RWANDA
NATURAL CAPITAL ACCOUNTS - WATER

Version 1.0

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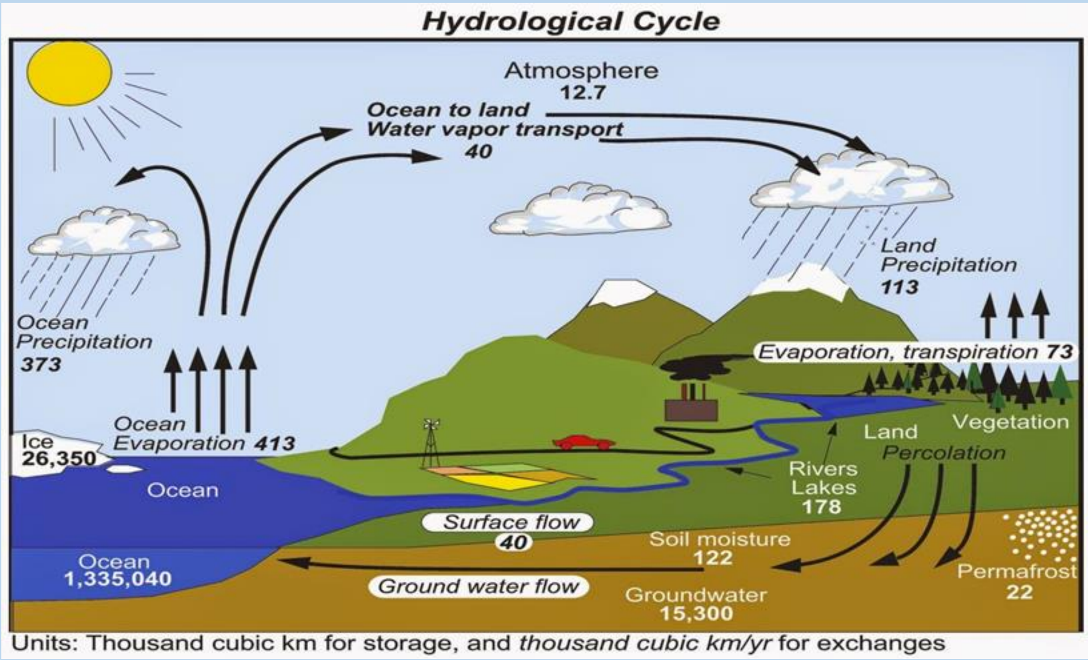

WAVES

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The Rwanda Natural Capital Accounts (NCA) for Water have been prepared through a collaborative effort of Ministry of Environment (MoE) and the National Institute of Statistics of Rwanda (NISR).[1] The Technical Working Group on Water Accounts included Tuyishime Ngondo Modest, Statistician, Ministry of Environment; Eng. Niyidufasha Gilbert (RWFA), Eng. Alsaad Ndayizeye (RWFA), Mr. Kanyesigye Nathan (RWFA), Mr. Kayitare Patrick Ivan (NISR), Mr. Ephrem Rutagarama (NISR), Ms. Umutoni Monique (RWFA), Eng. Bisangwa Innocent (MINAGRI), Mr. Mushinzimana JMV (RWFA), Eng. Nzabamwita Innocent (RAB), Eng. Hategekimana Emmanuel (MININFRA), Mr. Ruterana Lucien (WASAC), Jean Niyigaba, Economic Statistician (NISR), DG of RWFA, Mr. Prime Ngabonziza, former HoD RNRA/IWRM Department, HoD RWFA/WRM Department, Mr. Tetero Francois and the DG NISR, Mr. Yussuf Murangwa, contributed to the water analysis and access to water data sources.

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[1] This NCA effort for water began in 2015, working closely with officials from the Ministry of Natural Resources (MINIRENA) and Rwanda Natural Resources Authority (RNRA). In early 2017, RNRA was replaced by three specialized bodies: Rwanda Land Management and Use Authority, Rwanda Water and Forestry Authority, and Rwanda Mines, Petroleum and Gas Board. Also in 2017, the Ministry of Natural Resources was divided into a Ministry of Environment and a Ministry of Lands and Forestry. Recently MoE and the Ministry of Land and Forest where once again merged into MoE. Key technical staff have continued to support the process during this transition.

Executive Summary

The Government of Rwanda's strategic development plans emphasize the importance of environment protection, natural resource management and climate change preparedness. Natural Capital Accounts (NCA) are an important resource for tracking progress on socio-economic, environment and natural resource indicators. Natural Capital Accounting brings together information on how natural resources are contributing to the economy – information on resource stocks and flows, uses and users, scarcities and potentials – to improve development decisions. NCA is an extension of the System of National Accounts that helps to integrate natural resource use into economic development planning.

Rwanda is developing Natural Capital Accounts for land, water, minerals and ecosystems. This process is guided by a Steering Committee led by the Ministry of Environment and including members from the Ministry of Finance and Economic Planning (MINECOFIN), National Institute of Statistics of Rwanda (NISR), Ministry of Infrastructure, Ministry of Agriculture, Rwanda Development Board, and others. In 2013, Rwanda joined the Global Partnership on Wealth Accounting and Valuation of Ecosystem Services (WAVES) and accessed World Bank technical assistance to support its NCA efforts. Water was identified as a key resource for household uses, agricultural production and economic growth. Water accounts provide useful information on water supply and use within the economy and exchange with the natural environment. Integrating with the national economic accounts allows comparisons to economic growth and jobs by sector, as well as measures of productivity and efficiency. This analysis covers the period from 2012 to 2015.

Rwanda's Water Resources. Rwanda's rich water resources include a dense system of lakes, rivers, marshlands, ground water and soil water, all frequently replenished by abundant rainfall. However, these resources are under pressure due to population growth, intensification of agriculture, rapid urbanization, industrialization and climate change coupled with more weather extremes, adding to soil erosion, degradation and sedimentation. At the same time, development projects, such as terracing, agroforestry and agriculture investments, are being implemented in river catchments, affecting land and -water use, as well as the provisioning and regulating environmental services from land and water assets. The National Water Resources Master Plan of 2012 cautions that water availability may be constrained in many river catchments in coming decades, under plausible growth projections. Insufficient and deteriorating water quality is a key issue for future development. With future economic and population growth, water demand will increase, including competing demands on water resources, which may result in trade-offs or conflicts[2] that will need to be managed. Insufficient water management leads to an imbalance between the available water and the growing demand.

Rwanda's rainfall is highly variable, geographically and seasonally. The eastern and southeastern regions are most affected by seasonal droughts, while the northern and western regions experience intense rainfall, erosion, flooding and landslides. The vast majority of the population depends on rain-fed agriculture for their livelihood (REMA, 2015; Davis *et al.*, 2010 and Munyaneza, 2014b). This makes Rwanda highly vulnerable to changes in atmospheric conditions. Extreme weather events already negatively impact the economy. The additional

[2] MINIRENA (2017: page 33) - also referred to as RBM&E study - gives guidance on how to settle conflicts for three categories of water use conflicts including: (a) conflicts between water users due to management and availability of water (191 cases reported), (b) conflicts related to natural disasters like flooding and drought (176 cases cited), and (c) conflicts related to water quality issues (176 cases cited).

costs of climate change are estimated at 1 percent of GDP each year by 2030 (MINIRENA, 2011b), which could undermine progress toward development targets. Intense rainfall, flash floods, and landslides exacerbated by erosion can have a significant negative impact on agricultural production, food security, and infrastructure and electricity generation.

Rwanda's water resources are severely degraded (MINIRENA, 2013), primarily due to land degradation resulting in siltation of water bodies; pollution from point and non-point sources, including agricultural chemicals; inappropriately located human settlements[3]; poor or non-existent urban and industrial waste management and wastewater treatment[4]. Poor households tend to rely on low quality water resources which leads to health risks. Urban water provision remains uncertain and water supply infrastructure is inefficient with significant losses and leakages, due to old and damaged water supply infrastructure (GoR, 2014: page 8).

Increasing demand for water highlights the need for better policies and practices to manage water resources equitably and sustainably. Water demand for energy, agriculture, infrastructure, industry and household water demand is projected to increase by 27 percent in the next thirty years from 0.12 billion m^3 to 3.37 billion m^3 (RNRA, 2015). NCA for water is readily useful for policy analysis that aims to improve water resource use and management and economic development. The water flow accounts provide consistent and reliable data to support integrated assessments of natural resource, environmental and economic issues and potential trade-offs toward future development.

Natural Capital Accounting Approach. Water accounts follow the System of Environmental Economic Accounts (UN-SEEA), adopted by the United Nations Statistical Commission as an international standard in 2012, using the same structure and sectors as the System of National Accounts. The National Water Resources Master Plan of 2012 provided the starting point for data and issues covered under this NCA framework. This NCA for water extends results to cover 2012 to 2015, includes additional water sources (e.g., soil water and groundwater) and aligns sectoral water use with national economic data maintained by NISR.

The natural capital accounting approach shows total use of water by economic sector, but also the sources of that water from surface water, rain water or groundwater. This enables water decision makers to consider the distinct issues associated with each water source and the specific needs of different industries. The NCA approach also distinguishes and quantifies supply and use of 'soil water' which is critical considering Rwanda's heavy reliance on rain-fed agriculture. It is important to note that data challenges remain. Some data issues have been addressed through estimation, assumptions and professional judgment. Data quality, availability and compatibility can be improved in a systematic manner going forward.

Water Use by Economic Sector. Agriculture uses 96 percent of water *withdrawn* from the environment (including soil water), mostly for low value crops essential to the country's food

[3] Over the last three decades, however, Rwanda's water resources have been severely degraded, as evidenced by various observations like watershed destruction, inappropriate settlements, inappropriate agricultural practices, and inadequate sanitation have led to increased siltation and sedimentation, increased pollution and increased risk of invasive aquatic weeds (MoE, 2017: page 3).

[4] Rwanda has not yet invested in collective (water-borne) sanitation systems for densified urban area. Today, no national policy or harmonized regulatory framework addresses solid waste management, leaving the task to households, communities, NGOs, the private sector, community associations and district authorities operating with limited technical and financial means. However, Kigali and other towns are undertaking considerable efforts to maintain the urban environment clean and plastic bags are forbidden within the country (MININFRA, 2010b: page 8).

needs and the rural economy. The agriculture category includes rain-fed agriculture (80% of the total), as well as irrigation, fishing, forestry and livestock. Because most agriculture is rain-fed, this high level of use does not put much pressure on the man-made water supply infrastructure. Electricity and mining are also relatively large water users. Other smaller water users include industries, schools, water utilities, hospitals, and service sectors. In terms of trends, electricity grew the fastest, almost 20%, from 2012 to 2015. Water use for education also grew rapidly from a small base.

Measuring water *consumption* shows a different pattern from *withdrawal*. Agriculture is the largest consumer of water. Electricity and mining become much smaller factors in consumption. This is because agricultural production embodies water in the final product, while electricity and mining generally pass water through a process and return it to the environment, possibly with some pollution introduced. The smaller water consumers (in descending order) are: Education, Households, Electricity, Manufacturing, Mining, and Water Utilities.

Water Use by Source. Most water is withdrawn from soil water (mainly used in agriculture production) and from river systems (mainly for urban and rural water uses). Withdrawal from rivers has increased slightly during this four-year period from 314,348,000 m^3 in 2012 to 338,374,000 m^3 in 2015. This likely reflects the government's prioritization of hydro-electric power generation. Households are important users of both surface and ground water, and one of the fastest growing, rising 134 percent during 2012 to 2015. This reflects both higher population and improved hygienic conditions.

Households and water utilities lead in withdrawal of groundwater, around 80% and 10%, respectively. Rwanda's water utilities have very limited capacity and supply only a subset of people in cities and a small part of the Northwest. Most of the rest of the rural population is using harvested rain water, springs, and wells and other sources of groundwater.

Water Assets. Water asset accounts describe the stocks of water resources at the beginning and end of a period and the additions and reductions during that period. Rwanda's water assets include surface water stored in lakes, rivers and streams, artificial reservoirs, groundwater (wells, springs) and in soil water, inflows from other territories and water entering from precipitation. The main share of precipitation enters the soil and then percolates further into soil- and groundwater. Water from precipitation that enters the soil may predominantly be observed in the valleys and lowlands after first flowing as runoff from the steeper hillsides. Most of Rwanda's water is stored in lakes (around 80%) followed by groundwater (19%). Rivers and streams, soil water and artificial reservoirs constitute a much smaller volume, though they play an extremely important economic role, for example in agriculture.

In terms of annual additions and subtractions, rainfall and evapo-transpiration are the key entries in the asset tables. On average over four years, the largest inflow is from precipitation (32.3 billion m^3), about 90 percent of total additions to the stock. Evapo-transpiration accounts for about 21.9 billion m^3 of reductions in stock (mainly from ground- and soil- water). On average, Rwanda receives a net inflow (rainfall minus evapotranspiration) of about 11.3 billion m^3 per year, a measure called Internal Renewable Water Resources. Together with external inflow from foreign territory, this yields Total Renewable Water Resources, which is the amount available to support human uses, growth and development on a sustainable basis. It is important to note that this total volume arrives seasonally and with spatial variation, so water is not always available where it is needed and at the right season. To make these renewable water resources available where and when needed, water capture and storage in reservoirs or enhanced conservation in soils is likely needed. The NWRMP projected water demand to 2040 based on expected population growth. By then, total water demand is expected to reach 3.4 billion m^3, about a third of the water currently available annually. Irrigation accounts for about two-thirds of this projected demand and households represent a quarter. Current water demand as estimated in this water accounts is around 1.5 billion m^3 (average water demand for 2012-2015), excluding soil water.

Changes in water stocks over 2012 to 2015 can be reported with the caveat that the period is short for trend analysis. The data over this period show substantial variability in the seasonal availabilitiy of water. Analysis of trends is also limited because the annual values for water in soil water and groundwater are estimated not actually measured (an area for future improvement). During 2012 to 2015, the large volume of water stored in lakes decreased a small amount (half of one percent), while the small volume of water in artificial reservoirs increased by a large amount (63 percent). This increase is mainly related to the expansion of hydropower capacity and irrigated agriculture systems.

These data provide insights for policy makers. The increasing use of artificial reservoirs reinforces the need to protect the watersheds above these reservoirs. Protection of the riparian zone and upper watersheds is also important for protecting the quantity and quality of water in Rwanda's natural lakes. The water accounts also highlight the importance of soil water and groundwater assets, which are normally hidden from view, but extremely important for agricultural production. Preparing for future increases in water demand, as well as potential climate-induced changes in rainfall, policy makers may want to consider measures to reduce runoff and increase groundwater recharge. These kinds of interventions would make more water available for a longer period to meet crop demands seasonally and geographically. Reducing runoff, stabilizing soils and encouraging recharge can also help to reduce the potential for downstream effects of high rainfall on steep slopes (sedimentation and landslides).

Water Availability and Demand. Rwanda's water resources constitute a vital asset that significantly contributes to socio-economic development and poverty eradication. Water access is a key issue related to Vision 2020 and the Government's development program, National Strategy for Transformation (NST1), particularly as it relates to availability of water and sanitation services. The NST1 highlights that 100 percent of households should have access to clean drinking water by 2024. This will depend on the capacity to treat and distribute water. Currently, the availability of safe drinking water does not meet the needs of the population and distribution is still inadequate (WASAC, 2017). To achieve Rwanda's development targets and SDG Goal 6, there is a need to invest in water infrastructure and improved technologies. Understanding current and future water availability and demand by key sectors can help in planning for economic development, water management needs and ecosystem protection needs.

Future conditions will be affected by how the agriculture sector develops and by climate change, which will affect rainfall patterns and crop productivity, potentially. Decreasing regular precipitation, higher agricultural production levels, changes in technology, and introduction of water efficiency measures would all affect the water demand–supply balance. Regular update of water accounts can provide indicators that allow monitoring of water use and delivery and highlight where and when stresses may appear.

The water availability per capita calculated under the National Water Resources Master Plan based on long term annual average (LTAA) of surface runoff was found to be 670 m3 per capita per year. This figure is expected to be updated in 2020.

Considering the water availability and actual water withdrawn, Rwanda can be classified as a "no water stress country". However, by considering the water availability (especially using the method applied under the NWRMP) and based on population needs, Rwanda is classified as a water stress country mainly due to limited infrastructures to save rainwater. The estimated stress indicator is expected to change over time with population, economic growth, and the varying rainfall pattern. As the former two parameters (population and economic growth) increase in the future, the calculated stress (per capita) is expected to increase if the water resources in the country remain equal. With such a future growth scenario, water withdrawals (TWW) also tend to increase. Currently water resources per capita just suffices as illustrated by the score which contributes to the low level of just "no water stress of the country" that was computed in this water accounts version. However, the time period available for this water accounts version does not allow for long-term trend analysis but can inform decision makers on annual trends and areas that may deserve more attention.

Based on short term data and SEEA methodology which considers rainfall minus evapotranspiration, the annual water availability per capita was found to be about 1,000 m^3 per capita per year on average over the four-year study period (2012-2015). This water availability will vary annually and potentially with impact from climate change in the future. From this 'available water' however, a limited share actually can be used, as the timing of the availability not always is aligned with the need. Consequently, before it can be used, part of the received water is flown downstream to other stocks or compartments. This phenomenon indicates a potential for increasing the water that really is available per capita by investing in water storage and promoting ground water infiltration through water conservation measures. Continued population growth will gradually reduce water available per capita. Also, Water availability varies geographically. The Eastern and Southern Provinces experience lower levels of water availability per capita. More knowledge on water use and distribution is required for better management and planning of water resources.

Water and Economic Issues. NCA adds value by integrating physical data on water flows with the monetary and economic information in Rwanda's National Accounts. Linking the two allows analysis of water productivity and efficiency – economic output and value added per unit of water. Comparing water use with economic contribution and jobs, this analysis found that agriculture uses the largest share of water nationally, while contributing about 30 percent of GDP and almost half of overall employment. In contrast, service sectors use relatively small amounts of water relative to the value added that they generate.

Water productivity[5] is the value of what can be produced with a unit of water. It is an indicator for assessing how productively or efficiently Rwanda is using water and how that performance is changing over time. Rwanda's average water productivity is Rwf 4,762 per m^3, with economic value measured at constant 2014 prices. Agriculture has relatively low value per unit of water used and the indicator is growing slowly. Manufacturing, mining, electricity and utilities provide substantially higher value added per volume. The service sectors do not use much water but produce much higher value per volume. It is expected that sectors will have different water productivity and efficiency measures. These estimates can be useful for comparison with international benchmarks or sector standards to determine whether and where efficiency of water use can be improved.

[5] Productivity measures in practice show a range of definitions, starting from solely combining physical information (as a ratio) to combining with economic information (either output, Value Added or GDP), here with the aim to align with the SDG – format this is implemented as water use efficiency under SDG 6.4.1.

SDG Indicator 6.4.1 seeks to measure the ‘change in water use efficiency over time’ to shed light on the effect of economic development on use of water resources. Rwanda’s water use efficiency is increasing during the 4-year period analyzed here. Efficiency increased from about 4,500 to 5,100 Rwf/m^3, an improvement of nearly 13 percent. This clearly contributes to achieving key sustainable development goals. Looking at the three major sectors of the economy, manufacturing and services had efficiency gains over 20 percent. Efficiency in agriculture grew by 10 percent over the period. With economic output growing faster than water use, Rwanda is *decoupling* growth from water resource use, a positive trend.

Payment for Ecosystem Services (PES). Rwanda has vowed to embark on a journey towards a climate-resilient, low-carbon economy by 2050. It is in this line that the Payment for Ecosystem Services (PES) constitutes one of the pillars of Rwanda vision 2050, which sets the vision for the country as a whole going forward for its economic transformation and development agenda. Vision 2050 and other GoR documents show the need to combat soil erosion and foster new processes that help soil stabilization. Recently, Rwanda and Costa Rica signed a Memorandum of Understanding (MoU) on environment cooperation that will specifically focus on exchanging experiences on payments for ecosystem services. Payment for Ecosystem Services (PES) is an approach that promotes good management of environmental resources to provide ecological services. In March 2019, The GoR in partnership with the Netherlands launched a PES pilot program in Upper Nyabarongo catchment, which is one of the towers of Rwanda in terms of water resources. The piloting is intended to assess pathways towards the implementation of a proposed PES scheme that is expected to be implemented countrywide.

Water Values and Economic Incentives. Water has value for people, for the economy, and for the natural environment, where it sustains ecosystems and biodiversity. Sustainable management of water resources needs to take account of these different water uses and values. Allocation of water to different uses should be informed by the value of the water in productive uses, including non-consumptive uses, such as recreation and maintenance of environmental services. In addition to value or benefit, water has costs. Costs include the management of water in the natural environment; the cost of withdrawing, treating and distributing water to households and other end users; and the cost of treating waste water so that it can be reused or discharged into the environment. Water management and allocation decisions need to be informed not only by relative values, but also by the biophysical minimum amounts of water needed to sustain life or quality of life, including in natural ecosystems.

The costs and benefits of water management and use accrue to different parties. The public sector bears some of the costs of managing water in the natural environment. Water supply companies bear the cost of treating and delivering water to customers. Customers are willing to pay for water based on its quantity and quality and pay some of the cost of treatment and delivery, depending on the way water use fees are set up and assessed. Payments for delivered water create revenues that water supply companies can use to cover the cost of treating and delivering water and improving the distribution system – and hopefully also the cost of expanding access to high quality water.

As water demand grows along with the economy, Rwanda needs a coherent information and policy framework for making water allocation trade-offs to ensure that there is enough water of sufficient quality for all potential users. Policy instruments that can help to achieve sustainable use and management of water include: payment of water use fees (pricing) for catchment protection, water loss reduction measures, cost recovery measures, and specific investments in water supply, treatment and distribution.

The Government is committed to ensure both increased access and affordability of water to all Rwandans. The Government aims to raise rural and urban water supply coverage while also assisting the districts to plan, design, finance and implement water infrastructure projects. This will involve improvements to rural water supply infrastructure and ensuring sustainable operation and maintenance. To ensure sufficient revenue to finance these improvements, there will need to be an assessment of the water pricing structure that can ensure recovery of the cost of treatment, distribution, maintenance and expansion of services.

Water pricing and use permits are economic tools that can be used to encourage more effective and efficient water use and allocation. Water prices give economic agents a signal and incentive for using water efficiently, adjusting demand, stimulating supply, or correcting scarcity or distributional issues. Tariffs for water were almost halved in January 2017, aiming to increase access and affordability by potential customers. Lower tariffs may help with access but raise questions about cost recovery for water utility companies. However, in February 2019, WASAC raised water tariffs to more than a double for those in residential area consuming more than 20 m^3. The Government recognizes the need for a source of revenue for more general water management and protection activities, as well as the need to monitor and control access and allocations, as well as pollution and downstream impacts. The Government is considering wider application of water user fees. NCA can inform water pricing and permitting decisions.

Institutional Coordination. The water sector is coordinated through a thematic working group that holds regular meetings and serves as a convening point and sounding board for all water sector stakeholders, including civil society. This group may be an appropriate vehicle for discussing further improvements that can be made in coordination and sharing of data across the many agencies engaged in the sector, including agriculture, infrastructure, commercial water companies, natural resources, urbanization, and others.

Data Quality and Collection. Participants in the NCA process, from many agencies, stress the importance of monitoring water sector performance toward meeting the national planning targets, as well as the new SDG indicators. Monitoring and assessment require high quality and consistent data to report on indicators of interest to policymakers and the public. Resources and technology are needed to systematically maintain and improve the foundation for the indicators, measure successes and identify gaps in implementation of water sector priorities. Good performance management systems need to be supported by good analysis, good reporting, and good data – and these will need sufficient funding.

Capacity for Regular NCA Reporting and Analysis. Officials from the environment and natural resource institutions, NISR, and other agencies engaged in the NCA process have built their capacity and skills through training, exchanges, and day-to-day compilation of the accounts. In addition to regular publication of natural resource accounts, policy makers will need issue-based reports that analyze important trends, changes in values, or key questions of the day. There will be a continuing need to advance the capacity to systematically handle NCA in coming years. The University of Rwanda (UR) can supply training and technical assistance.

This NCA effort has shown that compiling Water Accounts is a complex, multi-disciplinary task – that can be achieved when many agencies and professionals work together. The water accounts provide a consistent source of quality data on water resource demand and use and link those data to the national economic accounts. The true value in NCA accounts emerges after several iterations are produced and a substantial time series is available for analysis and debate.

This compilation is Rwanda’s first effort to achieve SEEA-based accounting. The expectation is that this version will provide consistent data that helps the relevant departments address current issues and informs the development planning processes. It is also expected that the Government will pursue regular updates, through which the data, methods and consistency are continually strengthened.

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Director General
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Acronyms and Abbreviations

AQUASTAT:	Statistical water database at FAO
AV:	Added Value (Value Added; economic term)
CBE:	College of Business and Economics
CBOs:	Community Based Organizations
CSOs:	Civil Society Organizations
CST:	College of Science and Technology
DG:	Director General
EA:	Environmental Accounts (or referred to as NCA)
EAC:	East African Community
EDPRS:	Economic Development and Poverty Reduction Strategy
EIA:	Environmental Impact Assessment
EICV:	Integrated Household Living Conditions Survey
ERWR:	External Renewable (fresh) Water Resources
ET:	EvapoTranspiration
ETIa:	Actual EvapoTranspiration and Interception
EWSA:	Energy, Water and Sanitation Authority
FAO:	Food and Agricultural Organization of the United Nations
FEPEAR:	Forum of private operators of water and sanitation systems in Rwanda
GCF:	Green Climate Fund
GDP:	Gross Domestic Product
GDSA	Gaborone Declaration on Sustainability in Africa
GoR:	Government of Rwanda
GVA:	Gross Value Added (often by industry or sector)
GW:	Groundwater
GWP:	Global Water Partnership
HoD:	Head of Department
IBES:	Integrated Business Enterprise Survey
IRWR:	Internal Renewable (fresh) Water Resources
ISIC:	International Standard Industrial Classification
IWRM:	Integrated Water Resources Management
JICA:	Japan International Cooperation Agency
LFS:	Labor Force Survey
LTAA:	Long Term Annual Average (i.e. for precipitation)
LWH-RSSP:	Programs under MINAGRI with Rural Sector Support Program (RSSP) for agricultural productivity improvement and poverty reduction in various phases since 2001 and the Land-Husbandry, Water-Harvesting and Hillside Irrigation (LWH) program with partners aimed at agricultural productivity increase and commercialization on of Rwanda's hillsides
MIGEPROF:	Ministry of Family and Gender Promotion
MINAFFET:	Ministry of Foreign Affairs and International Cooperation
MINAGRI:	Ministry of Agriculture and Animal Resources
MINALOC:	Ministry of Local Government
MINICOM	Ministry of Trade and Industry
MINEACOM:	Ministry of Trade, Industry and East African Community
MINECOFIN:	Ministry of Finance and Economic Planning
MINEDUC:	Ministry of Education
MININFRA:	Ministry of Infrastructure
MINIRENA:	Ministry of Natural Resources

MINISANTE:	Ministry of Health
MIS:	Monitoring and Evaluation System (Management Information System)
Mm^3:	Million cubic meters (similar to $10^6 * m^3$)
MoE:	Ministry of Environment
NA:	National Accounts (following SNA)
NBCBN:	Nile Basin Capacity Building Network
NBDF:	Nile Basin Discourse Forum in Rwanda
NBI:	Nile Basin Initiative
NCA:	Natural Capital Accounting
NDC:	Rwanda's Nationally Determined Contributions to the Paris Agreement on Climate Change
NGOs:	Non-Government Organizations
NISR:	National Institute of Statistics of Rwanda
NRW:	Non-Revenue Water (covers treated water loss)
NSI:	National Statistical Institute
NST:	National Strategy for Transformation (NST1)-2017-2024
NWRMP:	National Water Resources Master Plan
PSUT:	Physical Supply and Use Table
RAB:	Rwanda Agriculture Board
RBM&E:	Results-Based Monitoring and Evaluation System
RDB:	Rwanda Development Board
REG:	Rwanda Energy Group
REMA:	Rwanda Environment Management Authority
RIWSP:	Rwanda Integrated Water Security Program
RMA:	Rwanda Meteorology Agency
RNRA:	Rwanda Natural Resources Authority
RRA:	Rwanda Revenue Authority
RSB:	Rwanda Standards Board
RURA:	Rwanda Utilities Regulatory Agency
Rwf:	Rwandan Franc
RWFA	Rwanda Water and Forestry Authority
SC:	Steering Committee
SDGs:	Sustainable Development Goals
SEEA:	System of Environmental-Economic Accounting
SEEA-CF:	SEEA – Central Framework
SEEA-EEA:	SEEA - Experimental Ecosystem Accounts
SEEA-W:	System of Environmental-Economic Accounting for Water
SNA:	System of National Accounts
SNAPP	Science for Nature and People Partnership
SW:	Surface Water
SWAp:	Sector Wide Approach
TRWR:	Total Renewable (fresh) Water Resources
TWG:	Technical Working Group
TWW:	Total water withdrawal (surface and groundwater)
UN:	United Nations
UNDP:	United Nations Development Programme
UNEP:	United Nations Environment Programme
UNESCO:	United Nations Educational, Scientific and Cultural Organization
UNSD:	United Nations Statistics Division
UR:	University of Rwanda

VA:	Value Added
W4GR:	Water for Growth Rwanda
WA:	Water Accounts (following SEEA – Water Accounts formats)
WACDEP:	Water Security and Climate Resilient Development Programme
WAPOR:	Water Productivity Open Access Portal (FAO)
WASAC:	Water and Sanitation Corporation
WAVES:	Wealth Accounting and Valuation of Ecosystem Services
WB:	World Bank
WBG:	World Bank Group
WCS:	Wildlife Conservation Society
WRM:	Water Resources Management
WUE:	Water Use Efficiency (SDG 6.4.1 Indicator)
WP:	Water Productivity
7YGP:	Seven-Year Government Programme

CHAPTER I: Introduction and Overview

Rwanda is engaged in developing Natural Capital Accounts, guided by a Steering Committee led by the Ministry of Environment and including members from the Ministry of Finance and Economic Planning (MINECOFIN), National Institute of Statistics of Rwanda (NISR), Ministry of Infrastructure, Ministry of Agriculture, Rwanda Development Board, the Wildlife Conservation Society, and others. Natural Capital Accounting (NCA) brings together information on how natural resources are contributing to the economy – information on resource stocks and flows, uses and users, scarcities and potentials – to help improve development decisions. NCA is an extension of the System of National Accounts that helps to describe the economy's use of natural assets, such as land, water, forests, and minerals. The approach helps to integrate natural resources into economic planning and can provide a broader picture of development progress than standard measures, such as Gross Domestic Product (www.wavespartnership.org).

1.1 Rwanda's Development and Policy Context and Natural Capital Accounting

Rwanda's National Strategy for Transformation, (NST1/ Seven Years Government Program (2017-2024) sets the priority for a Green Economy approach in its Economic Transformation Pillar that promotes "Sustainable Management of Natural Resources and Environment to Transition Rwanda towards a Green Economy". Moreover, Rwanda's vision 2050 focuses on becoming a high-income economy, with high quality of life and standards of living for its citizens (NST1 2018). The pathway to achieving the vision will substantially depend on how the environment, natural resources and climate change are managed. NST1 targets five specific subsectors: Forestry, Land, Water, Environment and Climate Change. These will enable achievement of the SDGs as well as Rwanda's Nationally Determined Contributions (NDC) to the Paris Agreement on Climate Change while enabling the realisation of Vision 2050 objectives. A key innovation will be the adoption of Natural Capital Accounting (NCA) practices to track the value of natural capital to the Rwandan economy so as to enhance evidence-based decision making.

