite a discussion on how the price that mining companies pay for water as an input reflects its actual value and whether this 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' total 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.

23 Both figures presented in 2020 current prices.

6. Conclusion

6.1 Summary of key findings

This study has applied market price and proportional production costs functions using scale-down approaches as methodology to estimate the hidden value of water in three of the most important sectors of the Tanzanian economy, namely agriculture, manufacturing, and mining. Limited to these three sectors, this study reveals that the low bound estimation of the value of water in Tanzania is approximately 4,816,560 million TZS (2,100.27 million USD), which is the equivalent of 3.31% of the GDP in 2020 (Table 21).

Table 21. Consolidated results of water valuation for Tanzania Mainland (Current prices 2020).

Sector	Subsector	Value Added Proportion Derived from Water	*National Value of water (TZS/year)*	*National Value of water (USD/year)*
Agriculture	Crops	17.66%	3,871,103,258,200	1,687,865,767
	Livestock	6.99%	742,933,793,947	323,931,560
Manufacturing		0.24%	27,173,364,839	11,848,042
Mining and Quarrying		1.78%	175,749,179,260	76,629,582
Total		-	**4,816,959,596,245**	**2,100,274,951**
GDP		3.31%	145,429,645,000,000	63,409,757,618

Note: GDP figures obtained from MoF (2023). Source: Elaborated by authors.

This research also contributed to revealing the following key findings:

- **Expected return ratio of bean irrigation is about 955%:** 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 2020 USD figures, this means that for every USD 1 spent on bean irrigation during the short-rainy season, an increased output of 11.47Kg was estimated. Based on the price of beans in 2020 of 0.83 USD/Kg, the expected return ratio of bean irrigation is about 955%.
- **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).
- This shows that water allocated to cattle consumption generates the most volumetric value, followed by the goat consumption, which generates almost twice as much as the water consumed by sheep. This is a point to be considered in terms of public policy especially in terms of water scarcity and drought where choices on water allocation per animal could be potentially decided based on the volumetric value generated.
- **Water related costs represent merely nothing for the manufacturing sector**: Water costs, both supply and water treatment, represent an average of 0.05% of the total costs for the manufacturing sector. Even the most water intensive manufacturing activities have very low proportional water costs; water costs of manufacturing food products and beverages represent only 0.104% and 0.914% of their total production costs.
- **Water treatment costs represent the vast majority of water-related costs:** Out of the total water-relates costs in the manufacturing and in the mining sector, this study revealed that 99.7% of costs related to water treatment. This indicates that water supply services and abstraction fees and licenses are set at a very low level, at least in relations to other production costs.

6.2 Discussion on valuation 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 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" (VWI, 2020).

The scale-down approaches that the authors used took information from reliable national statistics and interpreted them as market signals. By doing so, we 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. The overall value of water will always increase by improving the sources of information and including other economic sectors.

The results of the study are limited by the availability of information and the possibilities of the valuation methodologies. A limitation of the chosen valuation approach is that the obtained results are attached to market transactions, and the calculation does not include water which does not yield economic results. For instance, the calculations do not include the water to grow crops for self-consumption that, according to the NBS (2021), 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 2.7% of Tanzania's 2020 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 National Irrigation Management Plan 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.

The results of the valuation of this study present an opportunity for Tanzania to improve the national debate on water investments. For instance, it is shown that costs related to 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 Basin Water Boards to rethink and potentially consider increasing water abstraction fees and licences. 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. It should also trigger thinking around the potential of using cross-sectoral allocations towards investing in integrated water resources management.

6.3 Opportunities for future water valuation research

One of the hopes of this study is to spark interest on the need to conduct further water valuation research in Tanzania. Among the shadow price techniques, we would like to draw attention towards the opportunities which revealed and stated preference, damage avoidance, and next best alternative methods (Figure 4) could bring to the water valuation conversation.

The use of travel costs methods could be used especially in the context of assessing the value of water in the tourism sector (Menegaki et al., 2021) – n.b., latest data shows that the tourism industry generated 5,836,412 million TZS (2,528 million USD) in 2022 (MoF, 2023). Tanzania is home to several natural parks and lakes, some of which constitute key tourist destinations in the country. A travel costs study could be conducted to estimate the value of specific lakes and water-related ecosystems that are popular sites to visit for tourists (e.g., Lake Tanganyika or Lake Manyara). Surveys could be distributed among the tourists coming to a specific lake asking them about their travel related expenditures (flight, hotel, local travel, etc.) to come to this lake and how important is visiting this site as part of their travels to Tanzania. The idea is that the value of preserving the lake in good ecological condition would be at least equal to the amount tourist spend to come to see this freshwater body (Emerton and Bos, 2004). A similar hypothetical cost exercises could be done using stated preference methods (TInch et al., 2019).