The Government of Rwanda development planning documents have emphasized the importance of environment protection, natural resource management and climate change preparedness for some time. The Economic Development and Poverty Reduction Strategy 2 (2013-2018) emphasized water as a key resource for both rural livelihoods and new production. Improvements in water sources and sanitation were prioritized in both rural and urban areas (MINECOFIN, EDPRS2 2013 – 2018). Rwanda aims to have an efficient system of water permits for water abstraction that secures ownership and promotes investment in water for socio-economic development and poverty reduction. Water conservation and erosion prevention in agricultural soils have gained emphasis for example via planting measures and agroforestry development. National planning documents aim to ensure that development in Rwanda proceeds in a manner that protects the environmental qualities and natural resources and builds resilience to threats posed by climate change for the sustained support to economic, social and cultural development. The Government also promotes policies that secure and provide water of adequate quantity and quality for all social and economic needs for generations with all stakeholders participating in decisions affecting its management.

In line with these national goals, Rwanda has several related initiatives on environmental quality improvement, natural (and human) resource enhancement and climate change adaptation for economic growth and human security. The Green Growth and Climate

Resilience Strategy (2011) defined upstream planning requirements needed to mainstream climate-related interventions and development programs. A National Water Resources Master Plan (NWRMP) was adopted in 2015, with important recommendations for further Government action in the sector. The Master Plan proposed that all entities involved in water management have the means and capacity to provide the necessary functions be it strategy, planning, implementation, exploitation or monitoring; this includes water users. In 2010, Rwanda adopted the National Policy and Strategy for Water Supply and Sanitation Services to promote sustainable distribution of water across different users in different locations. In 2011, the National Policy for Water Resources Management was adopted mainly to protect and conserve the available water resources. This NCA initiative is one of the Government's initiatives to improve data, capacity, and coordination in water resources management information.

Rwanda has adopted a roadmap for domestication and implementation of the Sustainable Development Goals (SDGs), which highlight economic development, environmental sustainability, and social inclusion. As part of this, Rwanda has developed an analysis of gaps in policy and indicators for measuring progress due to different measures and policies against baselines (MINECOFIN, 2016). Rwanda is committed to actions to increase resilience or adapt to and reduce emissions in the face of climate change. To this end, Rwanda has established a national environment fund, FONERWA, and is accessing adaptation, mitigation, and resilience funding from all possible international sources, including the Green Climate Fund (GCF), multi-lateral development banks, and specialized climate funds, such as the Forest Investment Program, and the Pilot Program for Climate Resilience. Rwanda is also developing a Result Based Monitoring and Evaluation (RBM&E) System as a tool for efficiently monitoring and assessing performance of environment quality and natural resources against development targets, and to help identify trade-offs between economics, environment and natural resources plus constraints to development. Natural Capital Accounts are a relevant and important resource for developing indicators and tracking the progress on socio-economic, environment and natural resources targets against baselines under many of these initiatives.

In 2012, Rwanda signed the Gaborone Declaration on Sustainability in Africa (GDSA) and determined to use NCA as a tool to inform national sustainable development. GDSA encourages countries to collect and monitor information across ecosystems, agriculture, fisheries, and human well-being to provide information at multiple scales so that actors can make decisions with a better understanding of both the environmental and socio-economic consequences. Rwanda's NCA effort can support the GDSA approach and objectives.

In 2013, Rwanda joined the Global Partnership on Wealth Accounting and Valuation of Ecosystem Services (WAVES) and accessed World Bank technical assistance to support its NCA efforts. Based on early scoping efforts in 2014 and 2015, the Government determined to focus NCA development on land, water and mineral accounts. Water was identified as a key resource for domestic household uses and for agricultural production and an important input to most sectors of the economy. This report describes the first iteration of the water accounts developed with support from the World Bank and the WAVES Global Partnership.

1.2 Water Resources and Economic Issues

Water resources in Rwanda include lakes, hundreds of rivers, marshlands, ground water and soil water, all frequently replenished by rainfall. Nearly all (over 95%) of Rwanda's water resources originate from the country and less than 3% from outside its territory, essentially Burundi through the Ruvubu river. Rwanda has a net outflow mainly to the Nile Basin via the Akagera River and to the Congo Basin via the Rusizi River.

Rwanda has a very dense hydrological network and even can be classified as a water rich country. However, insufficient water management leads to an imbalance between the available water and the actual and growing demand and supply. The NWRMP (2015) cautions that although overall pressure on renewable water is not currently an issue for most river catchments in the country, there is a considerable risk that it will become a problem in numerous catchments over the coming twenty to thirty years for a wide range of plausible growth projections. Insufficient and deteriorating water quality may also add to water shortages in the future. Map 1 on page 4 illustrates Rwanda's network of lakes and rivers.

Rainfall is highly variable in Rwanda. Large flows of clean water entering the country via precipitation are a great natural asset that contributes to prosperity and livelihoods and sustains ecosystems. However, rainfall varies geographically and seasonally. The eastern and southeastern regions are most affected by seasonal droughts, while the northern and western regions experience intense rainfall, erosion, flooding and landslides. Extreme weather events already negatively impact the economy and the additional costs of climate change (on top of existing climate variability) have been estimated to be equivalent to a loss of almost 1 percent of GDP each year by 2030. Climate change threats, unless adequately addressed, could significantly undermine progress toward national development targets. Projections indicate that average annual rainfall may increase by up to 20 percent by the 2050s from the 1970 level. Increased intense rainfall, flash floods, landslides exacerbated by erosion (caused by unsustainable agricultural practices and intensification on steep slopes and deforestation for fuelwood) and a lack of adequate drainage have a significant impact on agricultural production, food security, infrastructure, and electricity generation. This underpins the priority to be given to soils in water conservation and provisioning throughout the season.

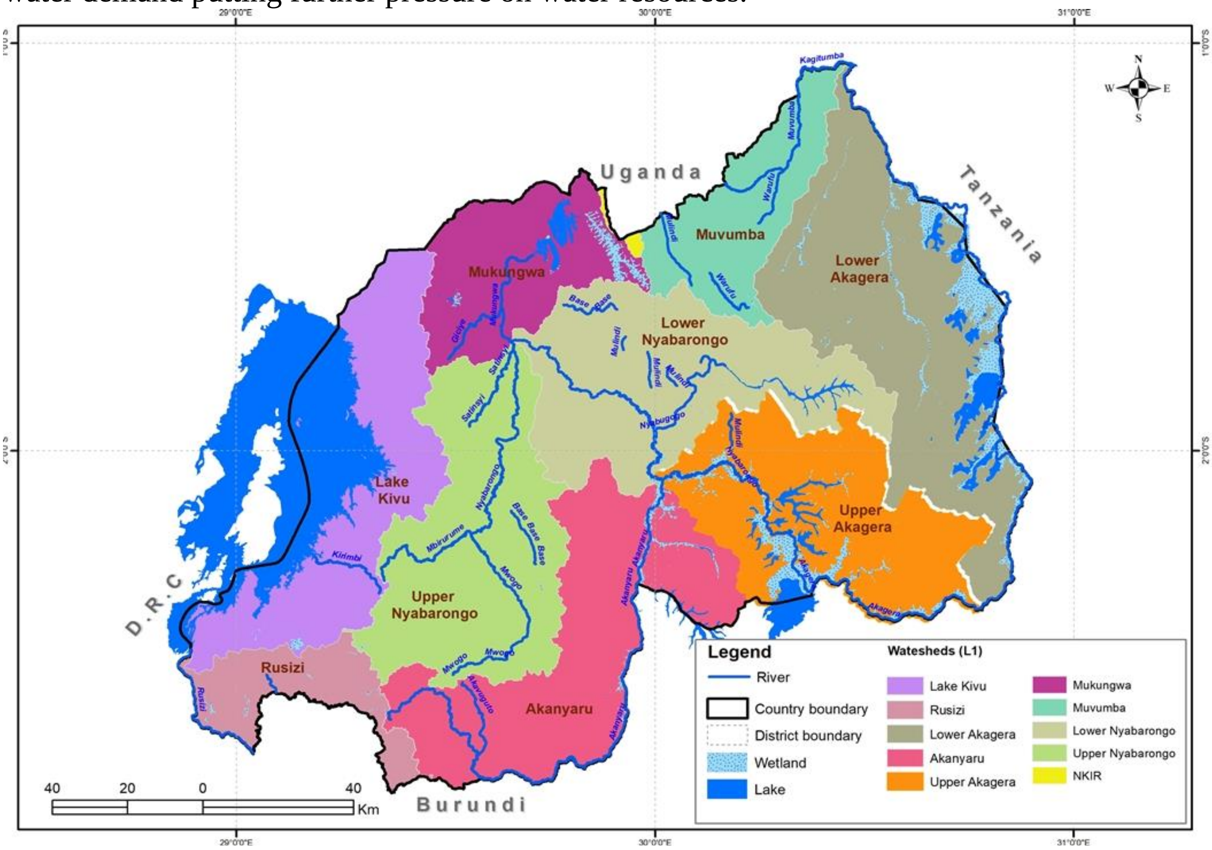
Rwanda's water resources are severely degraded (MINIRENA, 2013), primarily due to land degradation resulting in siltation of water bodies; pollution from point and non-point sources, including agricultural chemicals; inappropriately located human settlements; poor or non-existent urban and industrial waste management and wastewater treatment. Poor households tend to rely on low quality water resources which leads to health risks. People who are not connected to the piped water network consume unsafe water from non-protected water sources and are, therefore, exposed to worms, dysentery and cholera (Uwera and Stage 2015).

In addition, water resources are under pressure from population growth and rapid economic development. Rwanda's water balance is affected by the high population density, and its reliance on subsistence farming practices. Intensification of agriculture and increasing urbanization and industrialization are placing further demands on the quantity and quality of available water resources. Over-exploitation of land, a high dependence on biomass[6] for household energy needs and increasing urbanization[7] create significant pressure on scarce

[6] MININFRA (2013a, page 11) reports that around 85% of the overall primary energy consumption in Rwanda is based on biomass with 90% of all households using biomass for cooking, 11% consuming petroleum products (for transport, electricity generation and industrial use) and 4% for electricity. Interesting the GoR sector policy for biomass is to facilitate fuel switching from traditional biomass energy towards cleaner fuel alternatives to reduce non-renewable fuel wood consumption and related social, health, and environmental costs.

[7] Rwanda urban population has increased from 4.6% in 1978 to 16.5% in 2012. The vision 2020 had targeted to reach an urbanization level of 35% (MININFRA, 2015). The annual growth rates of urban population of 4.5% far exceeds the worldwide average of 1.8% (MININFRA, 2013b).

natural resources, notably land, fresh water and forests. With Rwanda's population projected to rise to around 17 million by 2032 and 26 million by 2050, there will certainly be increasing water demand putting further pressure on water resources.



Map 1: *Major waterbodies, with lakes and rivers in Rwanda*
Source*: Author's own elaboration with data from the MoE.*

Urban water provision remains uncertain and water supply infrastructure is inefficient with significant losses and leakages. Much of the existing water supply infrastructure is old and damaged, leading to high technical losses due to broken pipes, poor maintenance, and general breakdowns (Stage and Uwera, 2012). Due to the unreliable supply, most households respond by storing water until the next delivery. The water supply prospects are worsened due to the severe droughts of the long dry season of June-August each year (Munyaneza, 2014b). This requires adequate technologies to conserve, harvest and store water during the rainy season, including enhancing water conservation in soils. In the next 5 years, Rwanda's main water resources management challenge will be meeting the increasing multiple water demands in the face of declining water availability due to ecosystems degradation, pollution and climate change (7YGP, 2017; WASAC, 2016). To address this challenge, the country will need better institutional systems and coordination, as well as improved human resources, information systems such as accounting, and infrastructure.

Water availability impacts food security. Rwanda's abundant water resources, including rainfall that supports agriculture, are indeed a national asset. At the same time Rwanda's high dependence on traditional rain-fed agriculture makes it highly vulnerable to changes in atmospheric conditions, temperature and rainfall. Precipitation is unevenly distributed in time and space, with about 50 percent occurring in one quarter of the year. In 2012, MINAGRI reported a total irrigated area of 25,590 ha (MINAGRI, 2012). More recently, the figure has gone up to around 48,508 ha successfully developed for irrigation (see PSTA4, 2018: pages 11

& 44). The majority (70 percent) of annual water use from rivers and lakes is consumed by agriculture. With agricultural intensification and food security strategies in place, withdrawal of ground- and surface water by the agriculture sector will increase. Agriculture may account for up to 65 percent of total water demand from these sources by 2040 (RNRA, 2015).

Agriculture is crucial for livelihoods and employment. The vast majority of the population in Rwanda depends on agriculture (rain-fed subsistence farming) for their livelihood (REMA, 2015; Davis *et al.*, 2010 and Munyaneza, 2014b). The GoR has prioritized investment in irrigation infrastructure to increase agricultural productivity, reduce vulnerability to weather shocks and make rural households more resilient and adaptable to longer term shifts in seasonal rainfall and rising temperatures which will increase transpiration rates (World Bank, 2015). This constrains production and challenges resource managers to adopt innovative approaches to manage water resources equitably and sustainably. The increasing demand for irrigation highlights the need for better policy instruments to regulate the situation. Policies can affect the prices paid for water, cost recovery in the delivery of treated and piped water, and the incentives for conservation and efficiency in water use on supply and use of water across sectors. Policies that influence water demand and use efficiency will then affect the financial resources needed to repair and extend water treatment and supply infrastructure. NCA water accounts are tools to inform policymakers on these issues of allocation of scarce resources and pricing.

1.3 Natural Capital Accounting for Water: Rationale

Water is a cross-cutting resource. Water availability issues among regions and sectors could become a constraint to growth in key sectors such as agriculture, industry and service sector as well as for urban development. NCA covers natural resource supply and use across all economic sectors, includes above and below ground water assets and links physical data to Rwanda's economic accounts. NCA is thus readily useful for policy analyses that aim to optimize both natural resource management and economic development. The accounts can provide consistent and reliable data to support economic assessments integrated with natural resource and environmental assessments and help to identify trade-offs or potential constraints toward Rwanda's future development and widening self-reliance. NCA can also contribute to accountable governance by increasing the quality, credibility and consistency of water management statistics that support national development plans and targets.

Water accounts allow estimation of water use and indicators related to economic activities enumerated in the System of National Accounts (SNA) including growth, investment, value added, employment and income, at both macro- and meso-level. SEEA Water accounting tables cover water assets, water stocks and water flows in both physical and monetary terms and can be used to measure progress in both physical and economic terms through its alignment with the SNA. Water accounts can be disaggregated by industrial sector or geographic area to meet specific analytical needs. Preparation of water accounts also creates a process and platform for systematically organizing and exchanging data, including the spatial aspects of water via geographic information systems, among key institutions and fostering enhanced institutional coordination and innovation. The NCA process also can improve the quality of data used for management, inform water pricing and allocation decisions, and address questions of investment needs and cost recovery.

1.4 Organization of the Document

This document represents Rwanda's first effort to compile Natural Capital Accounts for Water, following the System of Environmental and Economic Accounts (SEEA), based on data up to 2015. Moreover, it connects the water accounts to the economic data in Rwanda's National Accounts describing its economic performance as well as employment in the different industries. National Physical Water Supply and Use Accounts as well as Water Assets Accounts are developed. The data and tables in the report are available from NISR and the Ministry of Environment and affiliated agencies.

The structure of the document is as follows: *Chapter I* provides an overview of Rwanda's development context and a description on water issues, as well as how NCA can inform water policies, management and planning. *Chapter II* presents physical water flows and shows some analytical results from these accounts. *Chapter III* mainly focuses on presentation of the physical water asset accounts. *Chapter IV* focuses on presentation of results related to the economic aspects of water accounts. *Chapter V* summarizes issues and implications that arose during the development of the water accounts. The Government of Rwanda (GoR) expects to update these water accounts at regular intervals. Stakeholder comments will be helpful to guide future refinements of the data and analysis.

CHAPTER II: Physical Water Flow Accounts - Supply and Use

2.1 Overview of Water Flow Statistics, Definitions, and Data Sources

Water accounts following the SEEA approach cover water resources, stocks, flows, and values. A key element of water flow accounts is the ‘physical water supply and use tables’ that describe water flows in physical units within the economy and between the environment and the economy. These physical accounts follow water from its initial withdrawal (abstraction) from the environment by the economy; through its supply and use between economic units within the economy; to its final discharge back into the environment (return flows), with all entries expressed quantitatively. These tables are constructed to satisfy the accounting rule that total supply equals total use. Hence, the origin of the flow (supply) and its destination (use) are clearly identified. The physical supply and use tables (PSUT) also have the same structure and sectors as the system of national accounts. Another key element of SEEA water accounts are the physical water asset tables, covering both opening and closing stocks, internal flows and external inflows (resources) as well as outflows and return flows. The water asset tables are described in Chapter III.

The National Water Resources Master Plan (NWRMP) provided the starting point for data and issues covered in this Water NCA document. The NWRMP covers the whole country with disaggregation to two main catchments at Level 0 (Nile and Congo basins), nine catchments at Level 1 and twenty catchments at Level 2. This first version of Water Accounts document focuses at the national level. Further disaggregation may be possible in later versions.

2.2 Water Use and Supply 2012

This section summarizes overall water flows in Rwanda for year 2012 as built from the NWRMP (RNRA, 2015) with additional data collected from key institutions. The NWRMP summarizes data on water use and supply for 2012 and covers the main water users including agriculture, manufacturing, mining, electricity and households. The NCA framework, however, goes beyond the sources and categories covered in the NWRMP, including data on some water types (e.g., soil water and groundwater). Further NCA, following SEEA, categorizes economic sectors following the International Standard Industrial Classification of All Economic Activities (ISIC), which facilitates comparison with national economic data in Rwanda’s National Accounts maintained by NISR. For agriculture, the NWRMP records data on irrigation and fishing but not on rain-fed agriculture and forestry, so for NCA there was a need to reference other data sources to complete the PSUT for 2012, especially considering the importance of rain-fed agriculture in the economy. Data quality and consistency issues are discussed in the next section.

The compiled 2012 NCA Physical Use (Table 1) and Supply (Table 2) matrix is shown in Tables 1 and Table 2 on the following pages. The 2012 table is featured here as an achievement of completion and data consistency that built the capacity and methods needed to extend the effort to years beyond the NWRMP base year. The tables for year 2013, 2014 and 2015 can be seen in Annex G.

Table 1: *Water exchanged between the environment and the economy (abstractions) and within the economy (use within the economy) for year 2012 based on NWRMP following PSUT – Use format, and based on collected additional data in 10^3 m^3*

'000 m^3		Industries (by ISIC categories)										Total Production activities	Households	U. Activities of extraterritorial organizations and bodies	Rest of the world	Total
		A. Agriculture, forestry and fishing	B. Mining and Quarrying	C. Manufacturing	D. Electricity, gas, steam and air conditioning supply	E. Water supply (WASAC & AquaVirunga)	I. Accommodation and food service activities	K. Banking and insurance activities	P. Education	Q. Human health and social work activities	S. Other service activities (Religious & Burial)					
ISIC-Rev.4 Code:		1-3	6-8	10-13. 22, 32	35	36-38	55-56	64-66, 71-72, 75	85	86, 88	94, 96	Total	98	99		
From the environment	**1 - Total abstraction (=1.a+1.b = 1.i+1.ii)**	**13,563,381**	**22,391**	**23,638**	**335,270**	**53,009**	**0**	**0**	**133**	**589**	**12**	**13,998,422**	**40,435**	**0**		**14,038,857**
	1.a Abstraction for own use	**13,563,381**	**22,391**	**23,552**	**335,270**	**3,213**	**0**	**0**	**133**	**589**	**12**	13,948,540	**40,435**	**0**		13,988,975
	1.b Abstraction for distribution	**0**	**0**	**86**	**0**	**49,796**	**0**	**0**	**0**	**0**	**0**	49,882	**0**	**0**		49,882
	1 - Total abstraction (1.i+1.ii)	**13,563,381**	**22,391**	**23,638**	**335,270**	**53,009**	**0**	**0**	**133**	**589**	**12**	**13,998,422**	**40,435**	**0**		**14,038,857**
	1.i From water resources:	**13,562,574**	**1,031**	**23,610**	**335,270**	**53,009**	**0**	**0**	**133**	**91**	**2**	**13,975,719**	**39,885**	**0**		**14,015,604**
	1.i.1 Surface water	**189,336**	**967**	**14,845**	**335,270**	**41,024**	**0**	**0**	**0**	**0**	**2**	581,444	**11,301**	**0**		592,745
	1.i.1.a Lakes	**13,252**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	13,252	**5,040**	**0**		18,292
	1.i.1.b Rivers	**109,805**	**967**	**11,482**	**145,952**	**41,024**	**0**	**0**	**0**	**0**	**2**	309,232	**5,116**	**0**		314,348
	1.i.1.c Reservoirs (Dams, ponds, ..)	**47,347**	**0**	**0**	**189,319**	**0**	**0**	**0**	**0**	**0**	**0**	236,665	**11**	**0**		236,677
	1.i.1.d Combined River & Reservoirs (Dams, ponds, ..)	**18,932**	**0**	**3,362**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	22,294	**1,134**	**0**		23,428
	1.i.2 Groundwater	**13,830**	**64**	**8,765**	**0**	**11,985**	**0**	**0**	**133**	**91**	**0**	34,867	**28,583**	**0**		63,451
	1.i.2a From Boreholes	**4,243**	**0**	**3,249**	**0**	**0**	**0**	**0**	**126**	**18**	**0**	7,637	**3,659**	**0**		11,296
	1.i.2b From Springs	**9,586**	**64**	**5,516**	**0**	**11,985**	**0**	**0**	**7**	**73**	**0**	27,230	**24,925**	**0**		52,155
	1.i.3 Soil water (green water)	**13,359,408**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	13,359,408	**0**	**0**		13,359,408
	1.ii From other sources	**807**	**21,360**	**28**	**0**	**0**	**0**	**0**	**0**	**498**	**10**	**22,703**	**550**	**0**		**23,253**
	1.ii.1 Collection of precipitation (rainwater harvesting; ..)	**807**	**21,360**	**28**	**0**	**0**	**0**	**0**	**0**	**498**	**10**	22,703	**550**	**0**		23,253
	1.ii.2 Abstraction from the sea	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	**0**	**0**		0
Within economy	**2. Use of water received from other economic units**	**90,250**	**0**	**642,764**	**0**	**0**	**16,673**	**76**	**224,372**	**3,721**	**132**	**977,987**	**176,061**	**6,515**		**1,160,563**
3. Total use of water (=1+2)		**13,653,631**	**22,391**	**666,402**	**335,270**	**53,009**	**16,673**	**76**	**224,505**	**4,310**	**143**	**14,976,409**	**216,496**	**6,515**		**15,199,420**

Table 2: *Water exchanged between the economy (abstractions) and the environment and within the economy (supply within the economy) for year 2012 based on NWRMP following PSUT – Supply format, and based on collected additional data in 10^3 m^3*

'000 m^3		Industries (by ISIC categories)											Households	U. Activities of extraterritorial organizations and bodies	Rest of the world	Total
		A. Agriculture, forestry and fishing	B. Mining and Quarrying	C. Manufacturing	D. Electricity, gas, steam and air conditioning supply	E. Water supply (WASAC & AquaVirunga)	I. Accommodation and food service activities	K. Banking and insurance activities	P. Education	Q. Human health and social work activities	S. Other service activities (Religious & Burial)					
		1-3	6-8	10-13. 22, 32	35	36-38	55-56	64-66, 71-72, 75	85	86, 88	94, 96	Total	98	99		
Within the economy	**4. Supply of water to other economic units**	**0**	**21,271**	**817**	**0**	**0**	**12,671**	**6**	**0**	**0**	**0**	34,765	**0**	**0**		**34,765**
	4.a Reused water	**0**	**21,271**	**346**	**0**	**0**	**12,671**	**2**	**0**	**0**	**0**	34,291	**0**	**0**		**34,291**
	4.b Wastewater to sewerage	**0**	**0**	**471**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	474	**0**	**0**		**474**
To the environment	**5. Total returns (= 5.a+5.b)**	**1,529,662**	**54**	**514,699**	**318,507**	**2,570**	**301**	**57**	**179,498**	**3,448**	**11**	2,548,806	**82,781**	**5,212**		**2,636,799**
	5.a To water resources	**1,529,662**	**54**	**514,699**	**318,507**	**2,570**	**301**	**57**	**179,498**	**3,448**	**11**	2,548,806	**72,433**	**5,212**		**2,626,451**
	5.a.1 Surface water	**769,541**	**1**	**514,526**	**318,507**	**2,570**	**159**	**47**	**44,210**	**0**	**1**	1,649,563	**41,390**	**4,689**		**1,695,642**
	5.a.2 Groundwater	**81,951**	**2**	**167**	**0**	**0**	**0**	**5**	**135,288**	**3,201**	**9**	220,623	**20,695**	**523**		**241,841**
	5.a.3 Soil water	**678,169**	**51**	**6**	**0**	**0**	**142**	**5**	**0**	**247**	**0**	678,620	**10,348**	**0**		**688,968**
	5.b To other sources (e.g. sea water)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	**10,348**	**0**		**10,348**
6. Total supply of water (= 4+5)		1,529,662	21,325	515,516	318,507	2,570	12,972	62	179,498	3,448	11	2,583,571	82,781	5,212		**2,671,564**
7. Consumption (3-6)		12,123,969	1,065	150,886	16,764	50,438	3,700	14	45,008	862	133	12,392,838	133,715	1,303		**12,527,856**

Notes:

- *Zero indicates missing data that may be available from some source, but not yet compiled here.*
- *Following the SEEA structure and for completeness, PSUT Tables 2 and 3 include a line for sewerage. Sewerage water accounted here is only for a few industries. Rwanda does not have a national system to treat wastewater but has semi centralized sewerage system in Kigali. Ministry of Infrastructure (MININFRA) has plans to implement a sewerage system through the Water and Sanitation Corporation (WASAC).*
- *Losses of water in the distribution system will receive more attention in the next version of the water accounts.*

Key features of the PSUT are the accounting framework and consistent structure featuring economic sectors and households across the top and sources of water inflows and outflows down the left side. Users of the matrix can see not only total use of water by economic sector, but also the sources of that water from surface water, rain water, groundwater, and soil water (reading down the columns). On the supply table, users can examine supply of water between economic sectors and how much water is eventually returned to the environment, specifically to surface or ground water systems. These tables are a rich data source for examining relationships of the physical supply and use flows and the economic use of water, even more so over time. The tables also provide opportunities to derive more valuable data and information that will help Rwanda report on the SDG6 water indicators. This is taken up in more detail in Chapter IV.

The PSUT also illustrate that the structure of the NCA Water Accounts allows disaggregation between groundwater, surface water and soil water. This enables water managers and decision makers to consider the distinct issues associated with each. The Netherlands Statistics Institute has noted that abstraction from surface waters may cause fewer problems to the environment and to water resource management than abstractions of fresh groundwater. The impact of groundwater abstraction may be more severe, leading to water stress situations (NSI, 2016). The NCA approach also distinguishes and quantifies supply and use of 'soil water' which is important to consider in Rwanda because of the dominance of rain-fed agriculture.

2.2.1 Water Flow Data Sources, Quality and Challenges

The compilation of a full set of physical water flow accounts tables for 2012 to 2015 started with data available in NWRMP (RNRA, 2015). However, the compilation was challenging as significant elements of basic data were incompatible or incomplete. The sources and types of data used in this NCA effort are shown in Table 3, along with challenges encountered in the quality and consistency of data. NISR's well-developed National Accounts facilitated the linkage with sectoral data on employment, value added and broader economic indicators. The physical water flow accounts and physical asset accounts are analyzed in connection with economic data in Chapters III and IV. Some additional data collection was conducted to fill gaps. In addition, there was a major effort by a comprehensive Technical Working Group (TWG) that considered wider literature, sectoral studies and expert advice to establish the physical water flow accounts.

To improve understanding of water supply and demand across sectors, the data gaps and inconsistencies need to be addressed in a systematic manner. This will also facilitate the compilation of water accounts in future versions that include more details at catchment level and at sectoral level. To guide future efforts to improve data sources and quality, and to improve consistency with the SEEA guidelines, the TWG developed a questionnaire that can guide data collection and recording across sectors (see Annex C).

Table 3: Water Flow Data Requirements and Issues in Rwanda

Data source	Type of data	Challenges
MoE & RWFA	Surface water and groundwater abstraction and use: • Total area covered by forestry • Mining sector uses of water • Surface water (Artificial reservoirs, Lakes, Rivers and Streams) • Groundwater (wells, springs) • Soil water (area from Land Use Change Matrix) • Sources of used water; and Water returns	• All water users are not recorded • All mining data was not recorded • Different and inconsistent data sets and formats • Lack of data on some important rivers (e.g., flows from Uganda through Muvumba river)
NISR	Household and (partial) industry water use: • Water abstraction and sources (incl. IBES) • Surface and ground water uses • Rain water harvesting uses • GDP and Value added; Formal employment • Business registry classified by economic sector (ISIC) 2012-2015 • Daily livestock water use as per the Rural Water Supply Guidelines-Local Government	• Data were based on estimation • Business registry of WASAC and AquaVirunga coded client data have significant overlap and there is a need for update and expansion
WASAC	Urban water supply: • Water abstracted for own use • Water abstracted for distribution and return water • Monetary data (costs) and water losses	• The data were summarized • This utility is supplying water in urban areas only
AQUA-VIRUNGA	Rural water supply: • Water abstracted for own use • Water abstracted for distribution • Water losses and returns • Monetary data (costs)	• This rural water supply utility is operating in a small part of the Northwest of the country
MINAGRI/ RAB	Agriculture and fishing data: • Land allocated for irrigation and the actual area cultivated/irrigated • Rain-fed agriculture areas • Water abstracted • Water use and sources of water • Livestock population and water use • Production, Costs and revenues	• Inconsistent data set based on estimation • Incomplete or unavailable data (e.g. water abstracted in many irrigated areas) • Inadequate farm level data
Rwanda Meteorology Agency (RMA)	• Rainfall data • Evaporation data • Soil moisture content data	• In some stations data are not continuous (data gaps)
Self-suppliers (or Private Operators); I.e. via RBM&E questionnaire	• Water abstraction and use for mining • Water production and use by source of water • Water losses • Monetary data (costs and revenues) • Livestock population • Daily livestock water use	• Uncertainty as to whether the data refer to abstraction/production or actual water use • Unmetered water abstraction data for the livestock sector • Incomplete data from some mines.
Water using sectors: Hotels, Industries, Schools, Hospitals, etc.)	• Water sources (abstracted water for own use) • Water use, losses and returns • Monetary data (costs) • Rainwater harvested	• Some water used is not recorded • Rainwater harvested is not known or considered in some institutions
Literature review	• Evapotranspiration data	• Sometimes estimates were used • Included FAO-WAPOR data

2.3 National Water Use and Supply and Trends for 2012-15

This section describes the state and change of water use and supply by sector and by source. This analysis is derived from the detailed water use and supply trends that are available at national level. These detailed trends can be found as annexes to this document, available for download from the NISR and RWFA websites (www.rwfa.rw).

Trends in Water Use by Industrial Sector. Figure 1 shows total abstraction of water as allocated to different economic sectors of the economy. These data are summarized from the PSUT annual tables in Annex G. The figure illustrates the importance of agriculture as a major water user, responsible for more than 96% of overall water use. More than 80% of this is due to rain-fed agricultural uses while the remaining is for irrigation, fishing, forestry and livestock. Agriculture water use fluctuated over this period, with no clear trend emerging. These proportions remained largely unchanged during 2012, 2013, 2014 and 2015. In terms of growth in water use, electricity was the fastest growing category, increasing by almost 20% from early 2012 to late 2015. Water use for education also grew rapidly (not visible in Figure 1 due to scale and dominance of agriculture) but remains relatively limited as share of the total.

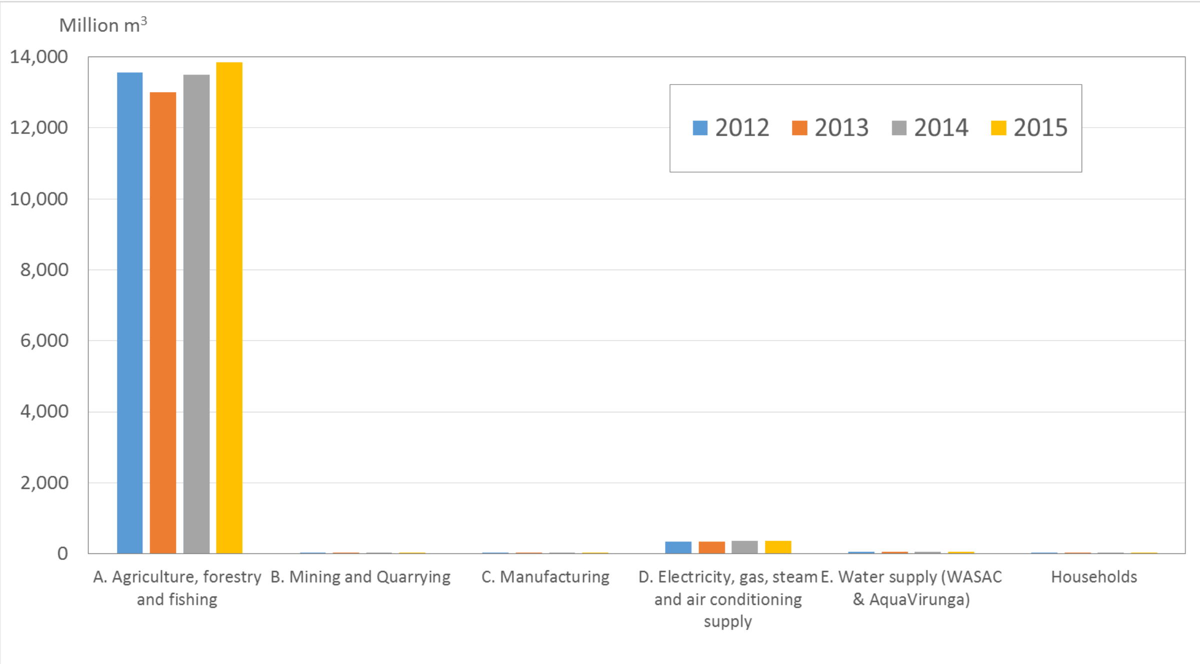


Figure 1: *Total Water Abstraction from environment, 2012-2015 (Mm^3)*

Figure 2 shows water consumption by sector, which shows a different pattern from abstraction (withdrawal). The Figure shows that agriculture is the largest consumer of water, while mining and electricity appear to be less important. This is because in agricultural production large volumes of water are diverted from the inland water system to the atmosphere and embodies some water in the final product, while electricity and mining generally pass the water through a process or turbine and return it directly to the inland water system, relatively unchanged (although there may be some pollution introduced).

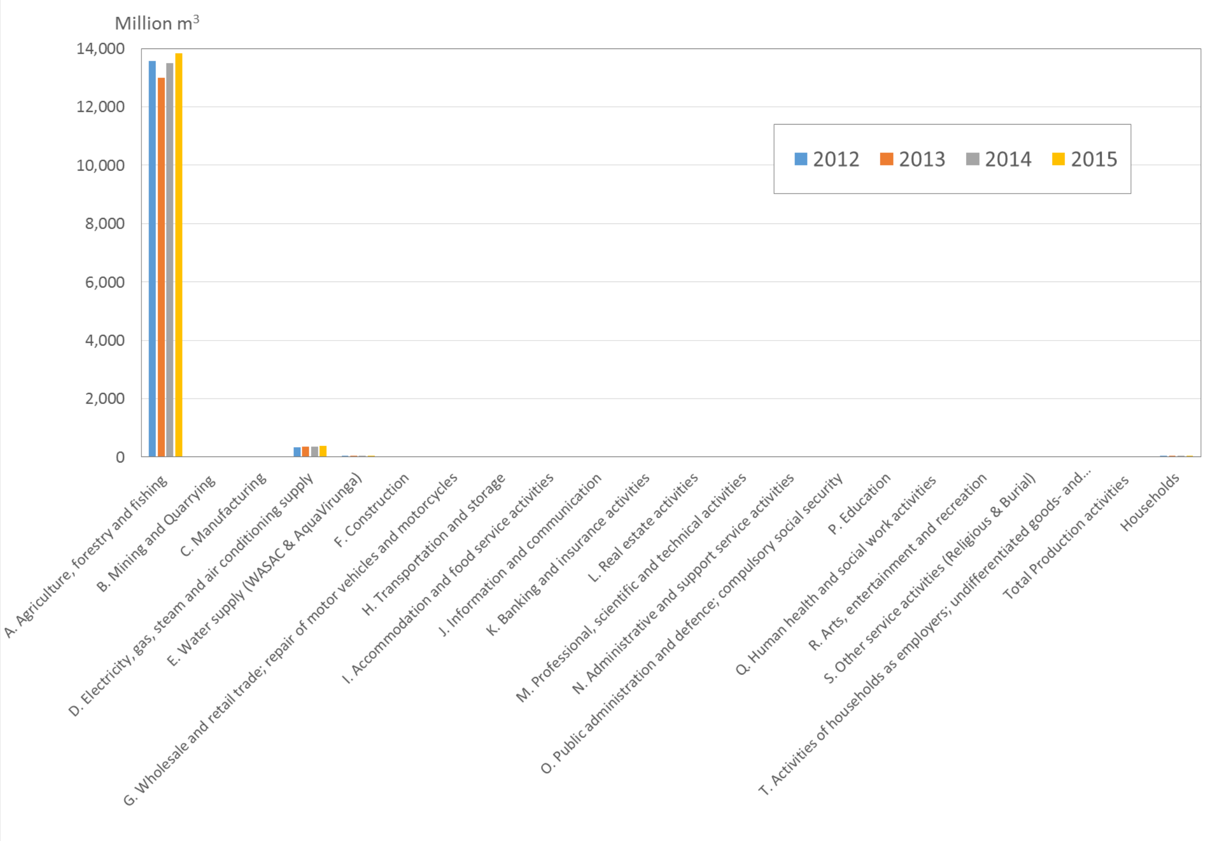


Figure 2: *Trends in Water Consumption by Sector, 2012-2015*

Because agriculture dominates the results above, Figure 3 below shows the same data without Agriculture to allow more detailed view of water consumption in other sectors. This shows that the second tier of water consumers are: Education, Households, Electricity, Manufacturing, Mining, and Water Utilities. Other service sectors are relatively minor water consumers by comparison: Accommodation, Banking and Insurance, Human Health, Religious and Burial and NGOs to year trends are not very marked, except for electricity, already mentioned as a high abstraction / low consumption sector.

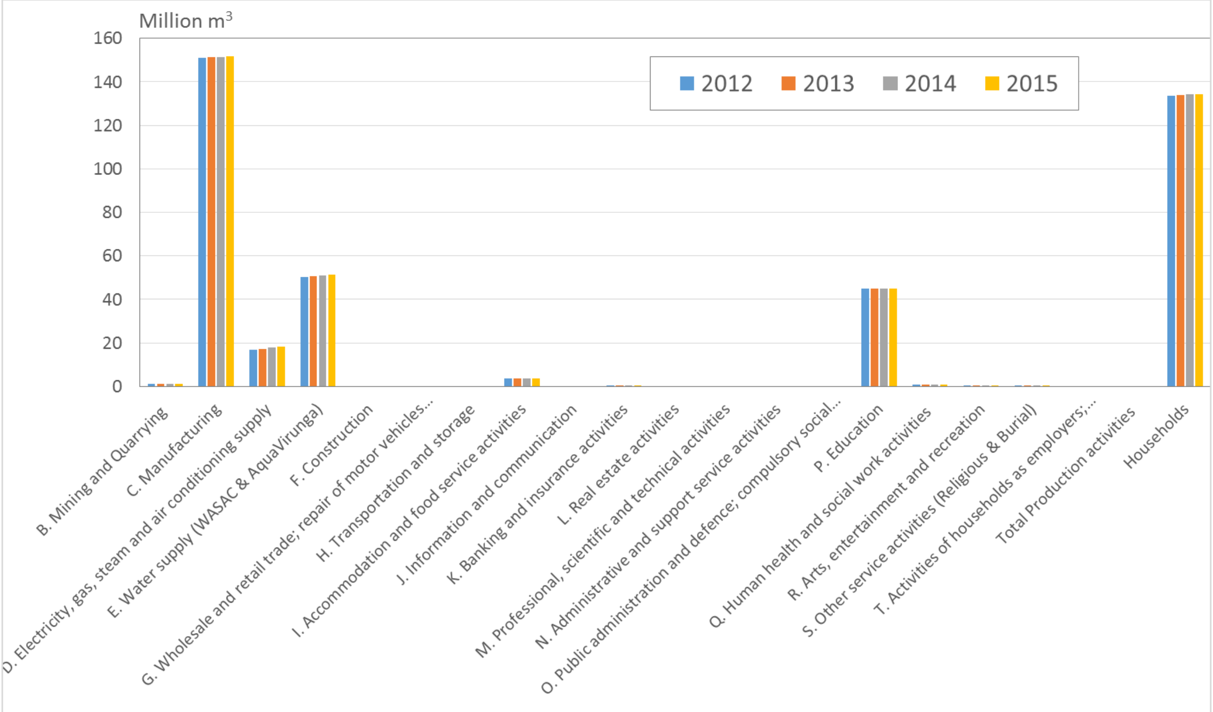


Figure 3: Water Consumption by ISIC categories (Excl. Agriculture), 2012-2015 (Mm^3).

Trends in Water Use by Source. This section examines water use based on the source of water: surface water, groundwater, soil water, etc. Figure 4 below shows abstraction of water from different water sources over the 2012-2015 period. This shows that most water is abstracted in the categories soil water/green water (mainly used in rain fed agriculture production), from land and from river systems (mainly other urban and rural water uses). As soil water is an integral part of the (agricultural) land it does not face competition from other sectors. The period of analysis for this water account is only four years, a short horizon for analysis of long term trends in water use. However, it is instructive to note that abstraction from rivers has tended to increase slightly year by year. This trend is discussed further below.

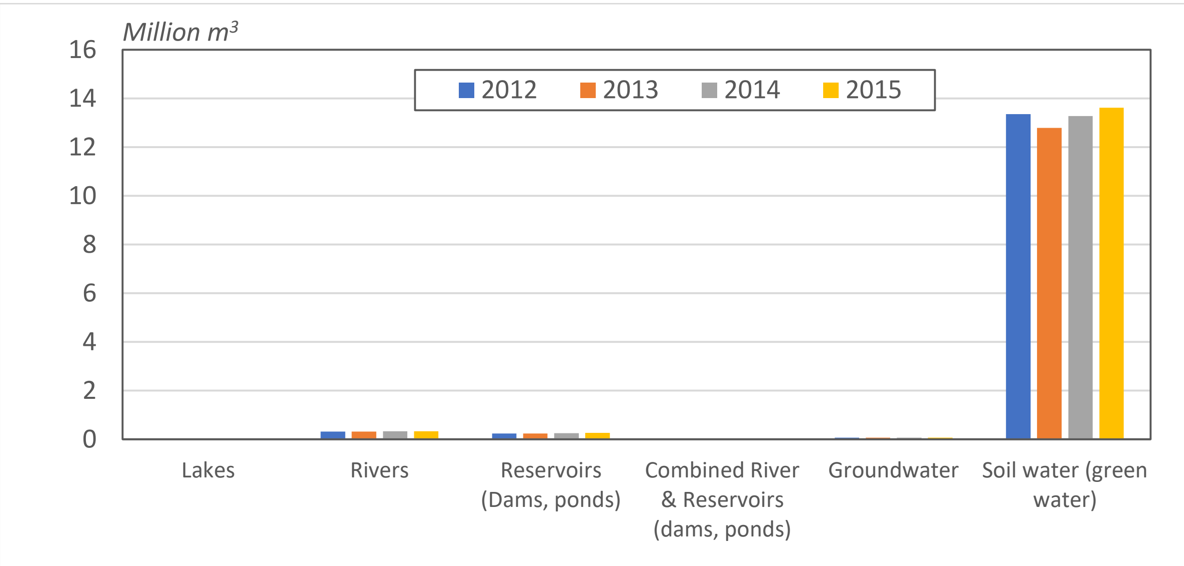


Figure 4: Overall Annual Water Abstraction by Water Source/Stock, 2012-2015

Figure 5 below focuses only on surface water and shows abstraction now broken down by industry/sector. The graph shows the highest levels of surface water abstraction by the electricity sector (increasing over the four-year period). The figure also shows a lower (but growing) level of abstraction by agriculture and by water supply operators. As noted, this is because agriculture relies more on rainfall (recharging soil water) than on direct abstraction from surface or groundwater.

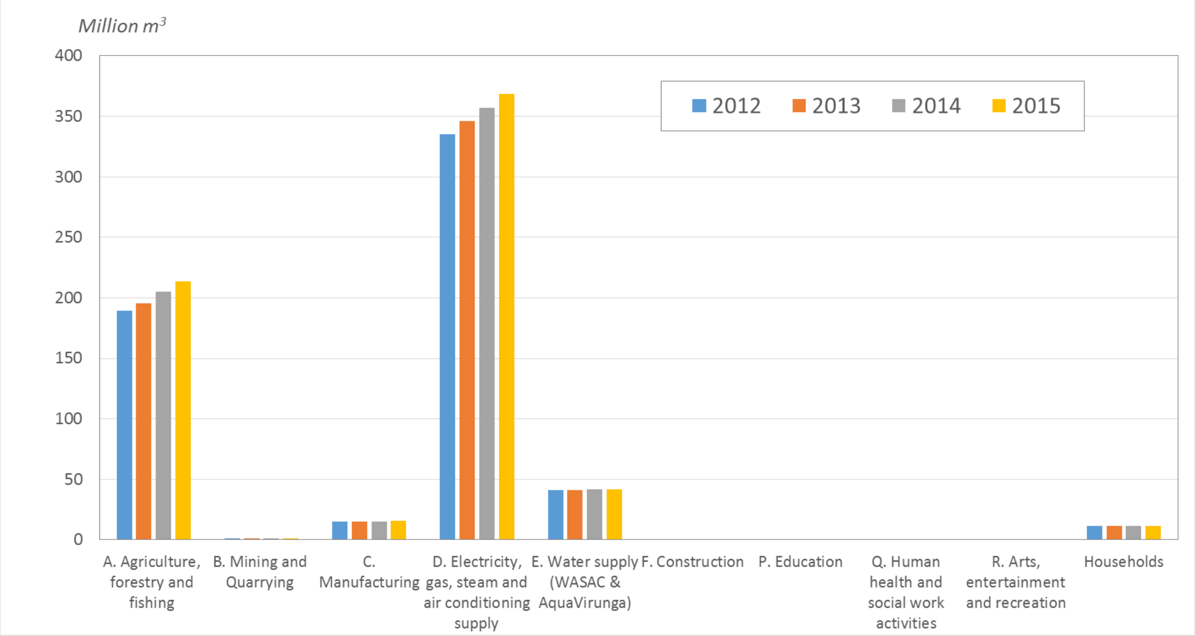


Figure 5: *Annual Abstraction of Surface Water by Industrial Sector, 2012-2015*

This observed level of abstraction from surface water can be understood in the context of Rwanda's national economic goals. To boost the economy, the GoR has prioritized both electricity generation and mining as an important source of revenue. Following this policy, hydropower electricity production increased by 21.16% from 2012 to 2014, resulting in an increase of 24% in water diverted from rivers during the same period. Rwanda's mining sector uses traditional and small-scale methods that require large quantities of water. The data do not yet show a large rate of increase year by year.

Households are another important user of both surface and ground water. Although the volume of water use by households is much lower than electricity and mining, the rate of increase of households is expected to rise in the coming years (it grew by 2% from 2012 to 2015).This is due to rapid increase of the population, as well as the improvement of hygienic conditions between 2012 and 2015. Households are also the largest and fastest growing user of groundwater, as shown in below.

Figure 6 below focuses only on ground water and shows abstraction broken down by industry/sector. The graph indicates that households, agriculture and water utilities lead in abstraction of groundwater, with around 45%, 22% and 19%, respectively. The amount of water abstracted at household level is more than two times that abstracted by water utility agencies. Rwanda's water utilities have very limited capacity and supply to a small number of the people located mainly in cities and a small part of the Northwestern part of the country. Most of the rest of the rural population is using other sources of water like harvested rain water, springs, and wells, and other sources of groundwater (ref. EICV2;-NISR, 2006; MINIRENA, 2017).

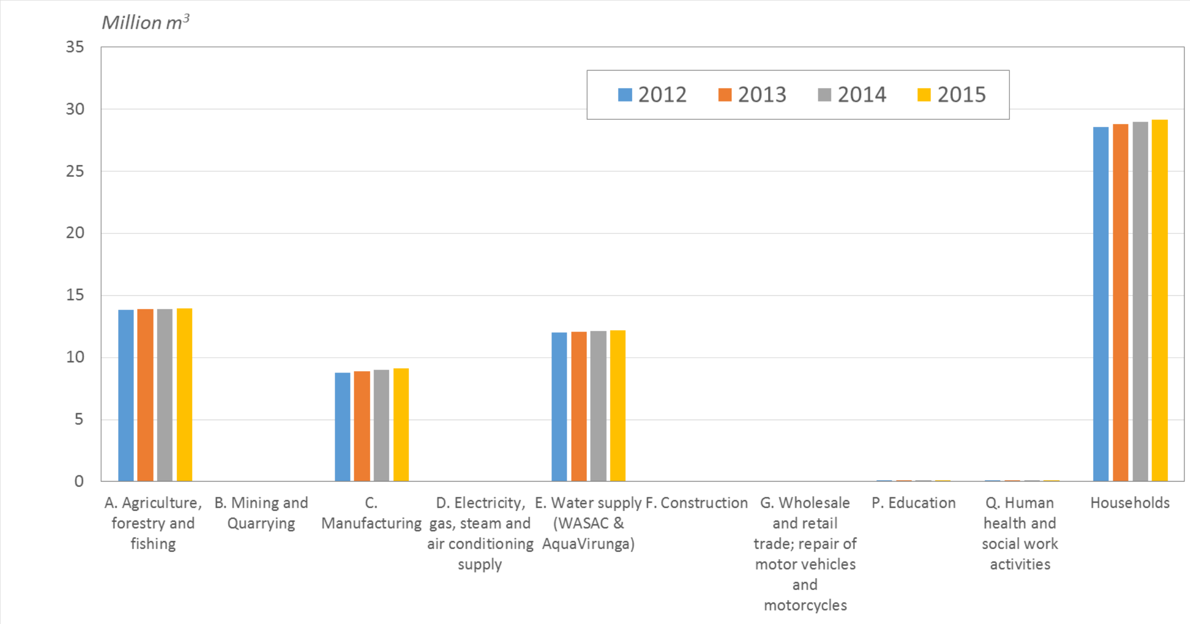


Figure 6: *Annual Abstraction of Groundwater by Industrial Sector and households, 2012-2015*

This section has shown how physical water accounts are useful for reporting and understanding water use by type of water body, by sector of the economy and households, over time. As the time series is lengthened by continuing production of the water accounts and documents, the data will become more useful for analyzing trends and analyzing questions that inform policy. This section also served to introduce the technical language of the water sector and the NCA process, with distinctions between abstraction and consumption and types of water sources. Future versions of the water accounts will aim to introduce a geographic dimension to the analysis.

CHAPTER III: Water Asset Accounts (Stocks/Resources)

3.1 Overview of Water Asset Accounts Statistics, Definitions, Data Sources

A full set of physical water asset accounts (tables) for the period 2012 to 2015 has been compiled through the efforts of a dedicated and skilled Technical Working Group (TWG), comprised of members from key institutions. The work started from key national references, such as the NWRMP, and progressed to include data from a wide range of sources and institutions. There were challenges where basic data were missing or incomplete. Some data issues have been addressed in this version of the accounts through estimation, assumptions and professional judgment. This process has highlighted data quality, availability and compatibility issues that should be addressed in a systematic manner going forward. These are summarized in Chapter V.

3.1.1 Water Asset Accounts Definitions

In the SEEA framework, water asset accounts describe the stocks of water resources at the beginning and the end of an accounting period and the changes in stocks that have occurred during that period. Water resource assets are defined as water found in freshwater, saline surface water and groundwater bodies within the national territory that provide direct use benefits, currently or in the future (option benefits), through the provision of raw material, and may be subject to quantitative depletion through human use. The SEEA-Water asset classification of water resources consists of the following categories (UN, 2012b): Surface water (artificial reservoirs, lakes, rivers and streams, glaciers, snow and ice), Groundwater and Soil water. For Rwanda, glaciers, snow and ice are not relevant.

Water asset accounts are a useful supplement to a country's System of National Accounts (SNA). The SNA defines water resources within its asset boundary as "*surface and ground water resources used for extraction to the extent that their scarcity leads to the enforcement of ownership and/or use of rights, market valuation and some measure of economic control*". Thus, SNA accounts for only a small portion of water being used in economic processes, while NCA aims for more complete coverage of a country's water assets, while also illustrating and quantifying provisioning and regulating services of the environment.

As Rwanda's NCA efforts advance, the SEEA framework allows adaptation and further disaggregation of the water asset classification in accordance with country priorities and data availability. For example, Rwanda could choose to further disaggregate artificial reservoirs according to the type of use, such as for water supply, agriculture, hydroelectric power generation or mixed use. Rivers could be further classified as perennial or seasonal, where water flows only intermittently.

Boundaries between the different categories in the asset classification, such as between lakes and artificial reservoirs and rivers and lakes/reservoirs, are not always precise. However, this is mostly a hydrological problem; it does not affect the accounts. Where clear separation of two categories is not possible, a combined category could be introduced in the table for ease of compilation. This version includes only national level data and estimates. For future versions of the Water Accounts, it could be useful to disaggregate the asset account to catchment level.

3.1.2 Water Asset Data Sources and Challenges

Water assets consist of physical water that is available to provide future benefit, such as the volume currently in a dam, lake, river, soil water and groundwater (Burrell and Nguyen, 2012). Water resources data compilation in Rwanda is a challenge, as in many countries, because data are maintained in different institutions for different purposes. There is no single database or institution where all water data can be accessed and analyzed. The water asset data compiled in this account was provided by a range of institutions that use, manage, plan, invest, monitor, and distribute water, including: MoE, RWFA, MINAGRI, RAB, WASAC, and Private operators. Data were also accessed from analytical reports and research documents available to the members of the Technical Working Group (TWG). The types of data provided by each institution as well as the data limitations are summarized in Table 4 below.

Table 4: *Water Asset Data Requirements and Issues in Rwanda*

Data source	Type of Data	Remarks / Limitation
MoE & RWFA	Water resources data: • Surface water data (Artificial reservoirs, Lakes, Rivers and streams) • Groundwater data (wells, springs) • Soil water (area obtained from NCA Land Use Change Matrix combined with soil layer, assessment of stock and provision of water from unsaturated (root) zone)	• Some of the data was obtained from NWRMP • Some of the data was estimated
Rwanda Meteo Agency (RMA)	• Rainfall (precipitation) and evaporation data • Evaporation • Soil moisture, national & regional	• Rainfall: Incomplete data, but largely available at daily level • Evaporation: It is estimated data, stations are not well distributed countrywide • Evapotranspiration (ET): Estimated from evaporation using mathematical equations
MINAGRI (LWH-RSSP, RAB)	• Dam and other reservoirs constructed capacity of artificial reservoirs • Number of water tanks and ponds constructed • Soil water, starting from soil layer description and knowledge	• Assessments on actual storage were conducted on estimation of average depth to capacity • Assess influence of sediment over time • Some required data are not available
Literature review	• Evapotranspiration (ET), ideally spatially explicit and preferably actual ET over potential ET	• Can be based on Remote Sensing (Satellite data and added model), as using FAO figures and/or guidelines • Can be based on groundwater modeling and resulting ET

The data collection and accounts compilation process for the water asset accounts included:

- Use of the estimates from NWRMP to compile water asset account for 2012. From there (for some parts) additional data is and in future will be collected for compilation of full series for 2012 – 2015 and beyond.
- Additional data are collected for variables like: precipitation (rainfall), evapotranspiration, soil water, surface water, groundwater and artificial reservoirs for 2012 - 2015.
- For a number of items in the asset table, data were collected and processed, including: opening stocks and closing stocks for each type of water, additions with internal flows and external inflows (resources) and returns of water, as well as reductions with

abstraction, loss via evaporation and transpiration, outflows and return flows and exchange between the inland water assets.

- In the last stage of compiling, the Water Asset table is 'balanced' following National Accounts procedures and data quality checking is done.
- Physical Water Asset Account tables were compiled and analysed.

In future versions of the water accounts, improvements will be needed in institutional capacity and systematization of data sources, which will allow more consistent and efficient compilation according to SEEA guidelines. As noted in Chapter II, a questionnaire in Annex C can contribute to data improvement as the accounts are updated for regular publication.

3.2 National Water Assets for 2012-2015 and Trends

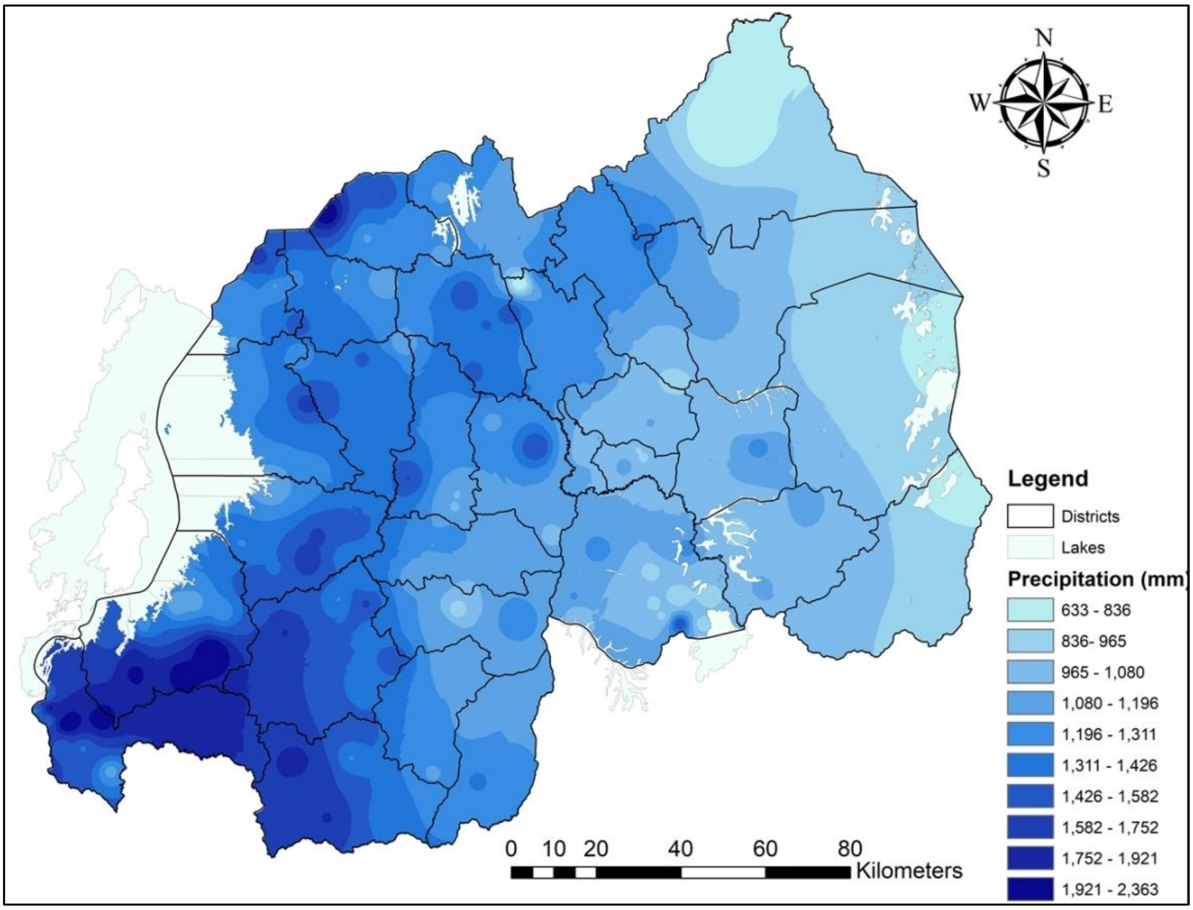
The compiled water asset table for 2012 is shown in Table 5 below. This section presents graphics that describe results on the state and change of water assets in Rwanda for a period of 2012 to 2015. This analysis is derived from the detailed water asset trends that can be derived from the asset accounts at national level. These data will be refined in future versions as monitoring, measurement and estimations are improved.

Table 5: *Physical Water Asset Account for 2012 (Million m^3)*

Units in Million Cubic Meters	Surface water			Soil water	Groundwater	Total	Internal Renewable water resources	Total Renewable water resources
	Lakes	Rivers and streams	Artificial reservoirs					
Opening stock water resources	258,132	1,264	60	3,389	62,127	324,972		
Additions to stock								
Returns of water	1	322	0	136	1	459		
Precipitation	2,205	2,627	108	28,620		33,560	33,560	33,560
Inflows from other territories	0	850	0		0	850		850
Inflows from other inland water resources	1,636	4,859	288	911	3,644	11,338		
Total additions to stock	3,842	8,657	396	29,667	3,646	46,208	33,560	34,410
Reductions in stock								
Abstraction of water	18	314	260	0	63	656		
Actual Evaporation and transpiration	1,401	56	17	21,277		22,751	22,751	22,751
Outflows to other territories		6,430	0		0	6,430		
Outflow to the sea		0	0		0	0		
Outflow to other inland water resources	2,863	1,857	117	8,390	3,582	16,810		
Total reductions in stock	4,283	8,658	393	29,667	3,645	46,647	22,751	22,751
Closing stock water resources	257,690	1,264	63	3,389	62,127	324,532	10,809.1	11,659.3

The asset tables originated with NWRMP data on surface water stored in artificial reservoirs, lakes, rivers and streams, groundwater (wells, springs) and in the soil water system. As noted, the process identified areas where additional data needed to be collected from other institutions during field visits and from desk studies and literature review conducted by the TWG. The asset tables for 2013 to 2015 are shown in Annex G, with yearly trends summarized here. Datasets can be found on the NISR and RWFA websites (www.rwfa.rw).

This physical asset account (Table 5) shows that lakes and groundwater make up most of the volume of Rwanda's overall water assets. Rivers and streams, soil water and artificial reservoirs constitute a much smaller volume, though they play an extremely important economic role, in terms of water provisioning and regulating services.