Damage cost avoidance methods could also be used to shed further light on the value of water to the national economy. Aside from the economic benefits related to tourism, the economic value of water related ecosystems can also be uncovered through the role they play in limiting the effects of disasters such as droughts, floods, or extreme weather events. Flood damage cost estimation models can show how much reconstruction and repair can be avoided due to the presence of a floodplain, for instance, which acts as a natural barrier. The logic here is that the value of that floodplain would be at least equal to the economic costs that would be required to repair the damages by floods that are otherwise contained by this nature-based infrastructure (Turpie et al., 1999).

A final method that we would like to introduce as a possibility for future research on water valuation in Tanzania is the next best alternative method. Similar to damage cost avoidance techniques, next best alternative methods shed light on the economic gains that are derived from the existing water-related infrastructure and services. Several coastal cities and localities in Tanzania currently rely on groundwater for drinking water supply (Olarinoye et al., 2023). If these sources run dry, the next best alternative are likely to be pumping water from distant sources or going for desalination – both alternatives would involve major capital and operation costs. While there are some investments made in rainwater harvesting, we have yet to see any major investments in groundwater replenishment initiatives (Dismas et al., 2018). Performing next best alternative estimates could be an entry point for a cost benefit analysis for investing in groundwater replenishment.

This research has shown that water brings many tangible contributions to different sectors of the national economy in Tanzania. Production functions and market-based approaches as well as the other shadow pricing methods can be used to raise awareness on the hidden value that water brings to each of these sectors. The more economic sectors would carry out such economic valuation exercises, the closer we would get to estimate the total value of water in the country. Since water knows no sectoral or political boundaries, a final implication of this study is, therefore, that reassessing water in Tanzania needs to be guided by a multi-stakeholder engagement process. We hope that this study contributes to igniting cross sectoral conversations and initiatives for (re)valuing in the country and in Africa.

References

Barbier, E. B. (2022). The economics of managing water crises. Philosophical Transactions of the Royal Society A, 380(2238), 20210295.

Champ, P. A., Boyle, K. J., and Brown, T. C. (2003). *A Primer on Nonmarket Valuation*. A H Dordrecht: Kluwer Academic Publishers.

Das, S., Fuchs, H., Philip, R., & Rao, P. (2023). A review of water valuation metrics: Supporting sustainable water use in manufacturing. *Water Resources and Industry*, *29*, 100199.

Dismas, J., Mulungu, D. M., & Mtalo, F. W. (2018). Advancing rainwater harvesting as a strategy to improve water access in Kinondoni municipality, Tanzania. *Water Science and Technology: Water supply*, *18*(3), 745-753.

Dupont, D. P., & Renzetti, S. (2001). The role of water in manufacturing. *Environmental and resource economics*, *18*, 411-432.

D'Odorico, P., Chiarelli, D. D., Rosa, L., Bini, A., Zilberman, D., & Rulli, M. C. (2020). The global value of water in agriculture. *Proceedings of the national academy of sciences*, *117*(36), 21985-21993.

Emerton, L., and Bos, E. (2004)*. Value, Counting Ecosystem as Water Infrastructure*. Gland, Switzerland and Cambridge, UK: IUCN.

Freeman III, A. M., Herriges, J. A., & Kling, C. L. (2014). *The measurement of environmental and resource values: theory and methods*. Routledge.

Mazzucato, M., Okonjo-Iweala, N., Rockström, J., & Shanmugaratnam, T. (2023). *Turning the Tide: A Call to Collective Action, Global Commission on the Economics of Water*, Paris. Available at:https://watercommission.org/wp-content/uploads/2023/03/Turning-the-Tide-Report-Web.pdf

IBM. (2023a). *Adjusted R squared*. Available at: https://www.ibm.com/docs/en/cognos-analytics/11.1.0?topic=terms-adjusted-r-squared

IBM. (2023b). *Significance value.* Available at: https://www.ibm.com/docs/en/cognos-analytics/11.1.0?topic=terms-significance-value

IUCN. (2005). *Catchment Ecosystems and Downstream Water: The Value of Water Resources in the Pangani Basin, Tanzania*. Lao PDR: IUCN Water, Nature and Economics Technical Paper No. 7, IUCN — The World Conservation Union, Ecosystems and Livelihoods Group Asia.