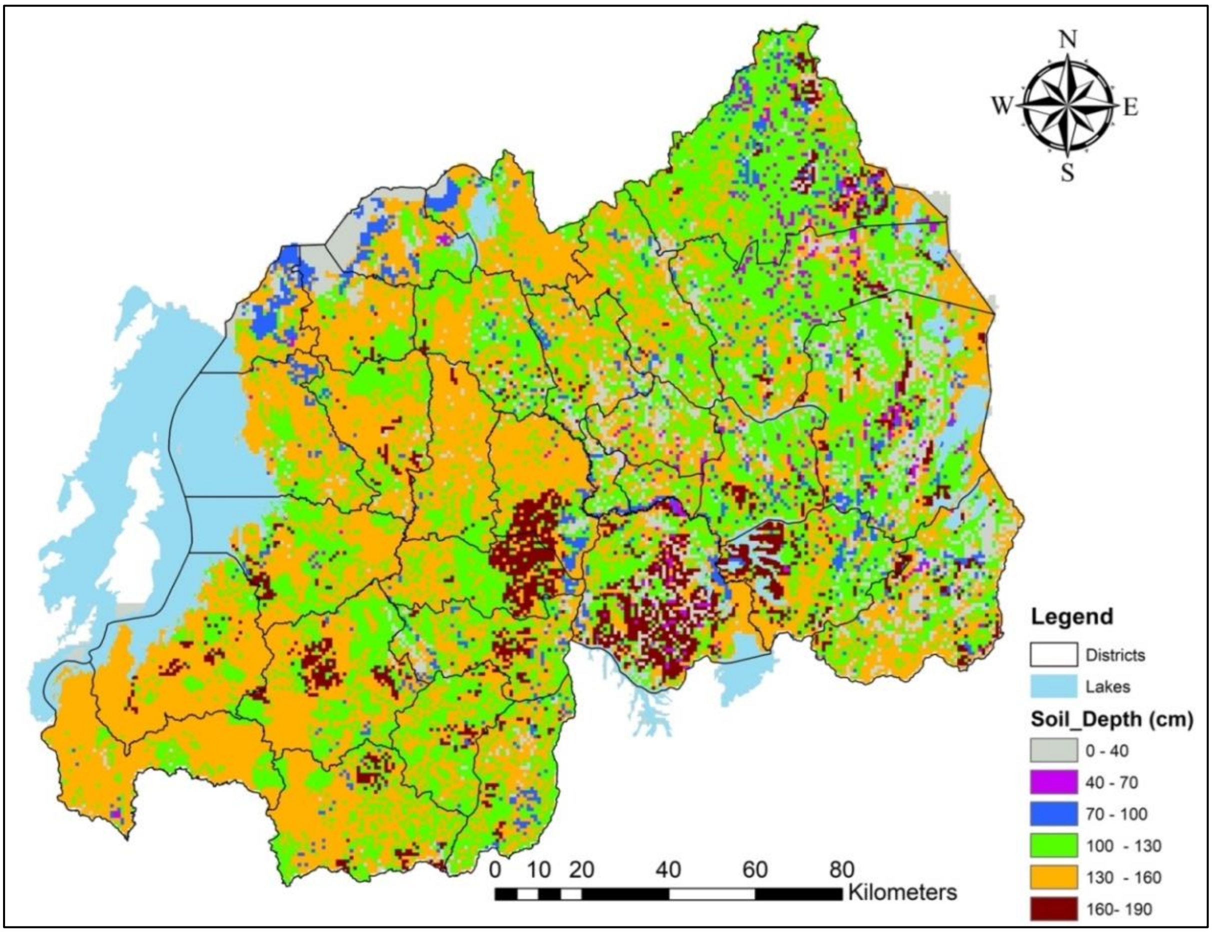


Map 2: *Average Annual Precipitation Rwanda, 2017*
Source*: Rwanda Meteorology Center*

Map 2 shows the distribution of precipitation over Rwanda[8]. The NCA Water Accounts precipitation figures are based on data from 85 rain gauge stations situated across the country, operated by Rwanda Meteorology Agency (RMA) and weighted. The physical asset accounts tables show that most precipitation infiltrates to the soil water system, all in a limited upper soil band of up to 2 meters. This asset table reflects a technical feature that there is no direct route from precipitation to groundwater. Precipitation first adds to soil water and then percolates further into groundwater. Water from precipitation first may flow as runoff from the steeper hillsides, but later can percolate into the soil- and ground-water system in low lands and valleys. For this reason, the share of rainfall entering to soil water varies by location and estimating the average rate for the country is challenging. In the next phase of water accounts compilation, the NCA initiative can examine the effect of varying the assumptions about the share of rainfall that flows as runoff instead of recharging the groundwater through sensitivity analysis that would help to illustrate the implications of any underlying assumptions.

[8] Map 2 is interpolated data from this RMA dataset. The interpolation method applied for distributing rainfall is the inverse distance weighting with power 2 at a spatial resolution of 50 meters.

Map 3 shows the distribution of soil layer thickness across the country, which is important for assessing water provisioning from ground- and soil water stored in the various soils and of retention of moisture. These are somewhat dated figures. Because of the concerns about erosion and soil loss, it will be useful to update the underlying data with more recent and actual measurements.



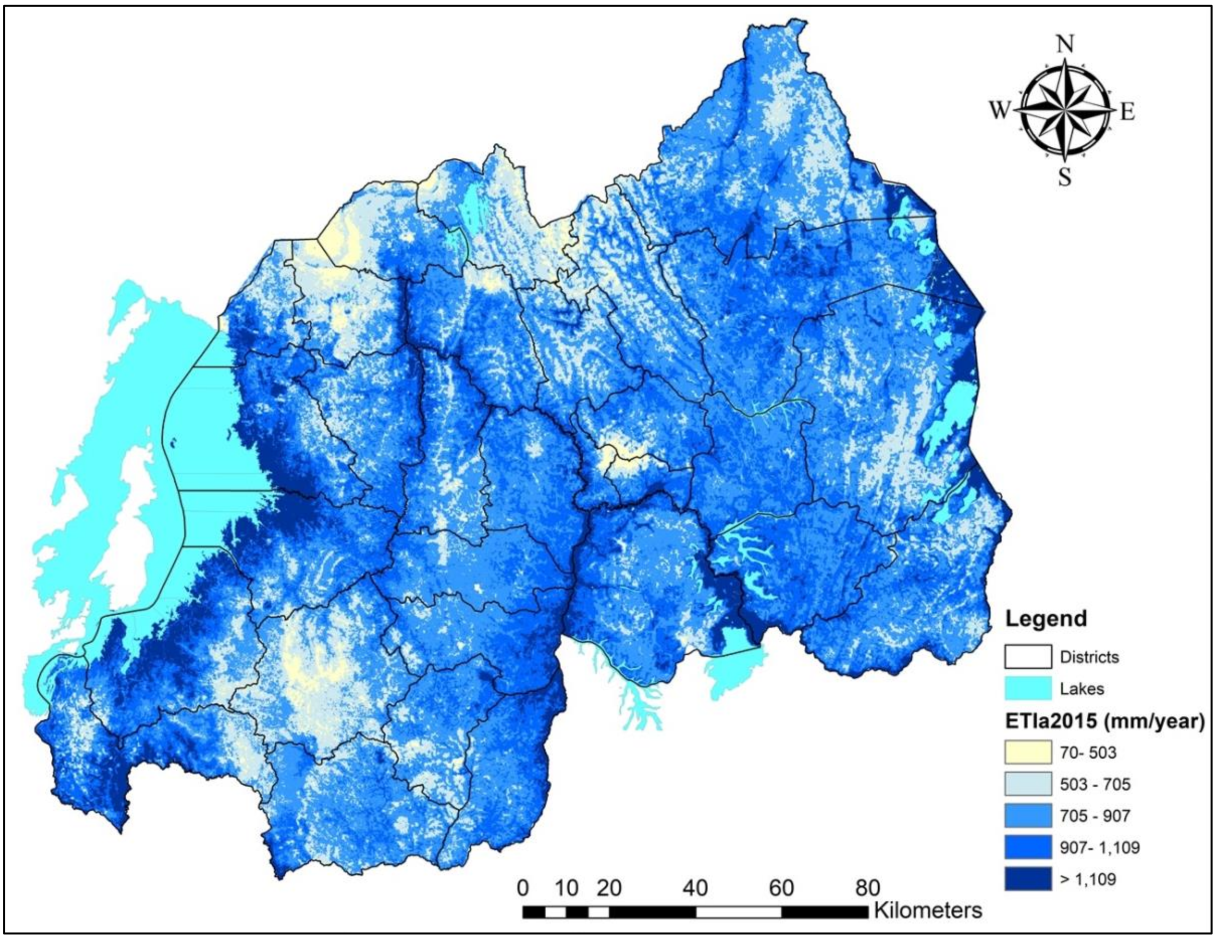
Map 3: *Soil Layer Depths for Ground- and Soil Water Provisioning and Retention, Rwanda*
Source*: MINAGRI*

The infiltration process from soil water into groundwater is quantified in the asset account via the element labeled "Inflows from other inland water resources," which is balanced with its counterpart at the bottom labeled "Outflows to other inland water resources."

Map 4 shows evapotranspiration across Rwanda.[9] The evaporation, plant transpiration and interception are influenced by climatic variables and soil condition including: wind speed, radiation, air temperature and soil moisture content (FAO, 2017). From 2012 to 2015, annual actual evapotranspiration at the national scale ranged from 118 mm/year up to 1670 mm/year and the annual average was 941, 920, 887 and 863 mm/year for the years 2012, 2013, 2014 and 2015 respectively, showing some decline. For the investigated period, the highest values of ETIa were observed in the Western province.

[9] Actual EvapoTranspiration and Interception (ETIa) is the sum of the soil Evaporation (E), canopy tiTration (T), and evaporation from rainfall intercepted by leaves (I). The data presented in Map 4 are national ETIa with grid cells at a spatial resolution of 100m*100m for the years 2012 up to 2015. The data were acquired from the UN-FAO portal to monitor water productivity through open access of remotely sensed derived data (WaPOR) initiative (FAO, 2017). The method and details for ETIa calculations are described in (FAO, 2018).

In terms of annual additions and subtractions, rainfall and actual evapotranspiration are the key factors. The largest inflow is from precipitation (33,560 Mm^3), which contributes about 90% of total additions to the stock. Actual evapotranspiration accounts for about 22,750 Mm^3 of reductions in stock. The net result of these additions and reductions is that the Internal Renewable Water Resources (IRWR) for 2012 was 10,809 Mm^3 while the Total Renewable Water Resources (TRWR) volume is 11,659 Mm^3 (due to relatively limited inflows from other territories). Previous precipitation figures were based on other sources and long-term averages.



Map 4: *Actual EvapoTranspiration and Interception (ETIa) Rwanda, 2015*
Source*: Rwanda Meteorology Center*

The Evapotranspiration figures represent actual ET values derived from potential evapotranspiration figures (reference crop), which itself is based on ideal soil moisture conditions. Because rainfall and actual ET are such key determinants of agricultural productivity, it will be important in the future to improve and use the best measures of the yearly precipitation and of Actual ET, both nationally and with geographic disaggregation One option is to use FAO's WaPOR database that is based on frequently updated satellite data and models that are calibrated with sufficient monitoring data on the ground.

Inflows and outflows to other countries are relatively small, compared to other sources of water. This reflects Rwanda's high elevation and mountainous terrain. The amount of water entering Rwanda from other territories upstream is substantially less than (about one-eighth) the volume that flows to other countries downstream.

Looking at 2012, the opening stock of water resources was about 325.0 billion m^3 while the closing stock was 324.5 billion m^3. This implies a small loss of about 0.01% of the total water stock (or 440 million m^3), noting that the estimates contain some uncertainties. This loss is not substantial but may merit a further look at more years of data to understand regular fluctuations and continuing trends.

3.2.1 Water Asset Trends

Rwanda's NWRMP provides water stock information for 2012. This water asset account extends the water stock information for each year through 2015. This allows thorough monitoring of precipitation and ET patterns. This section assesses water assets trends over this four-year period in Table 6 below. These are only preliminary results for several reasons. The four-year period does not allow analysis of long-term trends. Also, the available data and estimation methods resulted in the same annual figures for opening and closing stocks in rivers and streams, of soil water and groundwater for each of the four years. These placeholder estimates can be updated as further data collection and on-site measurement proceeds. There are positive future prospects for that, such as soil moisture measurements based on remote sensing and the gauging stations recently and currently installed in several rivers throughout the country. This will provide data and generate information to facilitate accounts compilation and better water management. This section provides an early exploration of changes for the different water stock categories, given the data and timeframe available.

Table 6: *Water Resource Stocks and Percent Changes For 2012-2015 in Mm^3.*

Units in Million Cubic Meters	Surface Water			Soil Water	Groundwater	Total
	Lakes	Rivers & streams	Artificial reservoirs			
Closing stock 2012	257,690	1,264	63	3,389	62,127	324,532
Closing stock 2013	257,248	1,264	68	3,389	62,127	324,096
Closing stock 2014	256,807	1,264	77	3,389	62,127	323,664
Closing stock 2015	256,365	1,264	102	3,389	62,127	323,247
Percent change over 2012-2015	**-0.51%**	**0.00%**	**63.14%**	**0.00%**	**0.00%**	**-0.40%**

Table 6 also shows that most of Rwanda's water is stored in lakes (around 80%) followed by groundwater (19%). Table 6 shows a very small reduction (0.4%) in overall water stock over the reporting period, due to the decrease reported in lake water. While the large volume of water stored in lakes decreased a small amount (0.5%), the small volume of water in artificial reservoirs is increased by a large amount (63.14%). Regarding the changes in lakes, this can be attributed to hydrological processes whereby rainfall is balancing with all water outflows in the inland water system while the data reported here for water in rivers remains constant. This is due to the estimation method. The water stock in rivers is based on historical data from 1955 to 2000 collected from different rivers (as reported in NWRMP, RNRA, 2015). Rwanda has a national monitoring system that measures surface water flows, water quality, and groundwater at a range of monitoring stations throughout the country[10]. This system is gaining in coverage and accuracy and can provide a basis for improving the estimates of water stocks and flows on an annual basis. The next versions of the water account will be updated with improved values and coverage of the years 2016 and 2017.

[10] See Rwanda's water portal: https://waterportal.rwfa.rw/ and for surface water: https://waterportal.rwfa.rw/data/surface_water, showing locations of stations with the option to download data.

Regarding the increase of water volume in artificial reservoirs, this could be related to a combination of Government policies that promote expansion of hydropower capacity, moving from rain-fed agriculture to irrigated systems (MINAGRI), as well as the rainwater harvesting policy established by the Ministry of Environment. Many dams are being constructed as years advance, both for irrigation and for power generation, and this is showing as an increase in artificial reservoirs water assets. Some of the increase of water resources in artificial reservoirs can also be explained by the increase in precipitation and inflow over evaporation and abstraction of water in each year. In 2012, for example, received precipitation in artificial reservoirs was 108 Mm^3 and inflows from other inland water resources was 221 Mm^3. In contrast, abstracted water for 2012 was 225 Mm^3 and evaporation was 17 Mm^3. Although water storage in reservoirs is increasing due to recent new capacity, the effects of erosion and resulting sedimentation in reservoirs can gradually reduce their water storage capacity. Erosion and sediment export models developed under the Science for Nature and People Partnership (SNAPP) project show increasing sediment export in the period from 2010 to 2015. These results are further developed in the Ecosystem Accounts that are under preparation. The Rwandan government seeks measures to restore the existing storage capacities in dams in the near future.

The natural capital accounts for water can provide guidance for policy makers. For example, since the use of artificial reservoirs is increasing, there will be a need to protect the watersheds of these reservoirs, which influence rainwater infiltration and runoff levels, as well as the quality of water entering them. Protection of the riparian zone and upper watersheds is also important for protecting the quantity and quality of water in Rwanda's natural lakes.

The accounts also highlight the importance of soil water and groundwater assets, which are normally hidden from view, but extremely important for agricultural production. Preparing for future increases in demand for water, particularly water available for agricultural production for food security, planners and policy makers may want to consider measures to reduce runoff and increase groundwater recharge. The GoR is already supporting terracing on steep and erosive hillsides. Other measures could promote locally available and basic technologies to increase infiltration, such as infiltration trenches along roads and near storm drains to reduce flooding and increase recharge by percolation.

3.2.2 Renewable Water Resources Availability Per Capita and Water Demand

Rwanda's water resources constitute a vital asset that significantly contributes to socio-economic development and poverty eradication (Nsubuga et al. 2014). Water demand in Rwanda is growing, influenced by both rapid population growth, economic growth and urbanization. Currently, the availability of safe drinking water does not meet the needs of the population and distribution is still inadequate (WASAC, 2017). To achieve Rwanda Vision 2020 targets and NST1, 2018-2024, (100% population access to improved water) and SDG Goal 6, Rwanda needs to invest in water infrastructure and improved technologies. Understanding current and future water availability and water demand by different sectors can help in planning for economic development, water management needs and ecosystem protection needs.

3.2.2.1 Water Resources Availability, Water Demand and Issues

On average for the four-year study period, Rwanda receives a total rainfall of 32.4 billion m^3 per year with total evapotranspiration (ET) diverted to the atmosphere of 21.9 billion m^3. From alternative source, a slightly varying value of 27.5 billion m^3 rainfall per year and total evapotranspiration (ET) of 20.7 billion m^3 (RNRA, 2015) were found. Together with external inflow from other territories, the difference between these large inflows and large outflows or 'loss' to the atmosphere, show the resulting net inflow, called total renewable water resources (TRWR), which is about 11.3 billion m^3 per year for the study period.

Table 7 shows projected water demand in 2040 based on expected population growth, based on the NWRMP (2015). Total water demand in 2040 by households, industries, crops, livestock, irrigation and power is estimated at 3,366 Mm^3, with irrigation accounting for about two-thirds of demand and households representing about a quarter of overall demand.[11] Thus, projected water demand in 2040 would be about one-third of the estimated TRWR of 11.3 billion m^3 per year, before including the amount of water consumed by agriculture production (non-irrigated). As shown previously (Figure 1), in 2012 more than 90% of the country's annual fresh water use (from rivers and lakes) was consumed by the agriculture sector, which also contributed 31% of GDP in 2016 (NISR). These future projections assume no changes in average available amount of renewable water resources and full implementation of proposed irrigation schemes, which might not necessarily be the case.

Table 7: *Water Availability by Catchment and Projected Water Demand by Category (Excluding Environmental Demand) to 2040 in '000 m³/year*

Basin code	Renewable water resources	Domestic Water Supply (HH)	Industries	Coffee WS	Live stock	Fish Ponds	Total Irrigation	Other Power	Total water demand by 2040
CKIV	898,000	115,633	34,690	38	3,047	1,245	151,403	6,421	312,475
CRUS	432,000	26,070	7,821	10	676	1,230	9,881	473	46,161
NNYU	1,290,000	119,166	35,750	8	4,600	6,915	189,875	0	356,313
NMUK	905,000	100,974	30,292	1	3,034	1,530	13,490	2,523	151,844
NNYL	899,000	172,942	51,883	20	5,405	9,045	367,594	580	607,469
NAKN	798,000	112,007	33,602	10	4,598	17,775	370,092	3,075	541,158
NAKU	504,00	89,009	26,703	9	3,017	10,770	527,848	0	657,356
NAKL	907,000	41,503	12,451	2	2,925	9,840	409,882	0	476,604
NMUV	193,00	47,578	14,274	0	1,946	7,860	144,839	0	216,497
SUM	**6,826,000**	**824,882**	**247,465**	**97**	**29,249**	**66,210**	**2,184,904**	**13,072**	**3,365,878**
% of Total Demand		24.5%	7.4%	0.0%	0.9%	2.0%	64.9%	0.9%	100%

Source: RNRA, 2015

Future conditions will be affected by how the agriculture sector develops and by climate change, which will affect rainfall patterns and potentially crop productivity. Decreasing regular precipitation, higher agricultural production levels, changes in technology, and introduction of water efficiency measures would all have effects on the water demand–supply balance. Regular update of water accounts can provide indicators that allow monitoring of water demand and supply levels that may highlight where and when stresses may appear.

3.2.2.2 Water Stress Level

Water resources in Rwanda are under pressure due to high rate of population growth, intensification of agriculture, climate change accompanied with more weather extremes, adding

[11] Projected water demand for irrigation is estimated considering the potential area for irrigation of 600,000 ha (National irrigation Master Plan, 2010) and an average water requirement of 5,000 m^3 per ha/year. Household demand is estimated based on the projected population of 16,332,184 (NISR Year Book, 2016).

to soil erosion and degradation, rapid urbanization (at 4.4% per year) and industrialization. At the same time, development projects are being regularly implemented in different catchments, such as terracing and agriculture investments, which affects land use and water use, as well as the provisioning and regulating environmental services from land and water assets.

The Sustainable Development Goals Target 6.4 relates to water use and scarcity, with the target defined as: "By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity." The SDG guidance notes that a "high level of water stress can result in negative effects on economic development, increasing competition and potential conflict among users, which calls for effective supply and demand management policies and an increase in water-use efficiency." (http://www.sdg6monitoring.org/indicators/target-64/).

Table 8 shows the internal renewable water resources availability per year per capita from 2012 as reported ~~per~~ by World Data Atlas (2014) with additional data from NWRMP (2015) and results from this NCA effort. The international standard (unwater.org, 2017) defines *water stress* when annual water supplies drop below 1,700 m^3 per person and *water scarcity* when annual water supplies drop below 1,000 m^3 per person. This table compares estimates of water availability from several sources to illustrate differences and highlight trends.

Table 8: *Internal Renewable Water Resources Availability Per Capita (m^3/capita/year)* [1)]

Source	Historic – Long-term	2012	2013	2014	2015
World Data Atlas		878	857		
NWRMP	670				
NCA		1031	863	1007	924

Source: World Data Atlas (2014), NWRMP (2015) MINIRENA (p.15; 2011a); and NCA Rwanda. NWRMP shows the long-term average based on time series of historic data starting from the 1980s. The assessment to update the long-term figure will be done in 2020.
[1)] *Empty cells are either for not-applicable or unavailable data.*

The NWRMP estimated the long-term average of annual surface water 'runoff' while the SEEA approach (followed in this NCA work) considers rainfall minus evapotranspiration as 'Internal Renewable Water Resources (IRWR)' on annual basis. It is an indicator of the volume of water a country can rely upon to meet socio-economic needs and requirements for food and livelihood, covering the water that remains in land after transpiration by plants and crop or loss via evaporation (together, these are 'evapotranspiration' (ET)). The differences and commonalities in these estimation approaches are explained in Text box 1

Text box 1. *Methodologies for assessment of Renewable Water Resources for Rwanda*

Differences and commonalities exist in methods applied under NWRMP and under the SEEA – based methodologies used for the NCA work.

IRWR (Internal renewable water resources):
SEEA-W: Average annual flow of surface water and recharge of groundwater generated from endogenous precipitation. It is often operationalized in NCA as domestic Precipitation minus Evaporation and transpiration. This result in the inland water system in groundwater recharge and runoff, contributing to river flows.

$IRWR = P \text{ -/- } ET$

NWRMP: the volume of long term annual average flow of surface water and groundwater generated from precipitation within the country.

$IRWR = R + I \text{ -/- } (Q_{OUT} \text{ -/- } Q_{IN})$

Where:

- P = Precipitation, rainfall and other inflow to inland (from the atmosphere)
- ET = Evapotranspiration = Evaporation and transpiration (to the atmosphere)
- R = surface runoff, the total volume of the flow of surface water generated by direct runoff from precipitation (for NWRMP showing the: long term annual average), after subtracting ET;
- I = groundwater recharge, generated from precipitation within the country, after subtracting ET;
- R + I = together the volume that results from precipitation and inland groundwater recharge, but both after subtracting ET;
- Q_{OUT} = groundwater drainage into rivers (typically, base flow of rivers);
- Q_{IN} = seepage from rivers into aquifers;
- (Q_{OUT} -/- Q_{IN}) do overlap, and principally show the (net) exchange of water between rivers and groundwater (incl. aquifers).

Conclusion: both definitions for IRWR show strong overlap. The net from Q_{OUT} -/- Q_{IN} were not assessed in the SEEA format, assuming there is gross but no net flow between groundwater and rivers. These elements are hard to assess separately and the net effect for each single year.

ERWR (External renewable water resources):
SEEA-W: Total external renewable water resources are the inflow from neighbouring countries (transboundary groundwater and surface water inflows), and the relevant part of the shared lakes and border rivers. The assessment considers the natural resources generally and shows the part of the country's renewable water resources shared from neighbouring countries. If there are reservations in neighbouring countries, they are called actual resources.

$ERWR = SW_{IN} + SW_{PR} + SW_{PL} + GW_{IN}$

NWRMP: The ERWR are equal to the volume of average annual flow of rivers and groundwater entering a country from neighbouring countries.

$ERWR_{NATURAL} = SW_{IN} + SW_{PR} + GW_{IN}$

Where:

- SW_{IN} = surface water entering the country;
- SW_{PR} = accounted flow of border rivers;
- SW_{PL} = accounted part of shared lakes;
- GW_{IN} = groundwater entering the country.

Conclusion: both definitions for ERWR show strong overlap. The accounted part of shared lakes is treated differently.

TRWR (Total renewable water resources):
SEEA-W: The sum of internal and external renewable water resources. The difference between Total natural and Total actual renewable water resources, depends on existence of agreements with other countries, often for the same river basin. Natural TRWR shows the maximum theoretical amount of water available for a country on an average year on a long reference period, while actual TRWR takes into consideration the quantity of flow reserved to upstream and downstream countries through formal or informal agreements or treaties and reduction of flow due to upstream withdrawal.
NWRMP: The TRWR equals the sum of IRWR and ERWR.

Sources: SEEA-Water (UN, 2012b); (RNRA, (2015).

The key point for water managers and policy makers is that the portion of overall water that effectively can be used to meet demand at the right place can be enhanced by implementing appropriate policies or interventions, such as reducing the direct surface runoff through catchment restoration, water transport, and water storage technologies.

Average domestic water use per capita is estimated as 6-8 liters per day (2-3 m^3/capita/year) (MININFRA, 2010, Sub-section '2.2.2 Water Supply', p.7), which is low compared to the minimum required standard by World Health Organization (WHO) of 20 liters per capita per day in rural areas and 40 liters (7-15 m^3/capita/year) in urban area (Republic of Rwanda, 2011). EICV5 reports that progress has been observed in improving use of safe drinking water (87% as compared to 85% in EICV4) and sanitation (86% as compared to 83% in EICV4), (NISR, 2018). Considering the current situation, more knowledge on water use and distribution is required for better management and planning of water resources.

Table 9 reports Total Renewable Water Resource (TRWR) trends for 2012-2015 as a key indicator taken from the water accounts, broken down by major inflows and outflows. The level of rainfall and evapotranspiration also vary year by year without a clear trend. This indicator can help to monitor changes over time that may result from climate change.

Table 9: *Total Renewable Water Resources, 2012-2015, in* Mm^3 [1)]

Units in Million Cubic Meters	**Total Renewable water resources (TRWR)**			
	2012	**2013**	**2014**	**2015**
Opening stock water resources				
Additions to stock				
Returns of water				
Precipitation	33,559.9	31,934.8	31,966.4	32,027.0
Inflows from other territories	850.2	850.2	850.2	850.2
Inflows from other inland water resources				
Total additions to stock	34,410.1	32,785.0	32,816.6	32,877.2
Reductions in stock				
Abstraction of water				
Actual Evaporation and transpiration	22,750.8	22,455.8	20,891.3	21,620.9
Outflows to other territories				
Outflow to the sea				
Outflow to other inland water resources				
Total reductions in stock	22,750.8	22,455.8	20,891.3	21,620.9
Total	**11,659.3**	**10,329.2**	**11,925.3**	**11,256.3**

[1)] *Empty cells are items of the water assets table structure, that are not part of the TRWR computation.*

According to UN-Water (2017b), for SDG 6.4.2, the level of water stress in a year is defined as a ratio between total freshwater withdrawn (TWW) by all major sectors and the total renewable freshwater resources (TRWR) available after considering environmental water flow requirements for preservation of nature and biodiversity. Water Stress (WS) is calculated as:

TWW / (TRWR-Environmental needs) * 100, expressed as a percentage

The severity of WS is classified by:

WS	<	10%			No water stress
10%	<	WS	<	20%	Low water stress
20%	<	WS	<	40%	Moderate water stress
40%	<	WS			High water stress

Combining the results shown in Table 9 with the annual water withdrawal (abstraction) in Figure 1, the level of water stress can be calculated, following the SDG 6.4.2 format as suggested by FAO. These figures are reported in Table 10(b). This preliminary analysis shows a relatively low level of stress (7.2% to 8.1) from 2012 to 2015[12].

Table 10(a): *Water Accounts Results on Water Availability per capita, National Level*

Year	TRWR	Population by NISR	TRWR / capita
	(Million m^3)	*(# capita)*	*(m^3/capita/yr)*
2012	11,659.3	10,482,641	1,112.0
2013	10,329.2	10,978,053	941.0
2014	11,925.3	11,002,628	1,084.0
2015	11,256.3	11,262,564	999.0

Table 10(b): *Water Accounts Results on Water Stress, National Level*

Year	TRWR (A)	Environmental needs (B)	TWW as by RBM&E study and NCA - WA (C)	Water Stress C / (A-B)
	(Million m^3)	*21.9% of TRWR*	*(Million m^3)*	
2012	11,659.3	2553.4	656.2	7.2%
2013	10,329.2	2262.1	673.3	8.3%
2014	11,925.3	2611.6	695.4	7.4%
2015	11,256.3	2465.1	716.2	8.1%

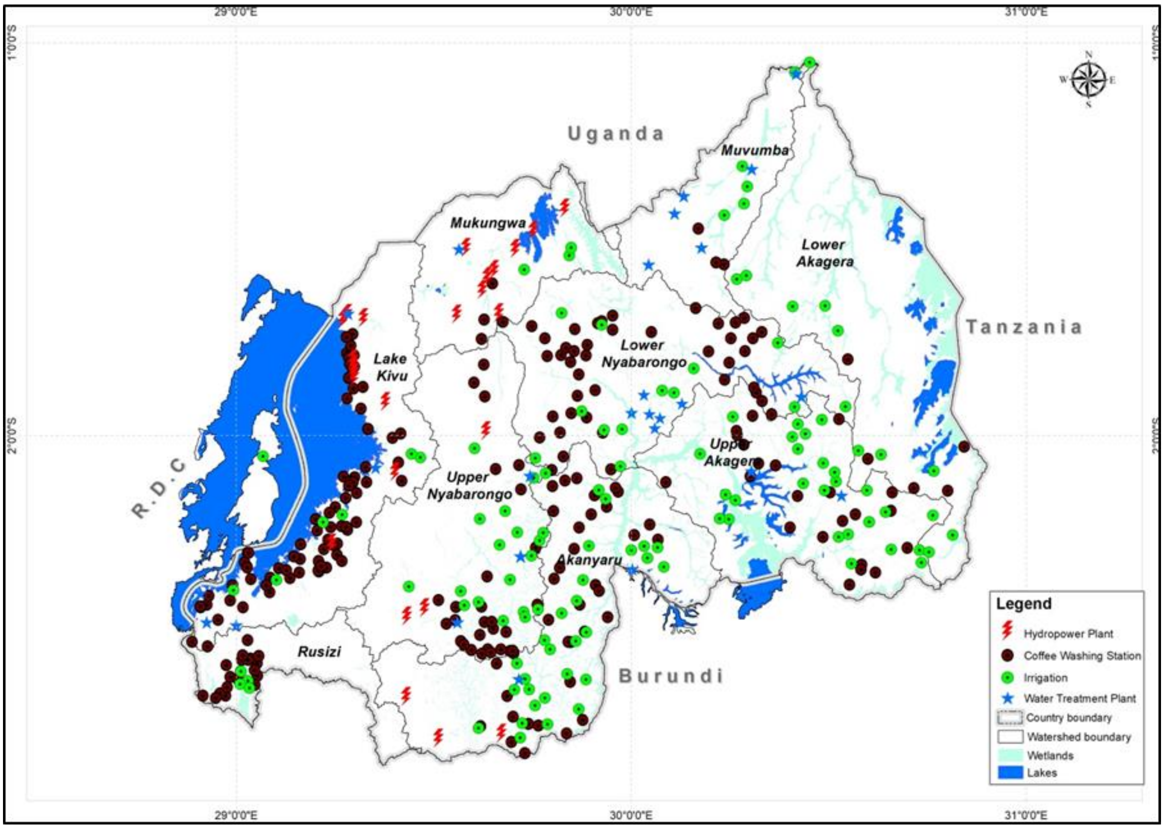
It is important to note the difference in various methods to measure water scarcity or water stress. The one used under table 10(a) considers water availability and population needs while the one under table 10(b) considers water availability and actual water withdrawn for use. The latter was selected to be used to measure the SDG 6.4.2 indicator on water scarcity.

By considering the water availability and actual water withdrawn, Rwanda can be classified as a "no water stress country". However, by considering the water availability (especially using the method applied under the NWRMP, which also means calculation of the historic Long-Term Annual Average, LTAA) and the population needs, Rwanda is classified as a "water stress country" mainly due to limited infrastructures to conserve rainwater. The estimated stress indicator changes over time with population and economic growth and the varying rainfall pattern also have an effect. As these two parameters (population and economic growth) increase, water withdrawals (TWW) also tend to increase, which contributes to the calculated level of water stress of a country. However, as noted above, the time period available for this analysis

[12] For comparison, the water stress indicator was calculated using historical data from FAO/AQUASTAT, together with NCA data. This alternate method estimated the water stress level as 7.5% for 2016. This small difference can be explained by the fact that AQUASTAT uses secondary sources, and the current water accounts results are not yet fully complete (for several industry classifications).

does not allow long-term trend analysis but can inform decision makers on areas that may deserve more attention.

The NCA Water Accounting tables allow calculation of the stress indicator measure for SDG 6.4.2. Table 10(a) shows the variation of the indicator and underlying variables over the four years and with dryer and wetter seasons. These figures will be updated to include longer trend analysis in future versions of the water accounts. Generally, it is expected that water withdrawals would increase over time due to population growth, urbanization and economic development in other sectors. Map 5 shows the location of water treatment facilities, hydroelectric dams and irrigation facility sites in 2017 as an illustration of the types and locations of water abstraction. The data and maps will continue to be refined in future versions of the water accounts.



Map 5: *Water Treatment, Hydroelectric and Irrigation Facility Sites, and Watersheds, 2017*[13]
Source*: Author's own elaboration with data from MINAGRI, WASAC, and REG.*

These Water Accounts bring together data on water supply and use (demand) from many sectors and link these data with economic / societal performance described by the National Accounts. Thus, water accounts can play a role in responding to questions related to efficiency, effectiveness and equity in allocation of the scarce water resource, and in providing indicators of water stress and scarcity and informing the preferred direction of water management. The water accounts (stocks, flows and values) also support derivation of indicators that can help Rwanda to implement its policy on water resources management, track progress under the National Strategy for Transformation (NST1), and report on objectives related to water quantity and SDG 6.4 targets.

[13] The location of irrigation sites provided by MINAGRI mainly corresponds to the water sources in WASAC database. There is a need to harmonize the two databases in order to separate irrigation sites from water sources.

Water accounts together with land use and cover accounts provide a useful base for conducting additional analyses. Rwanda is developing ecosystem accounts and this work was initiated in 2015 by the Wildlife Conservation Society and a consortium of partners under the Science for Nature and People Partnership (SNAPP). The ecosystems, land, and water accounts are expected to be used in an integrated manner to improve the understanding of the contribution of natural resources and ecosystem services to the economy.

Integration of the work on land, water and ecosystems can yield multiple insights, including on the value of land, alternative land use options around protected areas, impacts of land degradation on critical ecosystems – all of which will be useful in Rwanda's development planning process. Some preliminary results from ecosystem modeling are reported in Text Box 2.

Text Box 2. *Linkages between SEEA-Water and Ecosystem Accounts for Rwanda*

The SEEA Experimental Ecosystem Accounts (SEEA-EEA) link changes in the contribution of ecosystems to economic accounts. SEEA-EEA uses spatial modeling to analyze water-related ecosystem services that can build a more complete understanding of Rwanda's water resource management challenges. Ecosystem modeling for Rwanda is working to quantify changes in key ecosystem services for the years 1990, 2000, 2010, and 2015. Ecosystem account modeling efforts draw on land cover maps from the NCA Land Account and precipitation and watershed data from the NCA Water Account. While the work is still in progress, four key findings provide relevant information about the state and trends in Rwanda's water resources:

- First, seasonal water yield models show that 'quick flow' has been increasing, while local recharge has been declining. Quick flow increased by 35% from 1990 to 2015 and by 10% in the more recent period from 2010 to 2015. Quick flow is water that runs off quickly during and just after storms. Local recharge refers to water flows that recharge soil moisture and aquifers, then is slowly released as surface water. These changes in water runoff and recharge are due to land cover change - primarily conversion of forests to annual agriculture from 1990 to 2015. More quick flow can be indicative of flooding and water quality problems (though it is not a direct measure), because water is moving through the system faster with less natural filtration by soils and vegetation. In addition, because local recharge is released into rivers as base flow that keeps rivers running in the dry season, reduced local recharge also increases the risk of dry-season shortages. Recent changes (2010 to 2015) have been more pronounced in Kigali City and the Western and Northern provinces.
- Second, soil erosion models quantified increasing sediment export into water bodies. This measure increased by 123% from 1990 to 2015 and by 39% in the recent period from 2010 to 2015. Recent changes (2010 to 2015) were most pronounced in the Western, Northern, and Eastern provinces, and were less severe in Kigali City and the Southern Province. The Southern Province saw an improvement in soil erosion control, with less sediment export from 2010 to 2015.
- Third, the ecosystem accounts map changes in quick flow and soil erosion not just at the national scale but also for watersheds above the nation's hydroelectric dams, irrigation facilities, and water treatment plants. This modeling can thus identify which watersheds saw substantial increases in soil erosion and quick flow from 2010 to 2015. These analyses can highlight areas where land cover change may be producing water quality, quantity, and timing problems for specific water users.
- More recent experimental work has evaluated ecosystem service trends using models and scenarios for land cover change in Rwanda, projecting forward to the year 2035. Using a nutrient regulation model, land cover scenarios, and predictions of increased fertilizer application to crops (to 45 kg/ha/yr, consistent with the Strategic Plan for the Transformation of Agriculture), preliminary results show that nitrogen and phosphorus exports to Rwanda's rivers and lakes could increase by about 37%. This could constitute a major challenge for water quality and the water users that depend on it.

CHAPTER IV: Water Accounts Linked to Economic Issues

This chapter discusses steps to realize the integration of the physical water supply and use tables from Chapter III with the monetary and economic information in Rwanda's National Accounts (following the International Statistical Standard System of National Accounts, SNA 2008). Linking the two allows analysis of water productivity and efficiency – economic output and value added per unit of water – at the national level and disaggregated by industry sector. The importance of water in terms of employment can be also analyzed at the national and sectoral level. This linkage of the SEEA Water Accounts with National Accounts also enables Rwanda to calculate and monitor one of the key water indicators under the Sustainable Development Goals (SDGs): Water Use Efficiency (WUE) by sector, which is SDG 6.4. A range of additional indicators for comparing the performance of the water sector physically and economically will be discussed. As above, it is important to note that this is Rwanda's first effort to compile and summarize water accounts for the years 2012 to 2015. Data quality and consistency will continue to be improved in upcoming versions, for example in the categorization and comparability of industry sectors. The ability to analyze trends will be improved with inclusion of newer data for 2016 and 2019 in a second version of the accounts.

4.1 Integrated National Economic Account and Physical Water Use Account

The combination of physical accounts with monetary or economic accounts can be referred to as 'hybrid' flow accounts. This reflects the use of different measurement units – physical quantities matched with economic flows – in similarly structured accounts using the International Standard Industrial Classification code (ISIC, Rev.4) as the basis for relating the two datasets. This then allows analysis of the volume of water used with measures of economic activity, such as value of output, value added, and employment, as well as the derivation of indicators of water use efficiency or productivity. The strength of the SEEA – type accounts is this comparability with countries' National Accounts.

Figure 7 below compares water use, contribution to GDP and employment by sector. The figure presents the share of each measure by industry sector for 2015, the most recent year covered by this effort. The sector categories have been grouped for simpler exposition. For GDP, the National Accounts data reported by NISR for 2015 were used. For employment, the figures were reported for February 2016 in the NISR labour force survey and include "informal employment"[14]. The water figures are derived from the physical Water Accounts presented in Chapter III. Note that several indicators of water use can be developed and these yield different results when comparing across sectors. See Text Box 3 later in this chapter for discussion of water use indicators.

This figure shows, as in Chapter III, that the agriculture sector uses the largest share of water nationally (whether measuring water use or water consumption), while contributing about 30 percent to GDP and almost half of overall employment. This is in line with estimates for many other African countries whose economies rely on agriculture and natural resources. As discussed in Chapter III, this measure of water use includes rainwater, soil water, and water abstracted from surface and ground water. Because Rwandan agriculture is primarily rain-fed, the sector uses a lot of water but does not put much pressure on the country's water supply infrastructure. The main users of fresh water originally abstracted from surface and groundwater are mining, manufacturing, and electricity production sector, in that order. However, different indicators will produce different comparisons.

[14] NISR first introduced Labor Force Surveys (LFS) in line with international Standards in February 2016. Thus, given that such data were not available before, we thought it would be an acceptable move to report them for Rwanda labor statistics for year 2015.

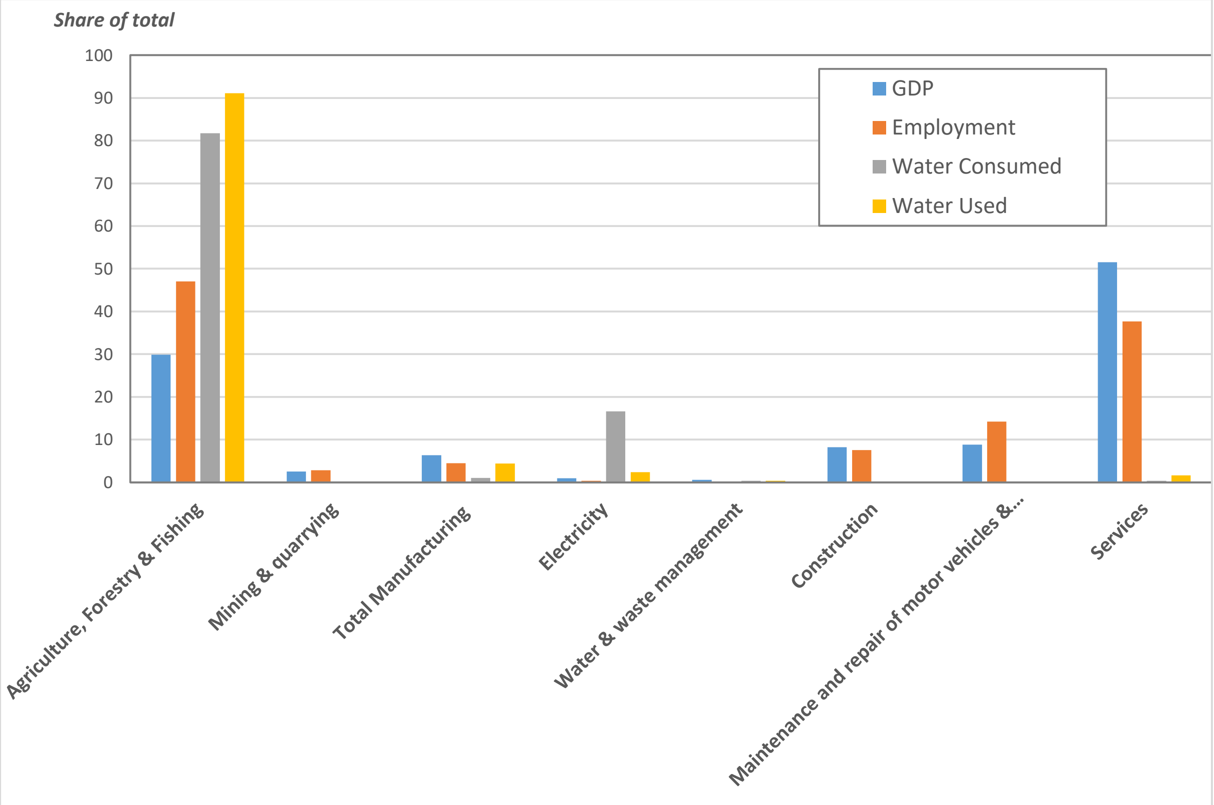


***Figure 7:** Shares of GDP, Employment, Water Used and Consumed (2015) by Industrial Sector*

Figure 8 shows that agriculture uses 96 percent of water captured for human use, and most of this is for low value crops. In contrast, less than 4% of water is consumed by industries, schools, hospitals, and other high value uses. Thus, even though service sectors may use very little water for high value products, total production output and value added, the average productivity remains low. However, planned developments in energy, agriculture, infrastructure, industry and household needs, indicate that water demand in these sectors is projected to increase by 27% in the next 30 years to 2040: from 2.47 billion to 3.37 Billion m^3. This water demand projection does not consider water demand for rain-fed agriculture and for hydropower production. Finally, about 13% of the 33.5 km^3 (2012) of annual rainfall (RNRA, 2015), leaves the country as runoff and is thus not available to recharge ground and soil water assets.

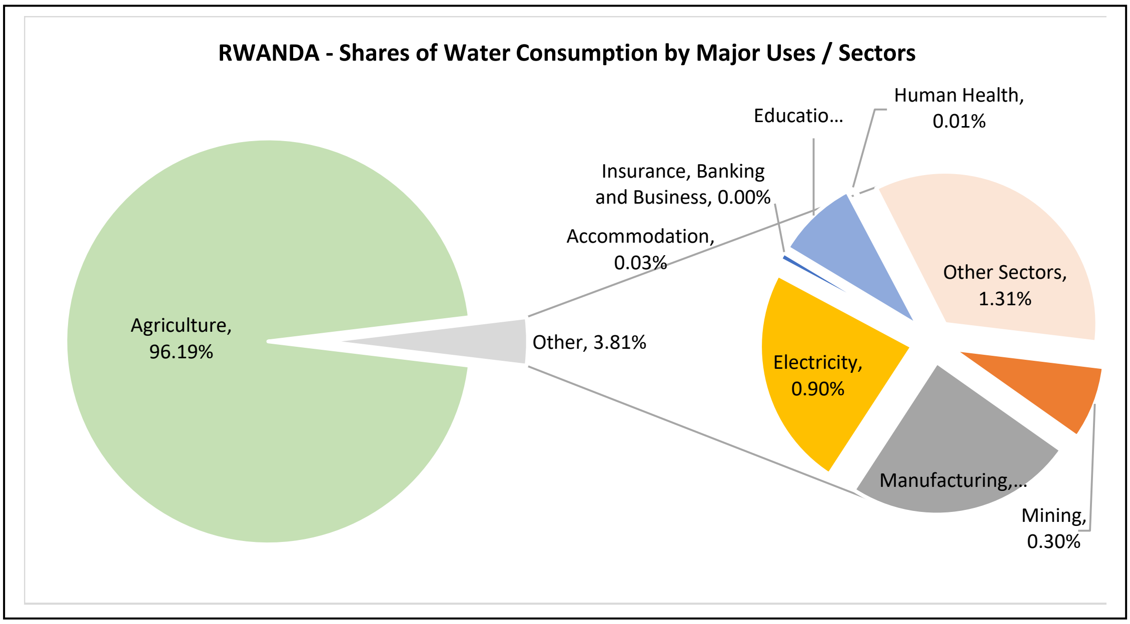


Figure 8: Shares of water consumption by major uses / sectors

Choice of Indicators Influences Results. Care must be taken in the production and comparison of water use and economic indicators (see Text Box 3 for some definitions). A variety of measures and indicators can be developed depending on the information needs of water managers and the priorities in the policy making process, as well as the views of different stakeholders, sectors, and regions.

Text Box 3. *Water Measures and Indicators Defined*

This table defines some of the key terms used in the text and analysis. The physical indicators of water volume, for example, can vary due to different points of measurement in the water use and distribution process. Due to losses in delivery, there can be a substantial difference between the volume of water taken from the environment and the volume of treated water delivered to customers. When water volume is used in a ratio with economic variables to create a new indicator about water use efficiency, then this difference in volume can affect the results. Care is needed to ensure full understanding of these differences when interpreting water sector indicators – and comparing across sectors or geographic areas. Annex 1 offers a more complete discussion of definitions and relationships used in the SEEA NCA process.

Indicator	Description
Physical Indicators	
• *Water Abstracted*	The amount of water that is removed from any source, either permanently or temporarily, in a given period of time for final consumption and production activities, including hydroelectric power generation. Total water abstraction can be broken down according to the type of source, such as water resources and other sources, and the type of use (UN SEEA-W, 2012)
• *Water Used*	Water intake of an economic unit. Water use is the sum of water use within the economy: The water intake of one economic unit, which is distributed by another economic unit. Further there is water use from the environment: Water abstracted from water resources, seas and oceans, and precipitation collected by an economic unit, including rain-fed agriculture (UN SEEA-W, 2012)
• *Water Consumed*	That part of water use, which is not distributed to other economic units and does not return to the environment (to water resources, sea and ocean) because during use it has been incorporated into products or consumed by households or livestock. It is calculated as the difference between total use and total supply; thus, it may include losses due to evaporation occurring in distribution and apparent losses due to illegal tapping and malfunctioning metering.
Economic indicators	
• *Water use efficiency*	The value added per water volume used, expressed in Rwf/m^3 (this is the UN SDG 6.4.1 indicator)
• *Water productivity*	The value of what can be produced with a unit of water Term is also used for output or yield per cubic meter of water
• *Water use intensity*	The volume of water used to produce a unit of value added, measured as m^3/Rwf.
Composite measures	
• *Green Water*	Refers to 'non-abstracted water,' including soil water originating from rainfall
• *Blue Water*	Water from natural water resources, including surface water, artificial reservoirs, groundwater and spring water – but excluding soil water originating from rainfall

Urban areas, for example, will have different water concerns than rural areas. A focus on Agriculture sector water use might seek more detailed information on 'green water' ('abstraction from soil water') for rain-fed crops, or abstraction from surface water for crop irrigation and watering livestock. For public water supply, water companies will focus more on 'blue water' obtainable via abstraction of groundwater and surface water. Households and sectoral water users may be more concerned about the delivery of clean drinking water through piped water systems. Having a range of different indicators can be useful to track annual progress at the macro level, or for particular sectors, such as agriculture or manufacturing, as well as for international benchmarking.

Different indicators can be used to examine different issues at macro level and according to sectoral concerns (and later possibly regional). Each indicator provides unique insights, but it can complicate presentation to consider too many alternatives. This section introduces a few example comparisons to illustrate the contrasts that result from different measures. As noted above, in terms of 'water consumed,' agriculture has the largest share. This is because of the combination of uptake by crops, losses to the atmosphere via transpiration and evaporation from the land surface. This is water removed from the country's inland water system. However, if 'water abstracted' from surface and ground water are reported, the graphic changes substantially, as in Figure 9, below.

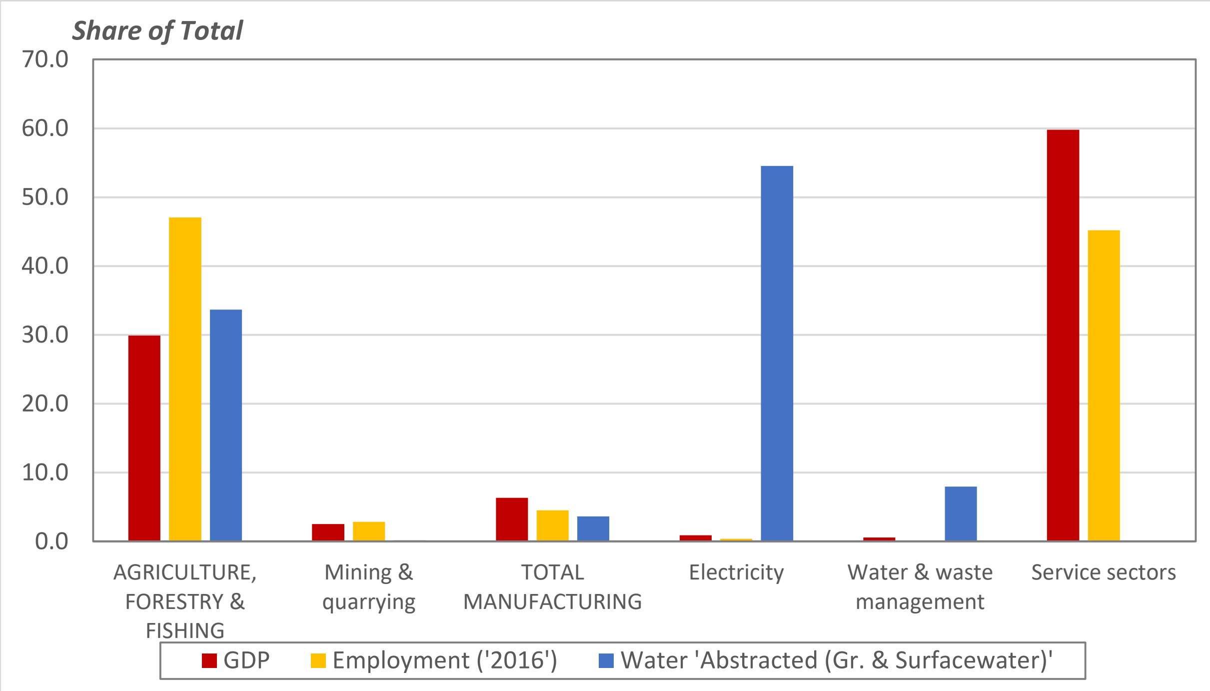


Figure 9: *Shares of GDP, Employment, Water 'Abstracted' (2015)*

The figure now shows that the electricity sector uses the largest share of abstracted water, agriculture is second, and public water supply is third. In Rwanda, the electricity sector 'uses' mainly surface water for hydro-power, but does not consume or transform it. After use, the water is returned to the environment and can be used by other sectors and users. Thus, a large amount of water is 'abstracted' but not 'consumed.' This illustrates the distinctions among different measures of water use. Similar arguments apply to economic and employment measures, which can be used to enrich the analysis. For other analytical purposes, other variables available from national accounts could be included, such as 'investments' or 'government revenue.'

4.2 Water Productivity and Water Use Efficiency

Water productivity is the value of what can be produced with a unit of water. This measure is also called *water use efficiency*, or the value added per volume of water utilized, expressed in Rwf/m^3. *Water use intensity* is the volume of water used to produce a unit of value added. It is the inverse of productivity. Both are useful measures for assessing how productively or efficiently Rwanda is using water and how that performance is changing over time. It is expected that sectors will have different water productivity and efficiency measures. These estimates can be useful for comparison with international benchmarks or sector standards to determine whether and where efficiency of water use can be improved. The annual production of these indicators also contributes to time series for assessing trends or tracking progress toward targets, set nationally or by sector or region.

Table 11 and Figure 11 below show water productivity (water use efficiency) and water use-intensity through indicators taken from the water accounts, broken down by major economic sectors. Average water productivity for 'total water use' is Rwf 204 per m^3. This average is calculated by dividing the GDP ('Value Added') from this selection of industries in the table by the 'total water use' by the same selection of industries. This is a low figure because the calculation includes the large water flows in (rain fed) agriculture. Once the water productivity calculation GDP or total value added of the country is connected to the much lower volumes of ground- and surface water abstracted, a much higher figure for water productivity results, of about Rwf 3,736 per m^3. This latter figure better relates to the preliminary water productivity (SDG 6.4.1 - water use efficiency) figure produced by the Food and Agriculture Organization (FAO) using AQUASTAT data and SDG calculation[15] format, US$ 23.4 per m^3 for 2012.

The data show high variability in the value added (contribution to GDP) produced per cubic meter of water used. The primary sectors – Agriculture and Mining – depend on water as an essential part of their production processes, and thus have a lower water productivity estimate

Table 11: *Water Productivity or 'Total Water Use' Efficiency (Rwf/m^3) for 2015 by Sector*

Economic Sector	Productivity or Use Efficiency = GDP / m^3 of water used (Rwf / m^3)	% of Water used
Agriculture	118.4	91.12%
Mining	6,236.1	0.15%
Manufacturing	523.0	4.36%
Electricity	138.4	2.41%
Water & waste management	576.1	0.35%
Accommodation	6.297.8	0.11%
Financial services	2,352,460.5	0.0005%
Education	699.3	1.47%
Human health	33,876.9	0.03%
Cultural, domestic & other services	2,133,842.5	0.001%
Value added (GDP) per m^3 of water used for the selected industries (Rwf / m^3)	**204.0**	

(due to larger denominator water). Economic activities in the service sectors, such as education and health care facilities, use far less water per unit of economic activity produced because water is not an essential factor in the business model.

Figure 10, in two parts, shows the productivity indicator graphically. Part a of the figure shows the primary and secondary economic sectors; Part b shows the tertiary, or service sectors, with a different vertical scale. Agriculture, mining and manufacturing use a lot of water in their productive activities, so the value added is in the range of 60 – 150 Rwf/m^3. In contrast, the service sectors have productivity values about 1000 times higher. This indicates that hotels, schools, hospitals and banks produce more value per input unit of water, because their business model and production activity are not mainly dependent on water use. In contrast, agriculture uses a lot of water, some of which is embodied in agricultural products and some lost to the atmosphere via transpiration. Some manufacturing industries have water embodied in their products, such as food or drinks in cans and bottles.

[15] FAO has the mandate to collect data and monitor how countries are implementing SDG 6 on water use issues.

Other factors that affect water productivity include losses in the abstraction and distribution systems, which would lower productivity. Also, in Rwanda, the largest water uses are agriculture and households, which produce relatively low economic values. In rural and agricultural areas, water is abstracted directly from rivers and lakes and used for irrigation, but these systems are inefficient and there are no incentives for economizing on water use. At the same time, the high value producing service sectors of the economy like education and finance, for example, use relatively small volumes of water. Thus, even though their productivity measures are very high, the volumes used are too small to pull up the average.

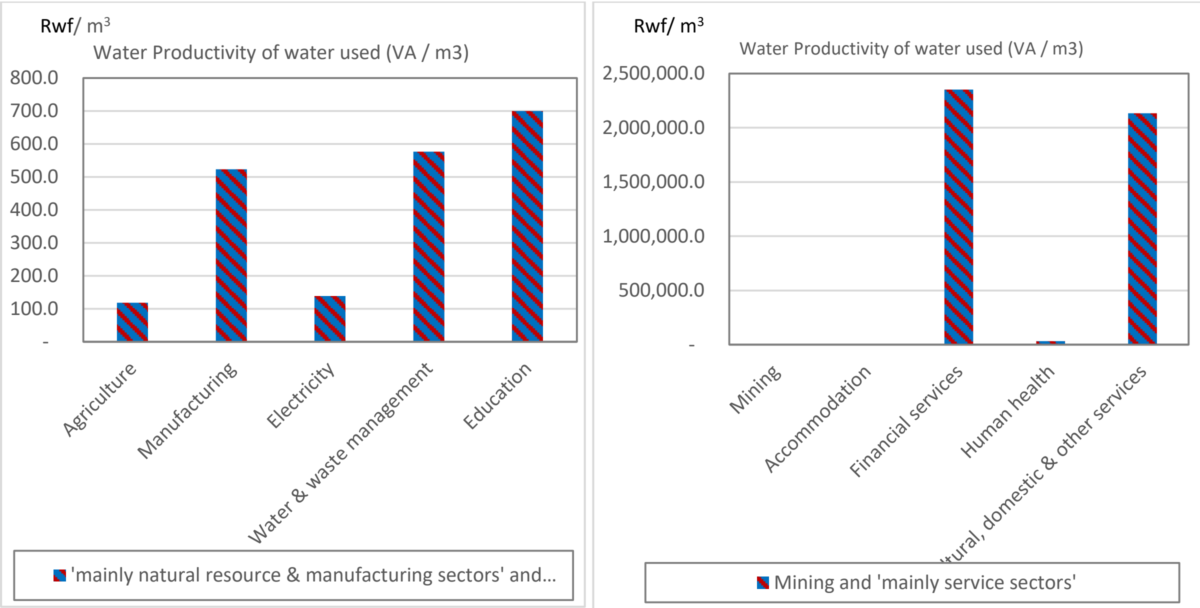


Figure 10: *Rwanda Water Productivity by Sector*
(generally high water using sectors on the left and low water using sectors on the right.)

Figure 11 focuses on fewer high water using sectors over time. With the caution that the time series is short, the data show water productivity increasing for most sectors in most years – though some are growing faster than the economy (GDP) and some are changing more slowly. Agriculture has relatively low water productivity (value per unit of water used) and the indicator is growing only relatively slowly. The mining and quarrying, manufacturing, electricity and water and waste management sectors provide substantially higher value added per m^3 than agriculture but nonetheless far less than the service sectors. For water and waste management and for mining, the data show a decline in water productivity in the most recent year of the (limited) series. It will be interesting to analyze further years of data to determine if this continues and to examine what measures would help to improve the trend.

Figure 12 adds in the service sector, which is a low water user, but vastly more productive in terms of value of output per cubic meter of water. This shows that the trend of increasing productivity is seen even more strongly in the services sectors of the economy. This trend reflects the economic growth in services as well as the relatively low water use in these sectors.

It is positive to see that both for the country as a whole and for these key sectors the steady increase of water productivity levels since 2012. This clearly contributes to achieving a number of Rwanda's key sustainable development goals. A deeper phase of examination could focus on whether these upward trends are happening sufficiently quickly – for example in the agriculture sector – relative to overall economic growth and water demand growth from other sectors.

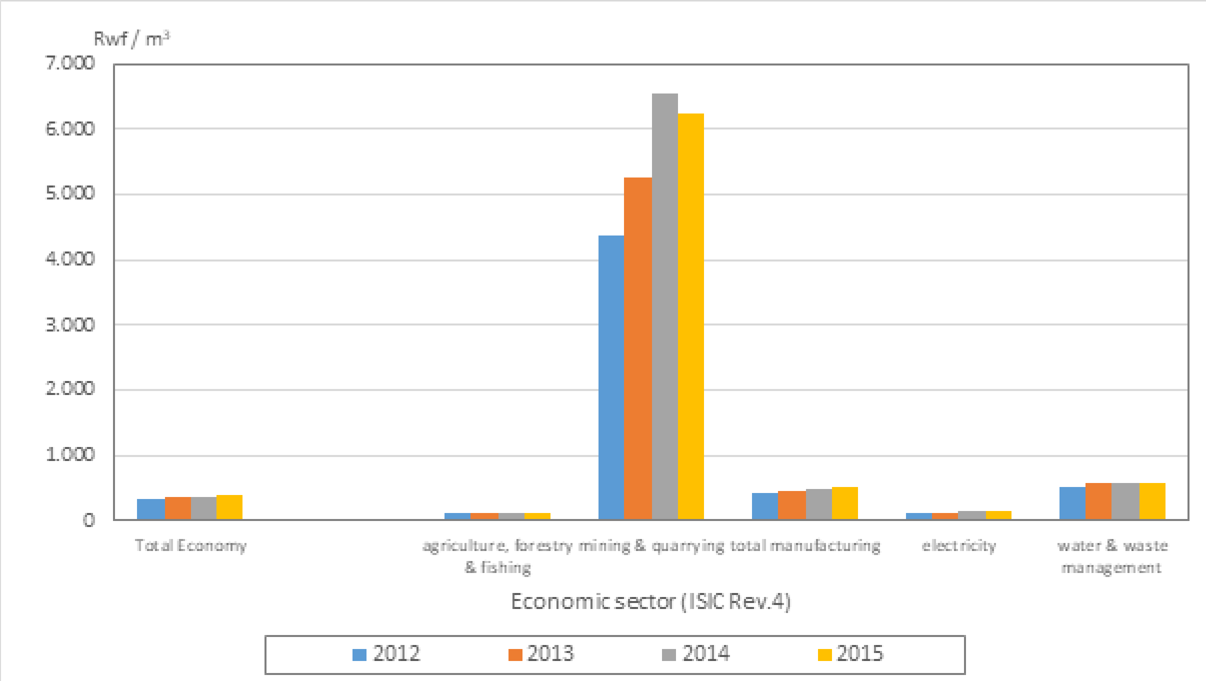


Figure 11: Water Productivity by Sector, Based on Water Use

Note: This figure leaves out the Service sectors (G - T), which have much higher productivity, but much lower water use. The service sectors range between 9,300 and 11,600 Rwf / m^3.