JICA. (2018). *The Project on the Revision of National Irrigation Master Plan in the United Republic of Tanzania. Final Report. Volume-I. Main Report*. Developed by Japan International Cooperation Agency (JICA), Nippon Koei Co. Ltd., and International Development Center of Japan Inc., on behalf of the National Irrigation Commission and Ministry of Water and Irrigation. Provided by per request Available at: https://openjicareport.jica.go.jp/pdf/12309340_01.pdf

Lugina, E. J., Mwakalobo, A. B. S., & Lwesya, F. (2022). Effects of industrialization on Tanzania's economic growth: a case of manufacturing sector. *Future Business Journal*, *8*(1), 1-11

Menegaki, A., Dionysopoulou, P., & Agiomirgianakis, G. (2021). A note on the contribution of Valuation economics in tourism. *European Journal of Tourism Research*, *29*, 2904. https://doi.org/10.54055/ejtr.v29i.2415

Möller Gulland, J., Hone, S., and Pohlner, H. (2020). *Position Paper on Valuing Water in Bangladesh*. Dhaka: Ministry of Water Resources, Government of the People's Republic of Bangladesh.

MoF. (2023). The United Republic of Tanzania: The Economic Survey 2022. https://www.mof.go.tz/uploads/documents/en-1691583449-THE%20ECONOMIC%20SURVEY%20_2022.pdf

MoW. (2019). *Tanzania Water Resources Atlas 2019*. Dodoma: Ministry of Water, developed by YEKOM Consulting Engineers. Available per request.

MoW. (2020). *Water Sector Status Report 2015-2020*. Dodoma: Ministry of Water. Available at: https://www.maji.go.tz/uploads/publications/en1593170637-WSSR%202015%20-%202020.pdf

MoW. (n.a.). *Water Resources Factsheets*. Dodoma, Ministry of Water. Available per request.

NBS. (2018). *Annual Survey of Industrial Production 2016. Statistical Report*. Dodoma: National Bureau of Statistics and Ministry of Industry, Trade, and Investment.

NBS. (2020). *National Data Archive*. Dodoma: National Bureau of Statistics. Retrieved from National Sample Census of Agriculture 2019-2020. Available at: https://www.nbs.go.tz/tnada/index.php/catalog/31

NBS. (2021). 2020 *Tanzania in Figures.* Dodoma: National Bureau of Statistics and Ministry of Finance and Planning. Available at: https://www.nbs.go.tz/index.php/en/tanzania-in-figures/641-tanzania-in-figures-2020

NBS. (2023). *Table Retrieval System (TRS).* Dodoma: National Bureau of Statistics. Retrieved from National Agricultural Census 2019/2020. Available at: http://data.nbs.go.tz:81/kilimo/index.php/ded/viewDashboard

Olarinoye, T., Foppen, J. W., Veerbeek, W., Morienyane, T., & Komakech, H. (2023). Exploring the future impacts of urbanization and climate change on groundwater in Arusha, Tanzania. In *Groundwater* (pp. 79-93). Routledge.

Ossa-Moreno, J., McIntyre, N., Ali, S., Smart, J. C., Rivera, D., Lall, U., & Keir, G. (2018). The hydro-economics of mining. *Ecological Economics*, *145*, 368-379.

Pandeya, B., Buytaert, W., Zulkafli, Z., Karpouzoglou, T., Mao, F., & Hannah, D. M. (2016). A comparative analysis of ecosystem services valuation approaches for application at the local scale and in data scarce regions. *Ecosystem Services*, *22*, 250-259.

Pearce, D. W., & Pretty, J. N. (1993). *Economic values and the natural world*. Earthscan.

Perman, R., Ma, Y., McGilvray, J., and Common, M. (2003). *Natural Resources and Environmental Economics.* Edinburgh: Pearson Education Limited.

Rietbergen McCracken, J., and Abaza, H. (2000). *Environmental Valuation a Worldwide Compendium of Case Studies*. London: Earthscan.

Scheiber, L., Ayora, C., & Vázquez-Suñé, E. (2018). Quantification of proportions of different water sources in a mining operation. *Science of the Total Environment*, *619*, 587-599.

Tinch, R., Beaumont, N., Sunderland, T., Ozdemiroglu, E., Barton, D., Bowe, C., ... & Ziv, G. (2019). Economic valuation of ecosystem goods and services: a review for decision makers. *Journal of Environmental Economics and Policy*, *8*(4), 359-378.

TEEB. (2010). *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations*. London and Washington: P. Kumar, Ed., Earthscan.

Turpie, J., Smith, B., Emerton, L., and Barnes, J. (1999). Economic value of the Zambezi basin wetlands. IUCN Regional Office for Southern Africa. https://portals.iucn.org/library/sites/library/files/documents/1999-098.pdf

United Nations. (2021). *The United Nations World Water Development Report 2021: Valuing Water*. Paris: UNESCO.

USAID. (2020). *Tanzania Water Sector Assessment for Strategy Development*. Supported by USAID and published by Mendez England & Associates. Available at: https://pdf.usaid.gov/pdf_docs/PA00WH9Z.pdf

Valuing Water Initiative. (2020). Valuing water: A conceptual framework for making better decisions impacting water. https://valuingwaterinitiative.org/reports/valuing-water-a-conceptual-framework-for-making-better-decisions-impacting-water/

Annex 1: Economic and social statistics

Table A1-1. Gross Domestic Product by kind of economic activity – current prices – Million TZS.