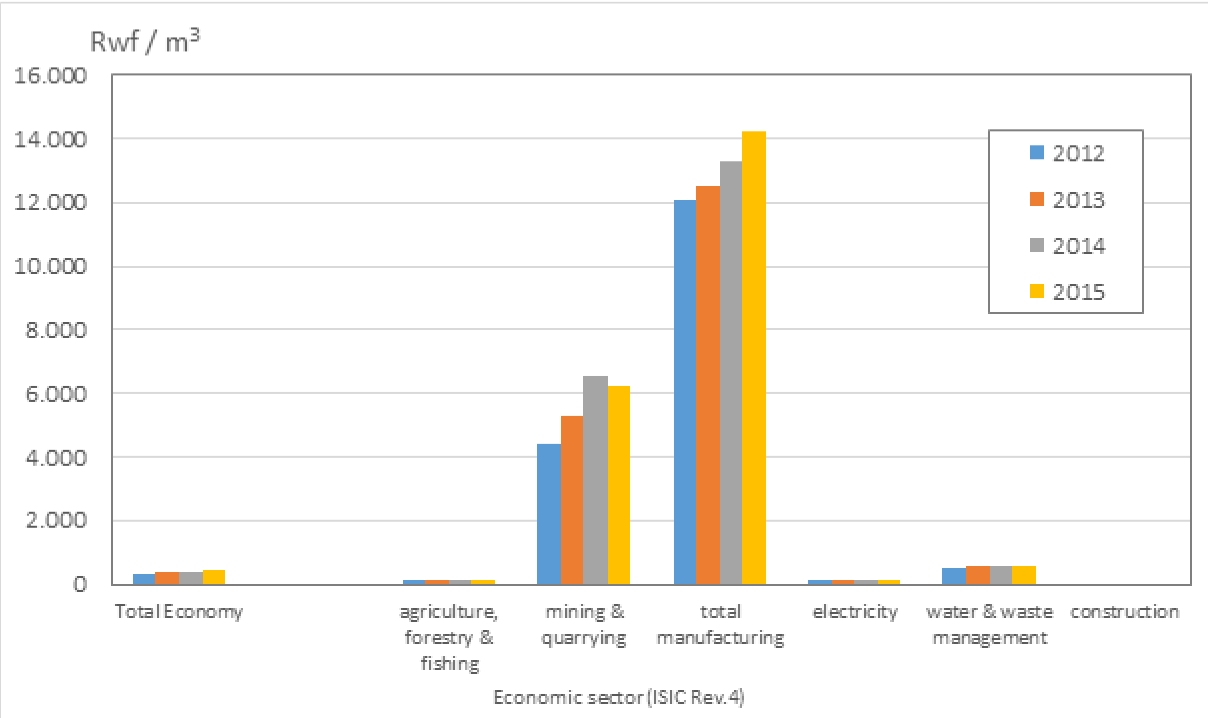


Figure 12: *Water Productivity by Sector, Based on Water Abstraction.*

The water supply sector merits a closer look because of its importance as a supplier of critical raw materials to other sectors, as well as health and sanitation at the household level (see Section 4.4). The water productivity indicator needs careful interpretation, especially in this sector. As noted, the trend toward greater productivity is not strong or continued in this sector. However, this 'industry' is not using water to produce economic output directly, but rather treating and distributing water primarily for the use of other sectors. For this reason, the measure of 'contribution to GDP' may be misleadingly narrow in this case. Further, there are losses of water in the process of abstraction to purification to distribution (more on this in section 4.4), which contributes to a higher measure of water 'use' (denominator of water productivity indicator) relative to the economic gains (numerator of indicator).

The water productivity measure yields important insights, but as noted in the text box above, these insights are influenced by the definition of inputs. In these figures, water productivity is calculated based on water "abstracted" not water "consumed." As seen with hydropower, a sector may *withdraw* a lot of water, but then return it quickly in the same form to the inland water supply, so that *consumption* is low. The mining sector is somewhat similar because it abstracts large amounts of water but consumes very little. In this case, however, the water used may become less useful for other economic activities as a result of pollution and reduced quality. (This version of the accounts covers only water quantity not water quality, which would require more detailed monitoring data on an agreed set of pollutants.)

The special features of agricultural water use also need some care in interpretation. Agricultural water use depends mainly on rainfall and soil water, rather than water abstracted from rivers, streams, springs and groundwater. If water productivity were calculated only on abstraction, leaving out soil water, agriculture productivity would be much higher (though this too would be misleading). The SDG water productivity indicator calculation focuses among others on irrigated agriculture. Note also that soil water, which originates from rainfall, is available to agriculture but cannot be used or transferred easily to other sectors of the economy – and thus does not face competition from other sectors. Discussions of competition or allocation of water among different sectors should focus on water supplied via the water supply infrastructure; only efficiency gains in this category of agricultural water use would free up water infrastructure for other water users. In summary, water productivity discussions and comparisons need to be nuanced with understanding of the level of water consumption, water pollution, and the degree to which the water is available for other uses.

This section has discussed how water account indicators can inform decision makers seeking to promote sustainable water management, including efficiency in water use and water management, as well as equitable water allocation. For example, measures or policies that improve water use efficiency would free up water that can contribute to further growth or relieve constraints on water availability in other sectors.

4.3 Water Accounts Help to Monitor SDG 6.4 on Water Use Efficiency

The SDG 6.4 target is '*By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity*'. Several indicators focus on the monitoring of this target, including SDG Indicator 6.4.1 which deals with the 'change in water use efficiency over time.' This is a new indicator compared to MDG monitoring and is designed to address the effect of economic development on the utilization of water resources. These water accounts provide a useful starting point for Rwanda for organizing the data and calculations needed to test and assess the practical usefulness of this indicator.

The 'change in water use efficiency over time' indicator is defined as: the value added per *water volume withdrawn*, expressed in monetary units per cubic meter, over time for each major (aggregated) sector. The major sectors are defined following the international ISIC classification and include agriculture, manufacturing and services. Note the nuance in the definition of the data inputs, which influences the interpretation of the indicator, as noted above.

According to the measurement/monitoring guidance (UN-Water, 2017a), this SDG indicator should be computed based only on 'runoff water' that is abstracted or withdrawn from natural water resources. This means that agricultural use of 'non-abstracted water,' – or green water that includes soil water originating from rainfall – needs to be subtracted before calculation of the indicator. As seen above, this point is particularly important considering the importance of rain-fed agriculture in Rwanda. The indicator demands a distinction between agricultural production done under rain-fed conditions and under irrigation schemes. The result then is somewhat different from the water productivity measures reported in the prior section, as it does not consider all the water used in a given activity as an input to production. Instead, this indicator focuses on how development of the economy is linked to the exploitation of natural water resources (excluding the important category of soil water though). The SDG measures are expected to be useful and relevant for comparing outcomes over time, and across sectors and countries, as the results are communicated to FAO (and UNSD) as the receiving and custodian agencies. These Water Accounts allow Rwanda to calculate indicator 6.4.1, based on freshwater withdrawal, obtained from the Physical Supply and Use Tables (Chapter III) and economic data from NISR. These accounts can also generate SDG indicator 6.4.2 on water stress, as seen in Chapter III.

Figure 13 presents SGD Indicator 6.4.1 at the national level calculated for the years of this analysis. Overall, this measure of water use efficiency increased from about 4500 Rwf/m^3 to nearly 5100 Rwf/m^3 [16]. This implies an efficiency improvement over three years of close to 20 percent. This is an average annual growth rate of around 6 percent, close to the economic growth rate and growing level of water use as well.

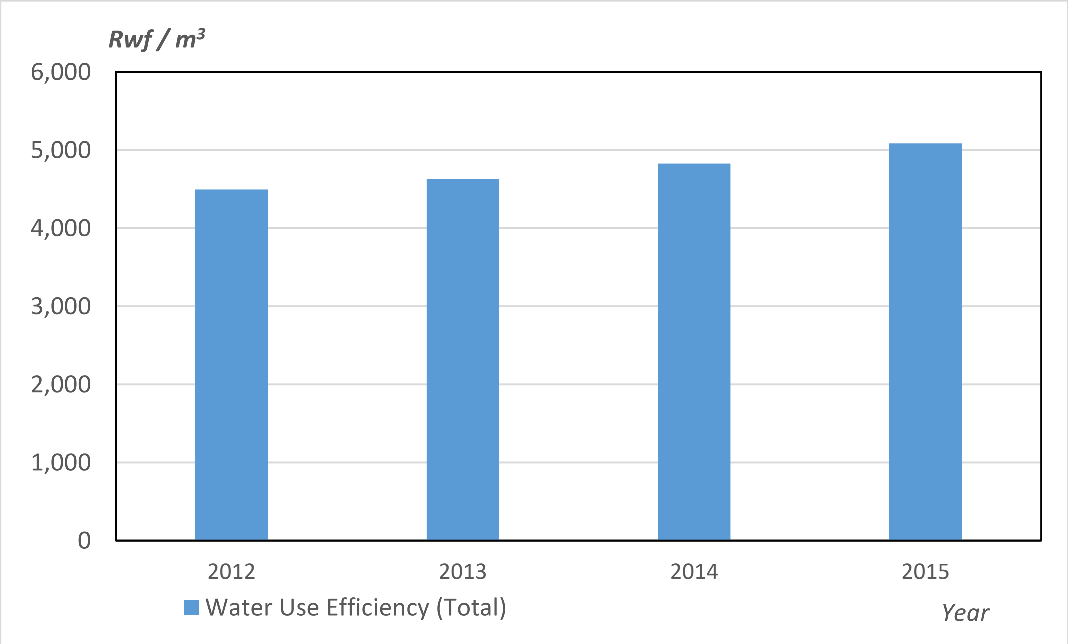


Figure 13: *Total Water Use Efficiency, Using definition of SDG 6.4.1 in Rwf/m^3*

Following the SDG 6.4.1 Water Use Efficiency indicator definition, this measure can be further disaggregated to the level of three main sectors of the economy, irrigated agriculture, industry

[16] GDP and Gross Value Added are shown at constant 2014 prices, to allow consistent comparison over time.

(manufacturing including mining) and the service sector[17]. Figure 14 shows the development of the water use efficiency indicator for the 3 main sectors plus the national economy (total), using an index set to 100 for 2012, to allow comparison over time. These results parallel those reported in the prior section (with a different definition of WUE): the industry and service sectors show water use efficiency gains of more than 20% over the time period, while irrigated agriculture shows the lowest WUE improvement, about 10 percent over the three-year period following 2012. These results (with appropriate caveats on sectoral differences, data quality and short trend) reinforce that it is worthwhile to explore the determinants of productivity and efficiency gains in agriculture, as already prioritized in Rwanda's development planning process. In the future, SDG reporting by countries will result in a database that can facilitate cross-country comparisons and inform national and sectoral decision makers, water managers and country policies related to water use, efficiency and scarcity issues.

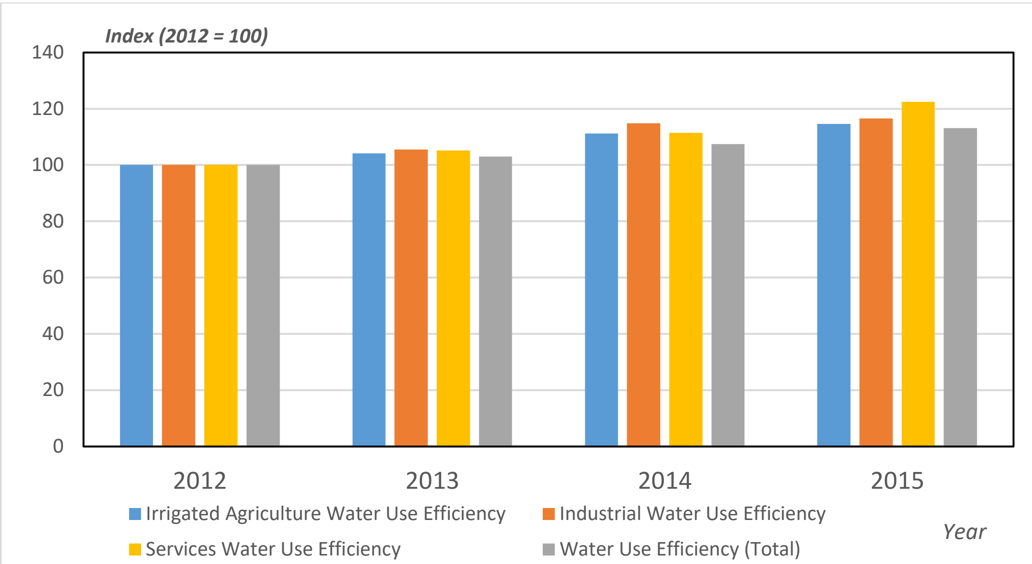


***Figure 14:** National and Sectoral Water Use Efficiency, 2012-2015, Indexed 2012=100*

"De-coupling" Economic Growth from Resource Use. The Natural Capital Accounts and the SDG indicators enable the analysis of the process of decoupling of economic development (growth) from environmental pressures (e.g., air or water emissions) and natural resource exploitation. Decoupling is observed when the growth rate of pressure on the environment or use of a natural resource is less than the growth rate of an indicator of economic activity, such as GDP. *Relative decoupling* is observed when the growth rate of the environmentally relevant variable is positive, but less than the growth rate of the economic variable. *Absolute decoupling* occurs when the natural resource (or environment) variable is stable or decreasing over time while the economic driving force is growing. This means that the pressure decreased in absolute terms, while the economy grew.

Using the SDG 6.4.1 indicator defined above for Rwanda, Figure 15 (in four parts) shows *relative decoupling* between Gross Value Added and Water Use at the national level, between 2012 and 2015. Over the analytical period, Value Added (in 2014 constant prices) grew by 25 percent, while water use grew by only 10 percent resulting in a 13 percent (rounded) decoupling in three years. Similar results are illustrated for the sectoral divisions of the economy, with somewhat less relative decoupling in the agriculture sector. In the Agriculture sector, value

[17] Although the three main sectors in the SDG 6.4.1 computations cover most of the national economy and water use, a few industries (ISIC categories) are not represented and non-irrigated agriculture is not included in the Gross Value Added for the agricultural sector.

added grew by 31 percent, while water use grew by 14 percent. For industry (manufacturing) value added grew by 28 percent, while water use grew by 9 percent. For the service sector, value added grew by 24 percent, while water use grew by only 2 percent. *Absolute decoupling* is not observed during 2012 – 2015. This makes sense as Rwanda's economy is growing, along with water supply and access, one would not expect to see stable or declining water use.

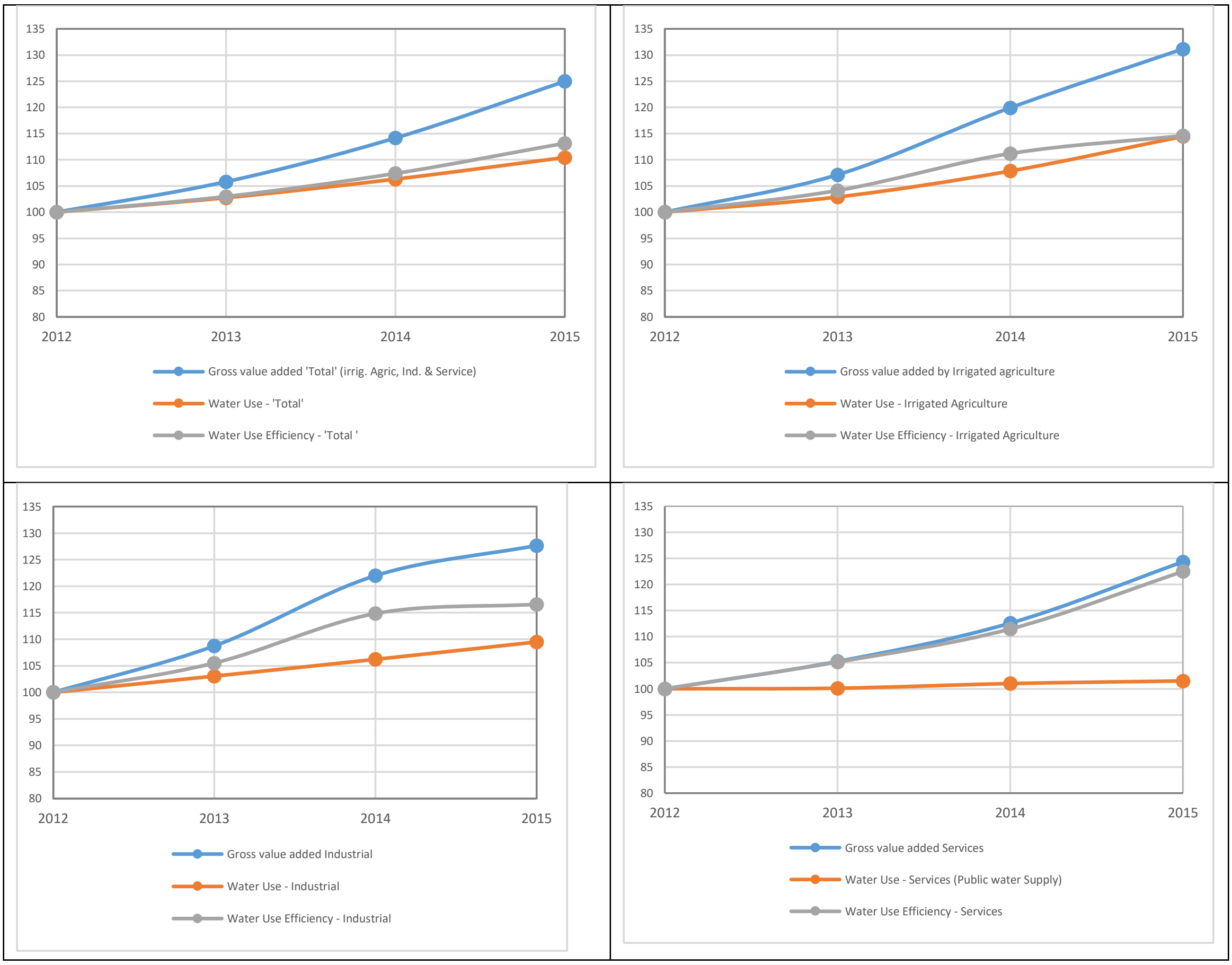


Figure 15: *Decoupling of Gross Value Added, Water Use and Water Use Efficiency*

4.4 Water Values and Economic Incentive Issues

Water has value for people, for the economy, and for the natural environment, where it sustains ecosystems and biodiversity. Sustainable management of water resources needs to take account of these different water uses and values. Allocation of water to different uses should be informed by the value of water in productive uses, including non-consumptive uses, such as recreation and its value or importance in maintaining environmental services. In addition to value or benefit, water has costs. These costs include the management of water in the natural environment; the cost of extracting, treating and distributing water to households and other end users; and the cost of treating waste water to a sufficient standard of quality so that it can be reused or discharged into the environment. There is also an opportunity cost of using water in one sector relative to its use in another sector. Water management and allocation decisions need to be informed not only by relative values, but also by the biophysical minimum amounts of water needed to sustain life or quality of life, for example the need for water used for sanitation, or the water needed to maintain stream flows that support the aquatic life and wildlife, or the maximum amount of water that can be stored in an artificial reservoir.

The costs and benefits of water management and use accrue to different parties. The public sector or government bears some of the costs of managing water in the natural environment. Water supply companies bear the cost of treating and delivering water to customers. Customers are willing to pay for water based on its quality and quantity and pay some of the cost of treatment and delivery, depending on the way water use fees are set up and assessed. Financial resources are needed to cover the costs of the public sector in managing the water systems and allocating water between different end uses. This may be the public treasury, or some defined set of fees and taxes assigned to cover water sector costs. Water user payments for delivered water create a stream of revenue that water supply companies can use to cover the cost of abstracting, treating and delivering water – and hopefully also the cost of operating, maintaining, and expanding the institutions and infrastructure involved in water delivery.

Rwanda has vowed to embark on a journey towards a climate-resilient, low-carbon economy by 2050. It is in this line that the Payment for Ecosystem Services (PES) constitutes one of the pillars of Rwanda vision 2050, which sets the vision for the country as a whole going forward for its economic transformation and development agenda. Vision 2050 and other GoR documents show the need to combat soil erosion and foster new processes that help soil stabilization. Recently, Rwanda and Costa Rica signed a Memorandum of Understanding (MoU) on environment cooperation that will specifically focus on exchanging experiences on payments for ecosystem services. Payment for Ecosystem Services (PES) is an approach that promotes good management of environmental resources to provide ecological services. In March 2019, The GoR in partnership with the Netherlands launched a PES pilot program in Upper Nyabarongo catchment, which is one of the towers of Rwanda in terms of water resources. The piloting is intended to assess pathways towards the implementation of a proposed PES scheme that is expected to be implemented countrywide.

This section reviews some information that pertains to these potential cost and revenue streams. When fully developed, Natural Capital Accounts can connect physical measures of water to more detailed information on the value of water, and thus inform questions about water pricing or allocation. For this Water NCA Version 1, the data and time were insufficient to achieve a complete analysis of all values and costs in the sector. Given the importance of these issues, this section summarizes some information about water values and outlines steps toward more complete analysis and compilation.

4.4.1 Water Supply Companies

Rwanda has several water supply companies permitted to abstract, treat and deliver water to customers. Rwanda Water and Sanitation Corporation (WASAC) is the largest of these and serving 15 cities and towns, with 150,000 connections and around 300 standpipes. WASAC contributed substantial information to the NCA effort, as summarized below. Aquavirunga Ltd Company, the second largest, is an independent private water supplier serving rural areas in the West. EKN (2016) reports that in rural areas, drinking water is supplied by 39 private operators or cooperatives, water users committees (650), and privately-owned systems (circa 60). The federation of private water operators, FEPEAR reports that there are 56 operators, of which 33 have joined the federation. Aquavirunga, Ayateke Star and Procom are among the larger systems in terms of systems operated and length of distribution networks. In addition to distribution through water utility companies, some users and households abstract water directly from the environment, as shown in the pie chart to the right. Some basic information about these water providers is summarized in Table 12. More analysis and data gathering are needed for a complete summary.

Table 12: Water Supply Companies, Population Served, 2015

Company	Estimated Population Served	Area Served / Comment
WASAC	2,500,000	Mainly urban areas
Aquavirunga	363,000	Mainly rural areas
Others: • Ayateke Star • Procom	1,429,000	
Total	4,292,000	~ 37.3% of 11.5 Million Rwandans

Rwanda Water and Sanitation Corporation. WASAC is a public utility, subject to regulations and pricing systems established by the Government. In 2015, WASAC had 22 Water treatment plants in operation with a production capacity of 134,600 m^3/day. WASAC had increased its capacity to treat and distribute water up to 42 million m^3 by 2015, as shown in Figure 16 below. The shares of water distributed to customers are shown to the right. Additional infrastructure for water treatment has come into operation in 2017 and 2018.

WASAC's output is distributed primarily for domestic (household) use, with a small share distributed to commercial enterprises. The second largest share of output, unfortunately, is lost to leakages or otherwise not billed. This issue of "non-revenue" water is discussed below.

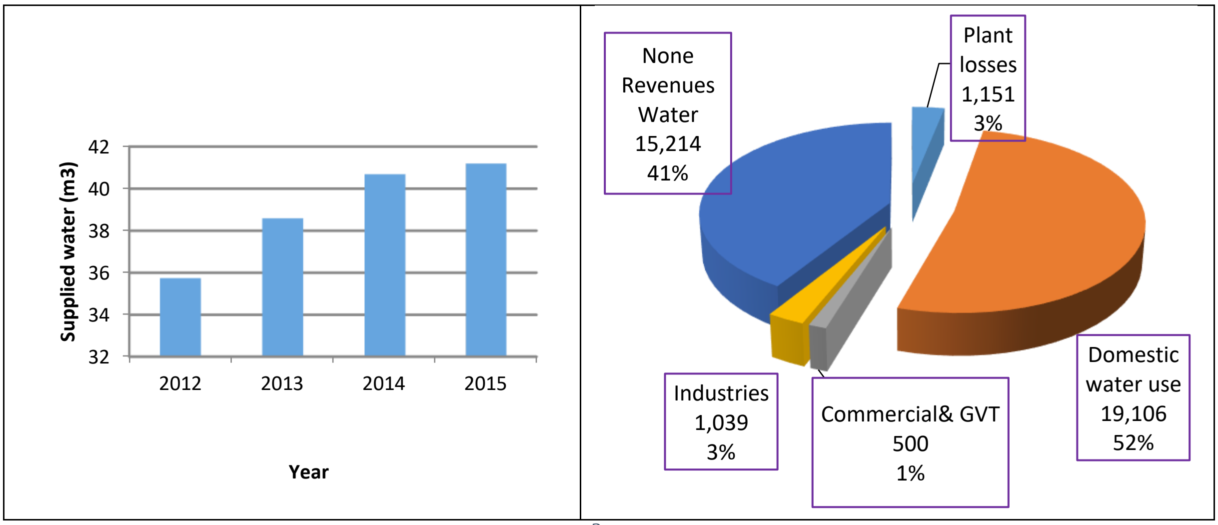


Figure 16: *Water Supplied by WASAC in Mm^3 and by Shares % for 2012*

A pricing schedule establishes how much water users pay based on the volume of water consumed monthly and the type of delivery or connection. Table 13 shows the graduated, progressive, rate system. The rates were fixed from 2008 to 2014, then were adjusted upward after 2014. Administered water prices in this form may not be designed to respond to market forces or to recover the costs of delivering water. They also may not be updated regularly enough to respond to changing economic conditions. Note that industrial water users pay a flat rate per m^3, regardless of volumes used or the cost of supplying that volume of water.

Table 13(a): *Water Tariffs in Urban Areas Before and After 2014 (Rwf/m³)*

Monthly 'Consumption'	Tariff / m^3 Before 2014	Tariff / m^3 After 2014
At Public Water Kiosk	240	323
For Household Connections		
• Between 0 and 5 m^3	240	323
• Between 6 and 20m^3	300	331
• Between 21 and 50m^3	400	413
• Between 51 and 100m^3	650	736
• Above 101 m^3	740	847
For Industry Connections	593	736

Source: WASAC, 2016. Figures exclude 18% VAT

Recently, WASAC tariffs were raised significantly and for some even doubled. Those getting water from public taps and industries are among a few whom tariffs did not change. These accounts cover the period for year 2012-2015, Table 13b below that shows new WASAC tariffs as of February 2019 is only displayed for illustration purposes (see also this link: https://wasac.rw/index.php/customer-information/tariffs-charges).

Table 14(b): *Water Tariffs in Urban Areas as of February 2019 (Rwf/m³)*

Customer category	**Bloc of consumption per month**	**Applied tariff in FRW (VAT exclusive)**
Public tap	Flat rate per m^3	323
Residential	0 - 5 m^3	340
	6 - 20 m^3	720
	21 - 50 m^3	845
	Above 50 m^3	877
Non-residential	0 - 50 m^3	877
	Above 50 m^3	895
Industries	Flat rate per m^3	736

Karamage and co-authors (2016) indicate that WASAC suffers from several economic and operating issues: low cost recovery and large water losses, among others. Under the current tariff structure, WASAC can only recover about 75% of its operational costs, compared to commercial break-even. To make the situation financially sustainable, there would need to be an increase of WASAC's water treatment capacity by about 2/3 (or 63.6 %) – which requires large investment costs – or an increase in the per cubic meter weighted average tariff to Rwf 700 – which requires political action by the Government – or a combination of the two approaches. WASAC benefits from an annual subsidy of Rwf 5.2 billion Rwf to meet its operating costs. Thus, the costs of water treatment and distribution are being paid by the society as a whole through the collection and allocation of government revenues. These financial constraints also undermine WASAC's ability to construct and maintain additional facilities to expand access to safe, clean water, a priority of the Government.

In addition to these tariff issues, WASAC's water treatment, distribution and billing system is inefficient and leaky. As noted above, the companies bill consumers for only about 58% of water distributed, while 42% is 'non-revenue water' (NRW[18]) that has been produced and treated, but then lost in the system due to leaks and inefficiencies – or delivered to consumers

[18] The American Water Works Association (AWWA) recommends that NRW be managed to less than 10% of overall volume. However, many water utilities in African countries have high shares of Non-Revenue Water.

who are not metered and do not pay for the water. This contributes to the financial difficulties because the company pays to treat and distribute the water but cannot recover those costs adequately. Figure 17 reports several efficiency and performance ratios calculated from data provided by WASAC. WASAC and the Government are aware of these challenges and working to resolve them. For example, WASAC has analyzed NRW by district and found that cost recovery ranges from 22 to 63 % from the worst to the best operating district. This provides a base for comparison and benchmarking that could help to improvements by learning from the best operators and focusing improvement efforts on the lower performing operators.

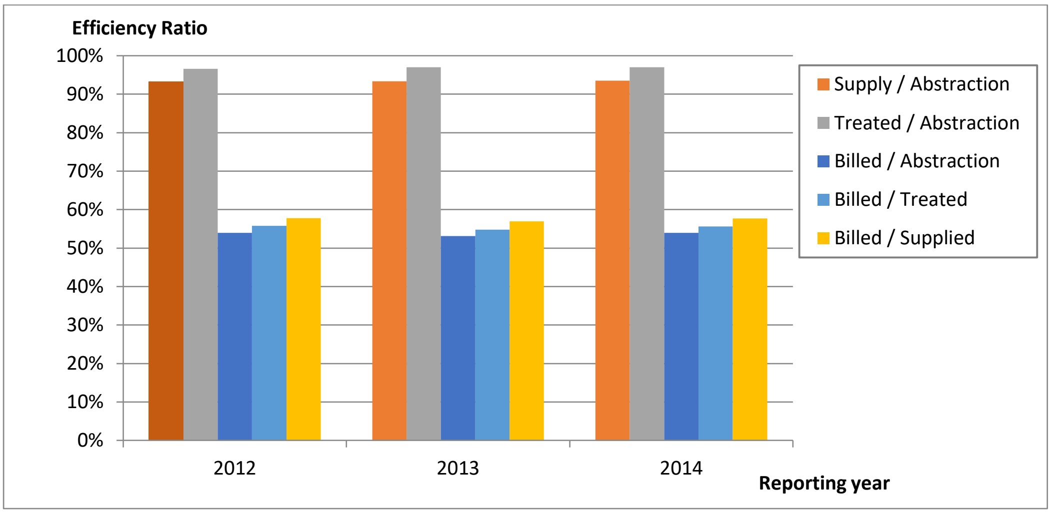


Figure 17: *Efficiency Ratios in Public Water Supply, WASAC, 2012 - 2014 (%)*

Karamage *et al*. (2016) documented annual NRW loss of 16.5 million m^3 (41%) with accompanying revenue loss of US$ 8.7 million (closely matching the NCA figure noted above). Most of WASAC water branches (14 of 15) exceeded the American Water Works Association's (AWWA) 10% NRW threshold. Lost revenue means that utilities do not cover operating revenue, but also that they lack the capital to expand treatment and services to meet the demands of the growing population and economy. If NRW could be reduced by 50%, a scenario examined by Karamage, the utility would have additional 8 million m^3 of treated water yearly, enough to serve an extra 42,000 households or irrigate 660 ha of cropland and generate US$ 4 million in revenue, reducing the financial gap in Rwanda's National Water Improvement Project by almost a quarter. The NCA effort is highlighting these issues for closer examination in more specific sectoral analyses.

Aquavirunga and other Water Supply Operators. Aquavirunga Ltd Company was founded in 2007. It is an independent private water supply company that serves rural areas, particularly in the three western districts, Rubavu, Nyabihu and Musanze. According to a study by the Embassy of the Kingdom of the Netherlands (EKN, 2016), the water tariffs charged by Aquavirunga vary between Rwf 667/m^3 and Rwf 1125/m,^{3} including VAT, the fee of the stand pipe keeper (Rwf 90), the fee paid to the district (Rwf 50), and the income tax (30%). The fee to be paid to the district is negotiated before signing the contract. It is split into 75% to a fund for water supply infrastructure asset renewal, 15% for contract auditing, and 10% for contract monitoring (EKN, 2016). The tariffs of the other water supply operators vary according to the energy use (EKN, 2016). The NCA effort did not focus on data from these companies and the financial viability of these operations has not been examined.

4.4.2 Government Efforts on Pricing and Access

Revised Water Tariff Structure. The government is committed to ensure both increased access and affordability of basic utilities (water and electricity) to all Rwandans. The Rwanda Utility Regulatory Authority (RURA) established tariffs for water and electricity that took effect from January 2017. Compared to the prior tariff structure, these newer tariffs (see Table 14) are much lower, almost halved, aiming to create an incentive for increased access and affordability by potential customers. Noting the discussion above, lower tariffs may help with one set of development objectives, but raise questions about cost recovery of water treatment and delivery costs for the commercial water suppliers, like WASAC and Aquavirunga.

Table 15: *Tariffs of Other Water Supply Operators Countrywide (2015/2016)*

Energy Source	No of operators	Current Average Tariff till end of 2016 (Rwf/m^3)		Proposed Ave Tariff From 2017 onwards (Rwf/m^3)	
		Connection	Per Jerrycan	Connection	Per Jerrycan
Gravity	9	394	8	182	4
Gravity, Elect	3	638	13	232	5
Electricity	5	610	12	409	8
Gravity, Diesel, Elect	2	875	18	509	11
Gravity, Diesel	3	808	16	589	12
Diesel, Electricity	3	575	12	406	9
Diesel	2	1175	24	675	14
Total	27	621	13	360	7

Source: WASAC, 2018.

Consideration of Other Taxes and Fees. The above tariff structure applies to water delivery. The Government also recognizes the need for a source of revenue for more general water management and protection activities, as well as the need to monitor and control access and allocations, as well as pollution and downstream impacts. The Department of Water Resources in the Rwanda Water and Forestry Authority (RWFA) under the Ministry of Environment takes the lead in coordinating stakeholders involved in the water sector including those working in domestic water supply, irrigation, ecosystems, financing, transboundary water level, and infrastructure development. RWFA is the lead coordinator for stakeholders working toward achievement of SDG 6 and implementation of the IWRM Agenda of the National Policy on Water Resources. The legal authorization to charge a water use fee is granted to RWFA. Box 3 introduces the role and uses of taxes and fees in producing incentives and revenue. This section discusses applications of water use fees in Rwanda and their potential for generating revenue to cover costs and fund investment to expand infrastructure and access.

In 2015, the Government and its development partner Embassy of the Kingdom of the Netherlands (EKN, 2016) conducted a study of Rwanda Water Use Fees under the Integrated

Text Box 4. *Environmental Taxes and Fees*

Environmental taxes and fees create incentives. Production and consumption activities that make use of natural resources may also generate waste and pollutants that negatively affect downstream users or degrade the environment. Governments can use environmental taxes or fees to help regulate or control these negative impacts. Taxes and fees for use of natural resources, such as water, create positive incentives to use the resource efficiently and improve its management. Taxes or fees placed on discharges to the environment can create a disincentive to continuing degradation or resource depletion. Taxes and fees are often used in combination with regulatory measures, such as monitoring requirements or performance standards.

Environmental taxes and fees produce revenue. In addition to influencing behavior, taxes and fees generate revenue for the Government. Taxes and fees are similar and are applied for similar reasons, but the application of the revenue stream may differ. Though the specifics depend on countries' laws and administrative systems, tax revenues often flow directly into the general budget, while fee revenues may be 'earmarked' for specific purposes. For example, water use fees may be earmarked for water management activities, likewise national park entrance fees may be directed to conservation management or park operations. Examples of environmental fees include charges on water abstraction or on sewage discharges or waste collection and processing services – where the fee is linked to a particular sector or service.

Water Resources Management Programme Rwanda. This technical report outlines the structure of a new Water Use Fee Scheme that would be based on the value of water generated by various economic activities, including Drinking water supply, Wastewater treatment plant, Irrigation, Aquaculture, Mining, Hydropower generation, and Industries (coffee, tea, beverages). Such a fee structure would be implemented in conjunction with a more comprehensive water use permit system. Currently, only a small portion of the existing water abstraction sites and wells are officially registered in the permitting system.

The proposed water use fee scheme would assess the value put onto the water based on the costs of service provision. The scheme also adopts some key principles, such as the importance of cost recovery for water utilities and that polluters should pay for damages caused. Fees would be set based on an assessment of the water users' capacity to pay, based on an assessment of operating revenues and margins. Recognizing the technical difficulty of monitoring and measuring the volume of water used by each operator, the scheme proposes applying the fees to different bases of observable indicators, depending on the activity. For example, irrigation fees could be set based on the area irrigated; mining water use fees could be based on the level of mineral production. Further adjustments and fine tuning are proposed to recognize special cases such as seasonal or short time frame / high volume activities.

The proposed water use fee scheme has been analyzed to determine its ability to raise needed revenue, to offset the costs of water resources management and to contribute toward financing further actions needed for water resources development and catchment conservation. To cover all these costs, revenue from water use fees would have to increase significantly from the current situation.

4.5 Discussion, Areas for Improvement

In this chapter, we analyzed the integration of SEEA water accounts with Rwanda's National Accounts. This integration allowed comparison of physical water use with value added (GDP contribution) and employment measures from the National Accounts and social statistics.

A wide range of indicators can be developed and compared – e.g., water abstraction, water use, water consumption – but caution is needed in their interpretation. The agriculture sector is the largest user of water and has the highest number of jobs, but its share of GDP contributions is low relative to sectors like manufacturing and services.

The integrated accounts also facilitated calculation of several crucial water productivity and efficiency measures that Rwanda can use for performance monitoring and for SDG 6 reporting. This analysis showed that water productivity and efficiency are increasing at the national and sectoral level. However, agriculture water use productivity is not increasing very much. We did not assess efficiency improvements in comparison to a benchmark or performance target. That type of assessment – how much water use productivity growth is desired to support Rwanda's development aspirations – can be developed under the next iteration of the water accounts.

The integrated approach also supported an analysis that showed significant relative decoupling nationally and for the three major sectors of the economy: Agriculture, Manufacturing and Services. More analyses and comparisons are needed in the future to assess if this rate of decoupling is sufficient in size or speed, relative to Rwanda's aspirations.

Thus, the NCA process has enriched and linked up the base of information available to support deeper analysis to inform national planning and policy processes and water management institutions on issues of water access, water abstraction, water supply, water use, distribution, and allocation. In future versions of the water accounts, more work is needed to extend the time series to allow more comprehensive trend analysis. Compiling the data for additional years and future NCA iterations can be further streamlined through improved data sharing and institutional collaboration, as discussed in Chapter V. More effort is needed to ensure that the ISIC classifications are well aligned to improve matching with GDP and employment data.

Results presented so far are at national and sectoral scale. Another possible improvement will be to disaggregate the data and analysis geographically to cover the 5 provinces or the 9 major river basin catchments. However, geographic disaggregation will require data sources and details that are only now being developed using geo-spatial data. Disaggregation will be time and resource intensive, so some reflection is required to ensure that it will meet a specific management or policy need.

Developing monetary water accounts is a task for the future, which will require deeper work on water values and pricing. In this version of the accounts, information was presented on water values, the uses of taxes and fees in management and revenue collection. Some information on the costs of water production and treatment was also presented, as well as the existing water supply utilities, their tariff structures and their need to recover costs to continue providing and expanding water supply services. There were several economically significant findings.

Current water tariffs are too low to cover the primary water utility's operating costs (more work would be needed to examine the other water utilities including the AQUAVIRUNGA and Ayateke Star, and Procom). Yet, Government policies are moving in the direction of lowering tariffs in the interest of improving access and protecting the poor. This state can make up the difference in the utilities' operational costs, but this approach may discount the need to plan for future investment and expansion. Another issue with water supply utilities is the large volume of non-revenue water, for which the utility incurs treatment and distribution costs, but recovers no revenue. NRW results from deficiencies in the physical infrastructure, as well as deficiencies in the billing and collection system. Resolving these issues requires analysis and investment that goes beyond the NCA effort. Fortunately, the Government is considering new fee and tax structures that would improve the situation.

The NCA effort can inform the approaches that are under development. Follow on or parallel studies can focus more exclusively on the financial situation of the utilities to better understand their revenue and cost structures. This effort can be informed also through the NISR Business Enterprise Survey for the water supply sector (ISIC 36).

CHAPTER V: Water Accounts: Issues and Policy Implications

This chapter first reviews the NCA issues and trends identified in the prior chapters and discusses implications for policy and development challenges that Rwanda faces. The subsequent sections review findings and lessons related to coordination and institutional issues; data collection and quality issues; and capacity and technology issues. Suggestions are included that may be relevant for consideration in the annual budgeting process, specifically to improve and institutionalize the preparation of natural capital accounts on a regular basis and to mainstream their use into the development planning process.

5.1 Policy and Development Planning Issues

Water Provision, Water Use Efficiency and Productivity. Natural capital accounts provide useful information on water supply and use within the economy and with the natural environment. The accounts allow quantification of the importance of sufficient supply of water by type of water source. Integrating with the national economic accounts allows comparisons to economic indicators and employment by sector, as well as measures of water productivity and efficiency (Chapter IV). This analysis confirmed that agriculture is the largest user of water and heavily depends on its recurring replenishment from precipitation. Agriculture is not the most efficient water user, however, and there may be room for improvement through adoption of technologies, changing behaviors, or incentives. This is useful to inform policy makers and support decisions on allocation of water across sectors. More analysis is needed to solidify the understanding of water values across sectors and by type of water.

Water provides Rwanda's people and economy with important provisioning, regulating, and cultural and ecosystem services and functions. Policies and allocations will need to recognize the productive use of water in the function of maintaining environmental services. With anticipated future economic and population growth, water demand will increase, including competing demands on specific water resources, which may result in trade-offs or conflicts that will need to be managed.

As water demand grows along with the economy, Rwanda needs a coherent information and policy framework for making water allocation trade-offs to ensure that there is enough water of sufficient quality for all potential users. For example, it will be important to consider how to allocate scarce investment resources in water infrastructure that serves different sectors. The NCA approach can help development planners to understand the economic implications of water allocation decisions across sources, anticipate future demand and evaluate policy options for meeting that demand. For example, it may be useful to consider options to improve efficiency in heavy water using sectors, such as promoting appropriate technologies and providing incentives to conserve and recycle water. It may also be necessary to improve cost recovery so that water utilities can sustainably meet water access and quality objectives and large water users contribute to the cost of water treatment and distribution.

Policy instruments that can help to achieve sustainable use and management of water include: payment of water use fees (pricing) for catchment protection, water loss reduction measures, cost recovery measures, and specific investments in water supply, operation, treatment and distribution. More disaggregated data can help to inform allocation decisions and refine policy options. In addition to proper regulation for water using sectors, there is a need for rules and water allocations that help to preserve the permanent green and attractive countryside that facilitates cultural functions like recreation and tourism.

Water Availability and Demand. Chapter III showed that during 2012 to 2015 Rwanda's large volume of water assets in lakes decreased a small amount (0.5%), while the relatively small volume in artificial reservoirs increased by 60 percent. This is mainly as a result of extending the capacity of the artificial reservoirs. More effort over a longer period will be needed to gauge the significance of the estimated changes in lake volume, which may be due to changes in water levels depending on short term fluctuations in rainfall or the calculation method based on available data.

In general, water demand is expected to grow following the country's economic development and population growth. Availability of surface water assets will also influence crop production, affecting food security. Climate change may also influence rainfall patterns and evapotranspiration, with some uncertainty over the level and timing of possible changes. New approaches and technologies for water resources management may be useful for addressing these uncertainties coupled with increasing future water demand. To respond to increased pressure on water resources, an increase in water storage capacity would be a reasonable part of an integrated solution for water resources management and use. Rwanda has already adopted water harvesting as part of the implementation of the National water resources master plan which provides for potential sites for water storage development with their estimated storage capacities. Water conservation policies and technologies would be another cost-effective approach to consider, particularly for high water using sectors. Water pricing and allocation policies can be effective in promoting water conservation and could help to ensure the continued availability of water in its provisioning function in the environment.

Water Allocation and Incentives. Chapter IV introduced some information on how NCA can provide data and information that can inform water pricing and permitting decisions. In this first NCA version, however, there is not yet sufficient water valuation data to develop monetary accounts or to assess water pricing options. Water pricing and use permits are economic tools that can be used to encourage more effective and efficient water use and allocation. Water prices give economic agents a signal and incentive for using water efficiently, adjusting demand, stimulating supply, or correcting scarcity or distributional issues. Water permits are in a similar category of tools that policymakers may use to address distributional and value issues in the use of water. Water usage permits (and associated fees) can help in regulating who is accessing and using water resources. Permits also support improved record keeping on abstractions and monitoring of users. The Government is exploring these instruments under other projects. For example, the RBM&E project plans to identify users who have water permits and those that do not.

Water Access. Water access is a key issue related to Vision 2020 and the Government's development program, NST1, particularly as it relates to availability of water and sanitation services. The NST1 highlights that clean drinking water should be accessed at household level at 100% by 2024 (NST1, 2017). The SEEA Water accounts will help to inform water access issues by estimating water use by households using NISR data on population. Water accounts can provide consistent and organized information from multiple sectors to ensure that there is common understanding of the definitions and data for estimating access and related trends. It also provides a crosscheck on data coming from different sectors and how they affect the quality and value of water sector data and indicators.

At the end of 2015, NISR reported that 84.8% of Rwandans had improved access to safe and clean drinking water while 83.4% had access to improved sanitation (NISR, EICV4 2016). More effort is needed to achieve the 100% targets in national planning documents for both the share of population with access to a clean drinking water source and share of households with improved sanitation facilities. Water access depends in part on the capacity to treat and distribute water to households. This is also an indicator of clean water access for SDGs on Goal number 6. Chapter IV reviewed some data and issues on the water supply companies that treat and deliver water to end users.

The GoR through WASAC aims to raise rural and urban water supply coverage while also assisting the districts to plan, design, finance and implement water infrastructure projects. The Government further intends to ensure sustainable functionality of rural water supply infrastructure by rehabilitating non-functional systems and ensuring sustainable operation and maintenance. To ensure sufficient revenue to finance these improvements, there will need to be an assessment of the water pricing structure that can ensure recovery of the cost of treatment, distribution, maintenance and expansion of services. Currently, even the highest rate of the increasing block tariff schedule for urban users is too low to achieve cost recovery for water delivery services, let alone the reinvestment necessary to maintain and upgrade the supply infrastructure.

Water Stress. Rapid population growth, economic development, weather extremes, and climate change all contribute to soil erosion and wider degradation and place pressure on water resources and provisioning services in Rwanda. The short time series covered in this report showed some increase in the level of stress to 7%. This is not yet a level of concern (over 10 or 20%). However, it has to be noted that this water stress level considers the actual water withdrawn for use and not the demand. Rwanda is already a water stress country by considering the water demand for socio-economic needs. The potential for increasing water stress is related to many of the issues discussed during the development of the water accounts, including high pressure on water resources, insufficient investment in technology and infrastructure to maintain water needed levels of water quantity and quality, and poor coordination of water sector interventions that may increase the risk of water resource degradation. Better and more integrated data collection and storage efforts (currently scattered) would strengthen the empirical base of information on water assets that is needed for sound and strategic investments. These Water Accounts are a tool that can support efforts to enhance integrated water resources management. New and enhanced management practices and technologies (groundwater recharge increase, reducing water losses and enhancing water use efficiency) can be applied to improve the wise use and expanded storage of available water resources. More up-to-date and coordinated information systems would help different institutions move toward more integrated and sustainable water use and allocation.

5.2 Coordination and Institutional Issues

The water sector is coordinated through a thematic working group that holds regular meetings and serves as a convening point and sounding board for all water sector stakeholders, including civil society. This group may be an appropriate vehicle for discussing further improvements that can be made in coordination and sharing of data across the many agencies engaged in the sector, including agriculture, infrastructure, commercial water companies, natural resources, urbanization, and others. Issues of data quality, consistency, collection, and coordination could be presented to this group as a first step in thinking through the right approach for addressing these issues going forward, so that both the NCA and the water sector can benefit from consistent and comparable data, shared effectively and efficiently to different users based on their needs. The NCA TWG may be in a good position to take the first step on this issue, considering that they have dealt with similar challenges in recent years.

Alignment of incentives and mandates. Of course, different ministries have different mandates regarding the water sector. They collect data for different purposes and store them in different forms. This is understandable based on history that influences how systems are organized today. But going forward, all these agencies could be encouraged to improve quality, consistency, and comparability of data by working together to improve, organize and share data toward the larger purpose of supporting Rwanda's national development.

Information sharing. Ease and efficiency of sharing data across agencies can certainly be improved. In the current process, participants found it difficult to gather and align all the information needed to compile the water accounts. Data sharing, in particular, is not systematized and relies on ad hoc requests from one agency to another, which places an administrative burden and time delay on the process. This is an issue that is not technically difficult to address but may require changes in attitudes plus more forceful direction from senior officials. The process can also be facilitated by technology. NISR, for example, has an on-line system through which data from the national accounts can be downloaded directly. Some agencies, such as RWFA and the Rwanda Meteorological Agency, have on-line systems that allow users to request information and later gain access to the requested data. This is not the case for all ministries engaged in water resource management processes.

Database linkages. In both land and water issues, the NCA functions as an integration process as it brings together data from multiple sectors and multiple sources. As a consequence, there are expected issues of consistency and comparability across different data sources. It is a manual effort that requires clearing some administrative hurdles and assessment of the best quality figures. There may be a need for a centralized process to review the quality of the current data sets and consider ways to improve the consistency of the information collected and the communication among the various databases. For example, if different databases use similar unit or enterprise identifiers, and similar field names and definitions it will become easier to collate data from different sources to develop more systematic higher-level indicators, and report in a consistent way on water sector issues. NISR, RWFA, WASAC, MINAGRI, MININFRA and others all have a stake in improving the quality and communication among water sector databases. The sector working group may be the appropriate level for convening and discussing how to move forward on this issue.

5.3 Data Quality and Data Collection Issues

Participants in the NCA process, from many agencies, stress the importance of monitoring performance of the water sector toward meeting the national planning targets, as well as the new SDG indicators. This monitoring and assessment function require high quality and consistent data available to report on indicators of interest to policymakers and the public. Thus, it is important to have the resources available to systematically maintain and improve the foundation for the indicators, measure successes and identify gaps in implementation of the nation’s priorities for water sector performance and access. Good performance management systems need to be supported by good data analysis, good reporting, and good data, which has been, reportedly, underfunded in some instances in the past.

Data quality and collection. The data on water assets, supply and use, is scattered among a range of agencies, ministries and knowledge institutions. Having these data in a more organized and compatible form helps not only with natural capital accounting, but also for related policy analysis and decision-making processes. As in many countries, multiple agencies have partial mandates over different aspects of water resource management, abstraction, treatment, distribution, and valuation. These use different information systems, data sets, collection processes, and indicators of success. Each of these different data systems has specific issues of data quality and gaps. As a positive example, the system for collecting rainfall data is being upgraded by Rwanda Meteorology Agency so that information is transmitted directly, electronically to the water resource data managers at RWFA. Yet, even this system could be further improved with wider geographic coverage, given the variation in rainfall across Rwanda's diverse landscape.

Ground and soil water. The water accounts have illustrated the importance of these water resources in terms of volume and contribution to agricultural productivity. Data on these water resources are not available in a system or database, because they are not regularly measured and monitored. For this reason, the water accounts are populated by estimation, using international literature sources or research available in Rwanda. Improving these data and estimates will be a longer-term investment.

5.4 Capacity and Technology Issues

This section discusses the institutional capacity issues and technology challenges that Rwanda faces as it seeks to compile and refine its natural capital accounts. Suggestions are offered to address these issues going forward.

Capacity for regular NCA updating. Current staff of the environment and natural resource agencies, NISR, and other agencies engaged in the NCA process to date have participated in training events and have built their skills through on-the-job work, training events, and workshops. There will, however, be a continuing need for training and expertise to continue to upgrade the government's capacity to systematically handle the NCA over the coming years. The University of Rwanda (UR) will be a useful institution to consider as a source of training on environmental economics, natural capital accounting, and cross-sectoral understanding of water issues, land, mining, and ecosystem issues. A Memorandum of Understanding is in place for scientific and research collaboration on these topics.

Capacity for analysis of issues and policies based on NCA. In addition to regular publication of natural resource accounts, policy makers may also need issue-based reports that provide information on important trends, changes in values, or key questions of the day. The Government may also want to consider commissioning specific studies from research organizations, working in parallel with existing staff of the WRM department. Researchers or organizations that conduct studies using WRM datasets should be encouraged to brief their results to the WRM department. The WRM department could also consider—if it has not already—to record these research products in an electronic library that the staff can use to respond to important probably policy issues that decision-makers are facing.

Staff skills and time constraints. For the longer-term institutionalization of NCA preparation and maintenance, the government may need to consider time constraints on mid-level government officials tasked with this work, as well as budgets needed for database maintenance, field verification, workshops, and further training. Currently, staff skills are adequate for the task, but there may be future needs as staff members move to new positions. There is also a staff development process where individuals are sponsored for post graduate studies, after which they are expected to remain at the agency for three years. The government also sponsors staff taking short-term courses when there is a need to boost skills in a specific area. Courses in environmental economics, accounting, and statistics should be eligible.

Technology capacity. The RWFA and other related water agencies have sufficient data storage capacity, but there is some question about the ability to regularly update and maintain databases. (https://waterportal.rwfa.rw/).

5.5 Conclusions and Next Steps

This NCA effort has shown that compiling Water Accounts is a complex, multi-disciplinary task – that can be achieved when many agencies and professionals work together. The water accounts provide a consistent source of quality data on water resource demand and use and link those data to the national economic accounts. The true value in NCA accounts emerges after several iterations are produced and a substantial time series is available for analysis and debate.

As noted, water demand is expected to grow following both the country's population growth and strong economic development. The overall supply of water will have to increase to keep up, and specifically the supply of high quality water for human consumption and use. At the same time, it is relevant and prudent to consider means to increase the efficiency and productivity of water use in the face of growing demand and costly supply – as well as measures to minimize negative effects of water use and the negative effects on water quality from other sectors (e.g., pollution, sedimentation). Integrated and well-balanced management of water will be crucial for Rwanda's future prosperity.

Improvements and additions expected in the Water Accounts 2nd version. This compilation of water accounts data and analysis is a first effort to achieve SEEA-based accounting. The expectation is that this version will provide consistent data that helps the relevant departments address current issues and informs the development planning processes. It is also expected that the product is useful enough that the Government pursues regular updates, through which the data, methods and consistency are continually strengthened.

Clearly, data gaps and issues remain. The intention for the second version of the NCA Water Accounts is to:

- Refine the estimates and methods based on wider consultation with sector experts and relevant departments' technical staff.
- Update the time series to include additional years beyond 2015.
- Develop more geographically based data presentations to illustrate key issues and challenges on maps.
- Include more disaggregated data and information at the level of nine catchments, to the extent possible, and in collaboration with other agencies. This will increase comparability with the SEEA land account, which is disaggregated to district level, based on the capabilities of the LAIS database.
- Improve alignment and data use from Rwanda Meteorology Agency and MINAGRI.
- Make more and better use of available geo-spatial data and representation in accounts compilation.
- Describe more fully how the data collection and management process can be improved and institutionalized.
- Improve on industry coverage in the physical water supply and use tables, aligned with the ISIC format used at NISR.
- Improve the linkage between the economic focus of the National Accounts and the physical supply and use data of the NCA to improve the estimation and disaggregation of indicators on water productivity and the sectoral contribution to GDP.

- Illustrate how the Water Accounts can be used as a tool for deriving and reporting on water-related Sustainable Development Goals (SDGs, including SDG 6.4), as well as other economic and green development indicators selected by the Government.
- Develop better data and analysis on the values of water in different uses, including possible more specific studies on water pricing in response to the demand by the relevant agencies.
- Make better use of results from water gauging stations for stock assessment, including the new stations being developed and installed throughout the country.

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Annexes

ANNEX A: The SEEA Water Accounts Framework

A.1 Introduction

The NCA Rwanda water accounts include physical flow accounts, physical asset accounts and monetary accounts. The program follows the System of Environmental-Economic Accounting (SEEA), an international statistical standard which contains internationally agreed standard concepts, definitions, classifications, accounting rules and tables for producing internationally comparable statistics on the environment and its relationship with the economy (UN 2012 a and b). The system organizes statistical data for the derivation of coherent indicators and descriptive statistics to monitor the interactions between the economy and the environment and the state of the environment to better inform decision-making.

The water accounts were developed using the manual specifically developed for water accounts, the SEEA-Water (UN, 2012b). The set of water accounts allows deriving indicators that inform issues surrounding situations of water stress, allocation of water, supply and use of fresh water, water productivity & water-use efficiency, sustainable abstractions, water competition and water pricing. This section provides methodological details for construction of flow accounts for 2012 up to 2015.

A.2 Framework for Water Accounts

The UN manual SEEA-Water provides a conceptual framework for organizing hydrological and economic information in a sound and consistent manner (UN, 2012a). It is a satellite system to the UN's System of National Accounts (SNA) that is used for compiling economic statistics and derivation of economic indicators such as the gross domestic product (GDP). SEEA-WA provides aggregate indicators for economic performance and set of statistics that supports decision making for resource utilization and management. A diagrammatic representation of the components of the framework is illustrated in Figure A1.

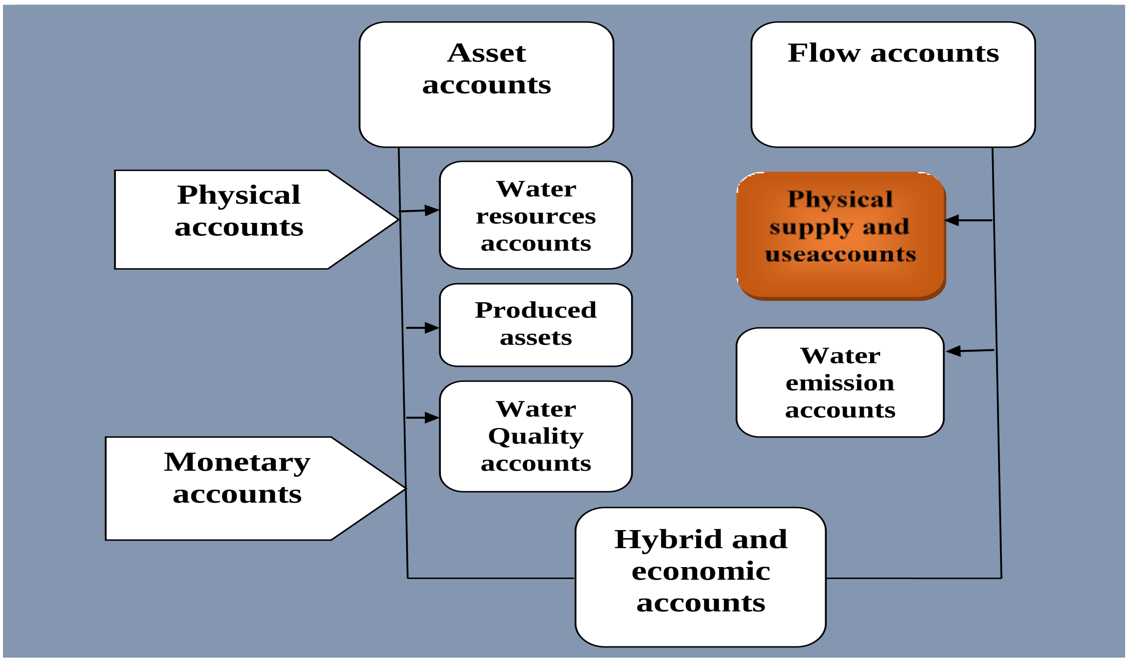

Figure A1. SEEA-Water framework

The main types of Environmental Accounts (EA) include:

- ***Physical flow accounts*****:** describe the physical flows of water, energy, and materials between the economy and the environment and within the economy. In this category of accounts, Physical supply and use tables (chap. III) are compiled and provide information on the volumes of water exchanged between the environment and the economy (abstractions and returns) and within the economy (supply and use within the economy). There are three types of water flows that can be distinguished (UN, 2012a): flows from the environment to the economy; flows within the economy; and flows from the economy.

- ***Physical asset accounts*****:** describe opening & closing stocks and changes therein during the accounting period of environmental assets. This category of accounts (chap. IV) comprises accounts for water resource assets measured mostly in physical terms. Asset accounts measure stocks at the beginning and the end of the accounting period and record the changes in the stocks that occur during the period. They describe all increases and decreases of the stock due to natural causes, such as precipitation, evapotranspiration, inflows and outflows, and human activities, such as abstraction and returns. These accounts are particularly useful because they link water abstraction and return to the availability of water in the environment, thus enabling the measurement of the pressure on physical water induced by the economy.

- ***Hybrid and economic accounts:*** aligns physical information recorded in the physical supply and use tables with the monetary supply and use tables of the 2008 SNA for Rwanda. These accounts are referred to as "hybrid" flow accounts in order to reflect the combination of different types of measurement units in the similar conceptualized accounts. In these accounts, physical quantities can be compared with matching economic flows, for example, linking the volumes of water used with monetary information on the production process, such as value added, and deriving indicators of water efficiency / water productivity.

Two major features of the framework are distinguished (UN, 2012a):

- Unlike other environmental information systems, SEEA-water directly links water data to the national accounts as they share similar set of definitions, concepts and classifications. For instance, both the SNA and SEEA-Water use the International Standard Industrial Classification (ISIC) that gives a breakdown of industrial or sectoral activities. ISIC is regularly updated, with the current set being ISIC Revision 4 published UN in New York 2008. Currently, Rwanda is implementing ISIC Rev.4 and this has been adopted in the water accounts. The same ISIC Rev.4 is also adopted in the National Accounts by NISR.
- The framework considers important water-economic interactions and this is important for addressing cross sectoral and broader issues related to water resources management such as IWRM. Countries are expected to compile a set of standard tables as per the SEEA-WA using harmonized definitions and classifications (GoB, 2015). SEEA-WA tables have been adopted in Rwanda water accounts such as PSUT and Physical asset tables.

The terms used under the SEEA-water framework should be carefully noted. The most pertinent ones for the Rwanda water accounts are listed in Table A1.