	2016	2017	2018	2019	2020	2021	2022
Agriculture, forestry, and fishing[24]	29,739,111	34,142,497	33,916,201	36,447,871	38,760,377	41,851,196	44,670,628
Crops	16,474,729	19,712,862	19,060,478	20,066,646	21,920,177	23,549,769	25,580,490
Livestock	8,205,007	8,867,810	9,251,173	10,357,287	10,622,499	11,269,820	11,479,664
Forestry	3,094,767	3,313,765	3,383,160	3,641,955	3,720,575	4,191,340	4,603,883
Fishing	1,929,747	2,248,060	2,221,390	2,381,982	2,497,126	2,840,267	3,006,591
Industry and Construction	26,937,139	29,735,584	33,422,366	37,269,750	42,549,256	45,762,018	52,700,656
Mining and quarrying	5,299,362	5,206,217	6,455,878	7,164,222	9,867,293	11,471,365	15,430,906
Manufacturing	8,467,126	9,102,282	9,811,013	10,512,034	11,207,276	11,237,325	12,157,760
Electricity supply	472,868	413,351	345,775	369,917	398,084	378,691	248,139
Water supply, sewerage, waste management	433,132	519,909	554,536	590,324	635,959	746,403	893,174
Construction	12,264,650	14,493,826	16,255,164	18,633,254	20,440,644	21,928,233	23,970,677
Services	42,747,407	45,065,892	46,855,883	50,912,265	53,994,408	57,385,569	60,146,729
Wholesale and retail trade; repairs	9,861,678	10,842,803	11,047,691	12,246,192	12,931,133	13,570,247	13,532,026
Transport and storage	7,549,484	7,897,993	8,381,276	9,622,792	10,701,520	10,860,302	11,397,028
Accommodation and Food Services	1,523,035	1,602,543	1,653,792	1,680,222	1,371,161	1,601,506	1,892,459
Information and communication	1,739,556	1,829,356	1,948,180	2,052,242	2,196,753	2,375,155	2,605,849
Financial and insurance activities	5,268,866	4,789,632	4,823,101	4,927,613	5,013,181	5,380,249	5,498,733
Real estate	3,162,290	3,334,171	3,553,630	3,869,528	4,348,618	4,581,584	4,877,501
Professional, scientific, and technical activities	617,914	726,707	711,807	753,302	822,440	1,088,002	1,175,442
Administrative and support service activities	2,661,978	3,027,384	3,078,145	3,340,939	3,692,864	4,022,127	4,297,339
Public administration and defence	4,846,491	4,986,287	5,131,630	5,354,893	5,530,738	5,875,519	6,243,146
Education	2,673,289	2,864,290	3,081,718	3,322,028	3,440,525	3,649,124	3,838,330
Human health and social work activities	1,540,484	1,681,353	1,816,738	1,932,964	2,060,600	2,213,486	2,392,940
Arts, entertainment, and recreation	285,626	322,353	374,924	427,887	416,049	513,448	623,721
Other service activities	831,216	959,148	1,037,687	1,140,417	1,217,190	1,358,754	1,465,396
Activities of households as employers;	185,501	201,872	215,564	241,246	251,635	296,065	306,818
Gross Value Added	*99,423,658*	**108,943,973**	**114,194,450**	**124,629,886**	**135,304,041**	**144,998,783**	**157,518,013**
Taxes on products	8,938,667	9,787,724	9,794,956	9,753,960	10,125,604	11,376,505	12,737,610
GDP at Market Prices	**108,362,324**	**118,731,697**	**123,989,406**	**134,383,846**	**145,429,645**	**156,375,288**	**170,255,623**

Sources: NBS (2021); MoF (2023).

24 In 2016, the "Agriculture, forestry, and fishing" sector also included "Agriculture support services". This line is not shown in this table as they do not appear in accounts post 2017, see MoF (2023).

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%
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%

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
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).

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 intakes 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

Table 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**

Table 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 A3-22. 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 A3-23. 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 A3-24: 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 Offtake	**571,673**	**2,421,979**	**23.60%**

Table A3-25. Total number of sheep intake purchased and average price per head by type and region during 2019/20 agricultural year.

	Ram		Castrated Sheep		She Sheep		Male Lamb		She Lamb	
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	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**

Are you interested in understanding how valuation methods work and can be applied to assess the economic contribution of water in your country? The SDG 6 IWRM Support Programme is available to provide technical assistance. Contact us on sdg6iwrmsp@gwp.org.