Table A1. Terminology for the water flow accounts

Abstraction of water	Abstraction is the amount of water that is removed from any source, either permanently or temporarily, in a given period of time. It includes the abstraction of water by households for own consumption, water used for hydroelectric power generation and water used as cooling water. Given the large volumes of water abstracted for hydroelectric power generation and for cooling purposes, these flows are separately identified as part of the abstraction of water. Abstraction also includes the abstraction of soil water by plants in areas of rain-fed agriculture and cultivated timber resources. The water abstracted from soil water is either absorbed by the plants or returned to the environment through transpiration.
Abstraction for distribution	Water abstracted for the purpose of its distribution.
Abstraction for own use	Water abstracted for own use. However, once water is used, it can be delivered to another user for reuse or for treatment.
Water consumption	That part of water use which is not distributed to other economic units and does not return to the environment (to water resources, sea and ocean) because during use it has been incorporated into products, or consumed by households or livestock. It is calculated as the difference between total use and total supply; thus, it may include losses due to evaporation occurring in distribution and apparent losses due to illegal tapping as well as malfunctioning metering.
Final water use	Final water use is equal to evaporation, transpiration and water incorporated into products. (Also referred to in water statistics as "water consumption")
Use of water received from other economic units	The amount of water that is delivered to an economic unit from another economic unit.
Supply of water to other economic units	The amount of water that is supplied by one economic unit to another and recorded net of losses in distribution.
Run off	The part of precipitation in a given country/territory and period of time that appears as stream flow. Urban runoff is that portion of precipitation on urban areas that does not naturally evaporate or percolate into the ground, but flows via overland flow, underflow, or channels, or is piped into a defined surface water channel or a constructed infiltration facility.
Actual evaporation	The amount of water that evaporates from the land surface and is transpired by the existing vegetation/plants when the ground is at its natural level of moisture content, which is determined by precipitation.
Groundwater recharge	The amount of water added from outside to the zone of saturation of an aquifer during a given period of time. Recharge of an aquifer is the sum of natural and artificial recharge.
Water returns	Water that is returned into the environment by an economic unit during a given period of time after use. Returns can be classified according to the receiving media (water resources and sea water) and to the type of water, such as treated water and cooling water).
Water losses in distribution	The volume of water lost during transport through leakages and evaporation between a point of abstraction and a point of use, and between points of use and reuse. Water lost due to leakages is recorded as a return flow as it percolates to an aquifer and is available for further abstraction; water lost due to evaporation is recorded as water consumption. When computed as the difference between the supply and use of an economic unit, it may also include illegal tapping.

Source: UN, 2012a and b.

A.3 Physical water accounts

A physical asset is an item of economic, commercial or exchange value that has a tangible or material existence. For most businesses, physical assets usually refer to cash, equipment, inventory and properties owned by the business. Intangible assets, such as leases, computer programs or agreements, are not included in physical assets.

Physical *asset* (stock) accounts describe opening & closing stocks and changes therein during the accounting period of environmental assets.

Physical water *flow* accounts consist of additions to the stock of water resources, and reductions in the stock of water resources. They account for flows between the environment and the economy, such water abstraction and discharges of water into the environment, as well as flows within the economy, such as the distribution of water from one industry to another or to households, and with the rest of the world.

Additions to the stock of water resources include the following flows (UN, 2012a): (a) *Returns*, which represent the total volume of water that is returned to the environment by economic units into surface water, soil and groundwater during the accounting period (Table A1).

(b) *Precipitation*, which consists of the volume of atmospheric precipitation (rain, snow, hail, etc.) on the territory of reference during the accounting period before evapotranspiration takes place. The major part of precipitation falls on the soil (see Table 6). A proportion of this precipitation will run off to rivers or lakes and is recorded as an addition to surface water. Amounts retained in the soil should be recorded as additions to soil water. Some precipitation also falls directly onto surface-water bodies. It is assumed that water would reach aquifers after having passed through either the soil or surface water (rivers, lakes, etc.), thus no precipitation is shown in the asset accounts for groundwater. The infiltration of precipitation to groundwater is recorded in the accounts as an inflow from other water resources into groundwater;

(c) *Inflows*, which represent the amount of water that flows into water resources during the accounting period. The inflows are disaggregated according to their origin:

(i) *Inflows from other territories* occur with shared water resources. For example, in the case of a river that enters the territory of reference, the inflow is the total volume of water that flows into the territory at its entry point during the accounting period. If a river borders two countries without eventually entering either of them, each country could claim a percentage of the flow to be attributed to its territory. If no formal convention exists, a practical solution is to attribute 50 per cent of the flow to each country.

(ii) *Inflows from other water resources* include transfers, both natural and man-made, between the resources within the territory. They include, for example, flows from desalination facilities and flows of infiltration and seepage;

(d) Discoveries *of water* in new aquifers. These flows should be recorded in terms of the quantity of water in the newly discovered aquifer as distinct from the overall capacity of the aquifer. Increases in the volume of water in a known aquifer should be included as an inflow of water resources to groundwater.

Reductions in the stock of water resources consist of the following flows(UN, 2012a):
(a) *Abstraction*, which is the amount of water removed from any source, either permanently or temporarily, in a given period of time (see Table A1);
(b) *Evaporation* and *actual evapotranspiration*, which constitute the amount of evaporation and actual evapotranspiration (Table A1). Actual evapotranspiration was typically estimated in this report using land use change matrix results from land accounts and using rainfall data collected from Rwanda Meteo to build the accounts of 2012-2015;
(c) *Outflows*, which represent the amount of water that flows out of water resources during the accounting period. Outflows are disaggregated according to the destination of the flow; i.e. (i)

other water resources within the territory,(ii) other territories/countries and(iii) the sea/ocean. The flow diagram in Figure A2 conceptualizes the compilation of physical water flows accounts (PSUT).

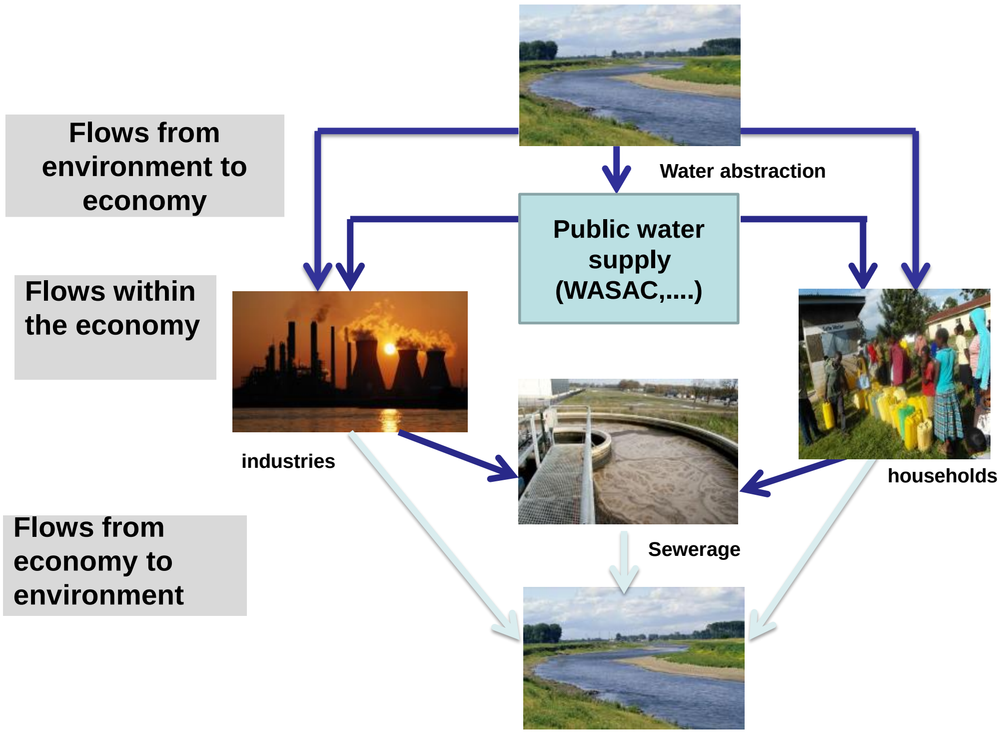

Figure A2. Components of Physical Supply and Use tables (PSUT)

Flows from the environment to the economy

Flows from the environment to the economy consist of water abstraction from the environment by economic units in the territory of reference for production and consumption activities. In particular, water is abstracted from the inland water resource system, which includes surface water, groundwater and soil water, as defined, and water from other sources. Abstraction from other sources includes abstraction from the sea or lakes, for example, for direct use in cooling, or for desalination purposes, and collection of precipitation, e.g. harvest of roof water.

Water is abstracted either to be used by the abstracting economic unit, in which case, it is referred to as "abstraction for own use", or to be supplied, possibly after some treatment, to other economic units, which constitutes "abstraction for distribution". Water service providers in Rwanda include mainly Water and Sanitation Corporation (WASAC), and Private Operators under Districts collaboration (AquaVirunga, Ayateke STAR, etc).

Flows within the economy

Flows within the economy show water that is used to produce other goods and services (intermediate consumption) and for consumption in households and government (final consumption), as well as water that is exported. It also involves water exchanges between economic units. Such exchanges are usually carried out through mains (pipes), but other means of transporting water are not excluded. It should be noted that the physical supply of water by households generally represents a flow of wastewater to sewerage.

During the process of distributing water (between a point of abstraction and a point of use or between points of use and reuse of water), there may be losses of water. Such losses may be caused by a number of factors: evaporation when water is distributed through open channels; leakages when water leaks from pipes into the ground; and illegal tapping when water is illegally diverted from the distribution network. In addition, when losses during distribution are computed as the difference between the amount of water supplied and received, there may also be errors in meter readings, malfunctioning meters, theft, etc. In the supply and use tables, the supply of water within the economy is recorded net of losses during the distribution process. Furthermore, the losses during distribution are recorded as return flows when they are due to leakages and as water consumption in all other cases.

Flows from the economy back into the environment

Flows from the economy back to the environment consist of discharges of wastewater (residual flows): Thus, the supplier is the economic agent responsible for the discharge (industries, households and the rest of the world) and the destination (user) of these flows is the environment. The environment is assumed to use all the water that is returned (supplied) to it. Hence, for such flows, use equals supply. In SEEA-Water, discharges of water back into the environment are also referred to as "returns" or "return flows".

Returns are classified according to the receiving media: a distinction is made between "water resources", which include surface water, groundwater and soil water, and "other sources" such as seas, oceans or lakes. Discharges of water by the rest of the world are those locally generated by non-resident units. These are often insignificant. Even in a country where there is a large presence of tourists, the discharges would generally take place through resident units, such as hotels and restaurants.

A.4 Economic Water Accounts

As noted above, a hybrid water account is a combination of physical water accounts and economic water accounts. The System of National Accounts (SNA) is a system to monitor nations' economic activity. It can be measured from the consumption side or the production side. From the production side, it is compiled as:

1. Gross output
2. -/-Intermediate consumption
3. = Value added ('GDP')

Intermediate consumption is the inputs used to produce a specific product. Value added is the net output, which includes compensation of employees, depreciation of capital and return to capital.

The SEEA presents some issues that arise in the valuation of water goods and services: namely, the scaling and aggregation of water values, the risk of double counting (as some of the value of water is already captured in the National Accounts), and the types of measures of value and their implications (UN, 2012a).Projects and policies are often implemented for a designated water management area, such as a river basin. There has been little experience in aggregating these localized values at the national level. Because water is a bulky commodity and the costs of transporting and storing it are often high, the value of water is determined by local and regional site-specific characteristics and options for its use (UN, 2012b). For example, the value of water as an input to agriculture will often vary a great deal by region because of differing factors that affect production costs and product value, including soil, climate, market demand, cost of inputs, etc. In addition, the timing of water availability, the quality of water and the reliability of its supply are also important determinants of the value of water.

The site-specific nature of water values means that those estimated for one area of a country cannot be assumed to apply in other areas. This poses a problem for constructing accounts for water value at the national level, because the method commonly employed formational accounts - scaling up to the national level from sample data – is not so accurate. It is more useful for policymakers to construct water accounts at the level of a river basin or an accounting catchment for which economic information can be compiled (UN, 2012b), and aggregate them at the national level in order to obtain national water accounts. In this first compilation of water accounts for Rwanda, it was not possible to follow this recommendation, but the next version of water account will be more focusing at catchment levels to have more insight on water economic issues at catchment level.

Correction factors

For compiling PSUT, we have used data collected from NWRMP and other institutions as explained above. In the absence of data, primary and secondary, assumptions and correction factors had to be applied. During the data collection, we have sampled a few institutions in each economic sector as shown in Table A2 and the correction factors have been applied. NISR is recommending to sample 30% of the whole population. Due to limited funds and time, we have sampled less than this. We recommend for the next version 2.0 of water accounts in Rwanda to go for the standard recommended sampling method.

Table A2 Multiplication factors used for PSUT

	Year			Visited Companies	Item	Source
	2012	2013	2014			
Number	416	416	416	3	Number of mining company	Newsletter: Unfolding the Rwandan Mining Sector
Mult Factor	138.7	138.7	**138.7**			
Number	17	17	17	4	Number of Licensed Banks	National Bank: **https://goo.gl/m3I9Sp**
Mult Factor	4.25	4.25	**4.3**			
Number	17	17	17	2	Number of Licensed Insurance Companies	National Bank: **https://goo.gl/mxAnJS**
Mult Factor	8.5	8.5	**8.5**			
Number	171	171	171	2	Number of INGO	Migration Office: **https://goo.gl/QDwUAE**
Mult Factor			**N/A**			
Number	10	10	10	2	Number of Security Companies	Security Companies: **https://goo.gl/yyVUfS**
Mult Factor	5	5	**5.0**			
Number	2,049	2,095	2,135	3	Number of Schools	Statistical Year Book 2014, Data from MINEDUC
Mult Factor	683	698.33	**711.7**			
Number	107	132	139	1	Number of Hospitals	Statistical Year Book 2015, Data from RBC
Mult Factor	107	132	**139.0**			
Number	234	253	261	5	Number of Industries	Statistical Year Book 2014, Data from National Account, NISR
Mult Factor	46.8	50.6	**52.2**			
Number	375	431	436	4	Number of Hotels	Statistical Year Book 2015, Data from RDB
Mult Factor	93.75	107.75	**109.0**			

Calculations and assumptions used

Where data have not been available to fully compile PSUT, we have used some calculations and assumptions according to literature or international standards as shown in Annex H and I of this document. The tables provided are available as Microsoft Excel Spreadsheets (.xls).

ANNEX B: Institutional Set-Up, Mandates, Roles and Responsibilities

Rwanda's environment and water resources sub-sector is governed under a complex institutional framework (see Table A3). The institutions involved in this sector can be categorized into policy and oversight institutions, management and implementation institutions, service provision institutions and regulatory institutions according to the way in which their mandates were defined by laws (see Table A3 the summary of mandates, roles and responsibilities of different institutions in regard to water resources). This is elementary in water governance and governance in general because it helps to avoid conflicts between stakeholders, individually and groups and among institutions. Instead, it brings about coherence and consistence towards successful implementation (Munyaneza, 2014a).

Moreover, to implement water resources management requires an institutional arrangement that allows transparent and effective flow of information, knowledge and financial resources (Munyaneza, 2014a). After political and institutional frameworks for IWRM were put in place, the GoR has adopted the Sector Wide Approach (SWAp) to achieve an integrated planning for water related issues, though in its infancy. Rwanda's water policy (2008) and National Water Resources Master Plan (2015) were proved to allow faster implementation of IWRM. Also a big number of local and international NGOs and CSOs attempt to contribute to water security programmes to supplement the government efforts. These include Rwanda WaterAid, World Vision, Rwanda Water for People, Nile Basin Initiative (NBI), World Bank (WB), Living Water International Rwanda, Nile Basin Capacity Building Network (NBCBN) and Nile Basin Discourse Forum in Rwanda (NBDF), JICA, and many others.

Table B1 Institutional framework for water resources management

Institution	Function and responsibilities related to WRM
	Policy and oversight institutions
Ministry of Environment (MoE): Department of Environment, Department of Water Resources Management and Department of Planning, Monitoring and Evaluation.	Formulation of Water resources management policy, strategic planning, coordination, quality assurance, monitoring, evaluation and capacity building. Put in place legal and regulatory framework.
Ministry of Local Government (MINALOC): Directorate of Planning, Monitoring and Evaluation and Directorate of Territorial Administration and governance.	Establishment, development and facilitation of the management of efficient and effective decentralized government systems capable of law enforcement and delivery of required services to the local communities.
Ministry of Agriculture and Animal Resources (MINAGRI): Directorate of Strategic Planning and Programmes Coordination.	Development, planning and coordination of the implementation of agricultural development policy in the country including irrigation, fishery and livestock as well as watershed management.
Ministry of Infrastructure (MININFRA): Department of Policy and Planning	Development of institutional and legal frameworks, national policies, strategies and master plans relating to water supply and sanitation, energy and transport sub-sectors.
Ministry of Health (MINISANTE): Maternal and Child Health Unit	Policy formulation and promotion of hygiene and public health
Ministry of Family and Gender Promotion (MIGEPROF): Department of Gender policy Development Unit	Coordination of gender, promotion and mainstreaming and family planning activities.
Ministry of Education (MINEDUC): Directorate General of Education Planning and Directorate General of	Promotion of education including/capacity building and curricula development relating to water sciences and research on water resources management in schools and other educational institutions (Universities and Colleges).

Institution	Function and responsibilities related to WRM
Science, Technology and Research.	
Ministry of Trade, Industry and East African Community Affairs(MINEACOM): Department of Planning, Monitoring and Evaluation, Industry and Trade Departments and Unit of Economic, Infrastructure and Productive Sector.	Policy formulation and promotion of investments by the private sector in water resources management/industries and manufacturing. Coordination of the implementation of EAC water resources management programs/activities in Rwanda
Ministry of Foreign Affairs and Cooperation (MINAFFET): Diplomatic Advisory, Policy and Strategic Planning, Coordination and Monitoring and Bilateral & Multilateral Affairs Units	Foreign and diplomatic relations including regional and international cooperation over shared waters.
	Financing Institutions
Ministry of Finance, Planning and Economic Development (MINECOFIN): National Development Planning & Research and National Budget Directorates	Mobilization and allocation of financial resources for water resources development.
Development partners such as USAID, European Union, FONERWA, UNICEF, Netherlands Embassy, UNDP, FAO, AfDB, CEPGL, ABAKIR, WB, JICA, IFAD, NBCBN and UNESCO	Provision and mobilization of financial and technical resources for implementing water resources management and development sector activities.
	Regulatory Institutions
Rwanda Environment Management Authority (REMA)	Develop regulations and ensure protection and conservation of the Environment and natural resources across the Country.
Rwanda Agriculture Board (RAB)	Conduct research activities on water resources management
Rwanda Meteorology Agency (RMA)	Provide weather, water and climate information services for safety of life and property and socio-economic development.
Rwanda Utilities Regulatory Agency (RURA)	Enforcement of compliance by public utilities with the laws governing their activities.
Rwanda Standards Board (RSB)	Provision of standards based solutions for Consumer Protection and Trade promotion for socio-economic growth in a safe and stable environment.
Rwanda Water and Forestry Authority (RWFA)	Autonomous agency responsible for management of water resources and allocation.
	Implementing/Service institutions
Water and Sanitation Corporation (WASAC)	Autonomous agency responsible for the delivery of water supply and sewerage services in the major towns (secondary cities) and large urban centers including provision of oversight and support services to the local communities and other water supply service providers.
Rwanda Development Board (RDB)	Facilitation of investment and support services to investors.
Districts	Implementation of the government policies and laws including water law and policies
Private Sector	Design, construction, operation and maintenance of water resources management infrastructure. Conduct training and capacity building for both central and local government staff. Provision of other commercial services.
Non Governmental Organizations (NGOs) and CBOs	Supplement the public sector efforts in water resource management and development.

ANNEX C: Template for Water Flow Questionnaire

	Year	2012		2013		2014		2015		2016	
I. Water source		**Qty (m^3)**	**Value (Rwf)**	**Qty (m^3)**	**Value (Rwf)**	**Qty (m^3)**	**Value (Rwf)**	**Qty (m^3)**	**Value (Rwf)**	**Qty (m^3)**	**Value (Rwf)**
From the environment	1a.Abstraction for own use										
	1b.Abstraction for distribution										
	1i.Reservoir water (Eg. Dams, Ponds,...)										
	1ii.Ground water										
	1iii.River water										
	1iv.Rainwater harvesting										
Within the economy	2. Use of water from other economic sectors (Eg. from WASAC, AquaVirunga, private operators,...)										
II. Water distribution (use within the institution)											
Within the economy	4a. Re-used water										
	4b. Wastewater to sewerage										
Into the environment	5.a.1. To Surface water (Eg. Rivers, lakes, channels,..)										
	5.a.2. To Groundwater										
	5.a.3. To Soil water (gardens, ...)										
	5.b. To other sources										
III. Employees within the institution											
		Qty (no)	**Value (Rwf)**	**Qty (no)**	**Value (Rwf)**	**Qty (no)**	**Value (Rwf)**	**Qty (no)**	**Value (Rwf)**	**Qty (no)**	**Value (Rwf)**
	Employees working in the institution (water related) (Plumbers, cleaners,.)										

ANNEX D: Physical Water Use and Supply Table for 2013, 2014, 2015

Table D1 Physical Water Use for 2013, in 10^3 m^3

'000 m^3		Industries (by ISIC categories)										Total Production activities				Total
		A. Agriculture, forestry and fishing	B. Mining and Quarrying	C. Manufacturing	D. Electricity, gas, steam and air conditioning supply	E. Water supply (WASAC & AquaVirunga)	I. Accommodation and food service activities	K. Banking and insurance activities	P. Education	Q. Human health and social work activities	S. Other service activities (Religious & Burial)		Households	U. Activities of extraterritorial organizations and bodies	Rest of the world	
ISIC-Rev.4 Code:		1-3	6-8	10-13. 22, 32	35	36-38	55-56	64-66, 71-72, 75	85	86, 88	94, 96	Total	98	99		
From the environment	**1 - Total abstraction (=1.a+1.b = 1.i+1.ii)**	13,010,019	22,410	23,938	345,951	53,274	0	0	133	589	12	**13,456,326**	40,633	0		**13,496,958**
	1.a Abstraction for own use	13,010,019	22,410	23,852	345,951	3,213	0	0	133	589	12	13,406,179	40,633	0		13,446,812
	1.b Abstraction for distribution	0	0	86	0	50,061	0	0	0	0	0	50,147	0	0		50,147
	1 - Total abstraction (1.i+1.ii)	13,010,019	22,410	23,938	345,951	53,069	0	0	133	589	12	**13,456,121**	40,633	0		**13,496,753**
	1.i From water resources:	13,009,212	1,050	23,910	345,951	53,069	0	0	133	91	2	**13,433,418**	40,083	0		**13,473,501**
	1.i.1 Surface water	195,157	986	15,027	345,951	41,024	0	0	0	0	2	598,148	11,301	0		609,449
	1.i.1.a Lakes	13,796	0	0	0	0	0	0	0	0	0	13,796	5,040	0		18,836
	1.i.1.b Rivers	114,307	986	11,597	148,871	41,024	0	0	0	0	2	316,787	5,116	0		321,903
	1.i.1.c Reservoirs (Dams, ponds, ..)	47,347	0	0	197,081	0	0	0	0	0	0	244,427	11	0		244,439
	1.i.1.d Combined River & Reservoirs (Dams, ponds, ..)	19,708	0	3,430	0	0	0	0	0	0	0	23,138	1,134	0		24,272
	1.i.2 Groundwater	13,878	64	8,883	0	12,045	0	0	133	91	0	35,093	28,781	0		63,874
	1.i.2a From Boreholes	4,243	0	3,314	0	0	0	0	126	18	0	7,702	3,732	0		
	1.i.2b From Springs	9,634	64	5,569	0	12,045	0	0	7	73	0	27,391	25,049	0		
	1.i.3 Soil water (green water)	12,800,177	0	0	0	0	0	0	0	0	0	12,800,177	0	0		12,800,177
	1.ii From other sources	807	21,360	28	0	0	0	0	0	498	10	**22,703**	550	0		**23,253**
	1.ii.1 Collection of precipitation (rainwater harvesting; ..)	807	21,360	28	0	0	0	0	0	498	10	22,703	550	0		23,253
	1.ii.2 Abstraction from the sea	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Within the economy	**2. Use of water received from other economic units**	90,250	0	642,764	0	0	16,673	76	224,372	3,721	132	**977,987**	176,061	6,515		**1,160,563**
3. Total use of water (=1+2)		**13,100,269**	**22,410**	**666,702**	**345,951**	**53,274**	**16,673**	**76**	**224,505**	**4,310**	**143**	**14,434,313**	**216,694**	**6,515**		**14,657,521**

Table D2 Physical Water Supply for 2013, in 10^3 m^3

'000 m^3		Industries (by ISIC categories)											Households	U. Activities of extraterritorial organizations and bodies	Rest of the world	Total
		A. Agriculture, forestry and fishing	B. Mining and Quarrying	C. Manufacturing	D. Electricity, gas, steam and air conditioning supply	E. Water supply (WASAC & AquaVirunga)	I. Accommodation and food service activities	K. Banking and insurance activities	P. Education	Q. Human health and social work activities	S. Other service activities (Religious & Burial)					
		1-3	6-8	10-13. 22, 32	35	36-38	55-56	64-66, 71-72, 75	85	86, 88	94, 96	Total	98	99		
Within the economy	**4. Supply of water to other economic units**	**0**	**21,290**	**817**	**0**	**0**	**12,671**	**6**	**0**	**0**	**0**	34,783	**0**	**0**		**34,783**
	4.a Reused water	**0**	**21,290**	**346**	**0**	**0**	**12,671**	**2**	**0**	**0**	**0**	34,309	**0**	**0**		**34,309**
	4.b Wastewater to sewerage	**0**	**0**	**471**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	474	**0**	**0**		**474**
To the environment	**5. Total returns (= 5.a+5.b)**	**1,474,326**	**54**	**514,699**	**328,654**	**2,570**	**301**	**57**	**179,498**	**3,448**	**11**	2,503,617	**82,781**	**5,212**		**2,591,610**
	5.a To water resources	**1,474,326**	**54**	**514,699**	**328,654**	**2,570**	**301**	**57**	**179,498**	**3,448**	**11**	2,503,617	**72,433**	**5,212**		**2,581,262**
	5.a.1 Surface water	**741,873**	**1**	**514,526**	**328,654**	**2,570**	**159**	**47**	**44,210**	**0**	**1**	1,632,042	**41,390**	**4,689**		**1,678,120**
	5.a.2 Groundwater	**81,951**	**2**	**167**	**0**	**0**	**0**	**5**	**135,288**	**3,201**	**9**	220,623	**20,695**	**523**		**241,841**
	5.a.3 Soil water	**650,501**	**51**	**6**	**0**	**0**	**142**	**5**	**0**	**247**	**0**	650,952	**10,348**	**0**		**661,300**
	5.b To other sources (e.g. sea water)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	**10,348**	**0**		**10,348**
6. Total supply of water (= 4+5)		1,474,326	21,344	515,516	328,654	2,570	12,972	62	179,498	3,448	11	2,538,400	82,781	5,212		**2,626,393**
7. Consumption (3-6)		11,625,943	1,066	151,186	17,298	50,704	3,700	14	45,008	862	133	11,895,913	133,913	1,303		**12,031,128**

Table D3 Physical Water Use for 2014, in 10^3 m^3

'000 m^3		Industries (by ISIC categories)										Total Production activities	Households	U. Activities of extraterritorial organizations and bodies	Rest of the world	Total
		A. Agriculture, forestry and fishing	B. Mining and Quarrying	C. Manufacturing	D. Electricity, gas, steam and air conditioning supply	E. Water supply (WASAC & AquaVirunga)	I. Accommodation and food service activities	K. Banking and insurance activities	P. Education	Q. Human health and social work activities	S. Other service activities (Religious & Burial)					
ISIC-Rev.4 Code:		1-3	6-8	10-13. 22, 32	35	36-38	55-56	64-66, 71-72, 75	85	86, 88	94, 96	Total	98	99		
From the environment	**1 - Total abstraction (=1.a+1.b = 1.i+1.ii)**	13,506,848	22,430	24,242	357,009	53,540	0	0	133	589	12	**13,964,803**	40,833	0		**14,005,636**
	1.a Abstraction for own use	13,506,848	22,430	24,157	357,009	3,213	0	0	133	589	12	13,914,390	40,833	0		13,955,223
	1.b Abstraction for distribution	0	0	86	0	50,327	0	0	0	0	0	50,413	0	0		50,413
	1 - Total abstraction (1.i+1.ii)	13,506,848	22,430	24,242	357,009	53,540	0	0	133	589	12	**13,964,803**	40,833	0		**14,005,636**
	1.i From water resources:	13,506,041	1,070	24,214	357,009	53,540	0	0	133	91	2	**13,942,100**	40,283	0		**13,982,383**
	1.i.1 Surface water	205,178	1,006	15,211	357,009	41,435	0	0	0	0	2	619,842	11,302	0		631,144
	1.i.1.a Lakes	14,361	0	0	0	0	0	0	0	0	0	14,361	5,040	0		19,401
	1.i.1.b Rivers	118,993	1,006	11,713	151,848	41,435	0	0	0	0	2	324,998	5,116	0		330,114
	1.i.1.c Reservoirs (Dams, ponds, ..)	51,308	0	0	205,161	0	0	0	0	0	0	256,468	12	0		256,480
	1.i.1.d Combined River & Reservoirs (Dams, ponds, ..)	20,516	0	3,498	0	0	0	0	0	0	0	24,014	1,134	0		25,148
	1.i.2 Groundwater	13,926	64	9,003	0	12,105	0	0	133	91	0	35,321	28,981	0		64,302
	1.i.2a From Boreholes	4,243	0	3,381	0	0	0	0	126	18	0	7,769	3,807	0		
	1.i.2b From Springs	9,682	64	5,622	0	12,105	0	0	7	73	0	27,553	25,174	0		
	1.i.3 Soil water (green water)	13,286,937	0	0	0	0	0	0	0	0	0	13,286,937	0	0		13,286,937
	1.ii From other sources	807	21,360	28	0	0	0	0	0	498	10	**22,703**	550	0		**23,253**
	1.ii.1 Collection of precipitation (rainwater harvesting; ..)	807	21,360	28	0	0	0	0	0	498	10	22,703	550	0		23,253
	1.ii.2 Abstraction from the sea	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Within the economy	**2. Use of water received from other economic units**	90,250	0	642,764	0	0	16,673	76	224,372	3,721	132	**977,987**	176,061	6,515		**1,160,563**
3. Total use of water (=1+2)		**13,597,098**	**22,430**	**667,006**	**357,009**	**53,540**	**16,673**	**76**	**224,505**	**4,310**	**143**	**14,942,790**	**216,894**	**6,515**		**15,166,199**

Table D4 Physical Water Supply for 2014, in 10^3 m^3

'000 m^3		Industries (by ISIC categories)											Households	U. Activities of extraterritorial organizations and bodies	Rest of the world	Total
		A. Agriculture, forestry and fishing	B. Mining and Quarrying	C. Manufacturing	D. Electricity, gas, steam and air conditioning supply	E. Water supply (WASAC & AquaVirunga)	I. Accommod ation and food service activities	K. Banking and insurance activities	P. Education	Q. Human health and social work activities	S. Other service activities (Religious & Burial)					
		1-3	6-8	10-13. 22, 32	35	36-38	55-56	64-66, 71-72, 75	85	86, 88	94, 96	Total	98	99		
Within the economy	**4. Supply of water to other economic units**	**0**	**21,308**	**817**	**0**	**0**	**12,671**	**6**	**0**	**0**	**0**	34,802	**0**	**0**		**34,802**
	4.a Reused water	**0**	**21,308**	**346**	**0**	**0**	**12,671**	**2**	**0**	**0**	**0**	34,328	**0**	**0**		**34,328**
	4.b Wastewater to sewerage	**0**	**0**	**471**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	474	**0**	**0**		**474**
To the environment	**5. Total returns (= 5.a+5.b)**	**1,524,008**	**54**	**514,699**	**339,159**	**2,570**	**301**	**57**	**179,498**	**3,448**	**11**	2,563,805	**82,781**	**5,212**		**2,651,798**
	5.a To water resources	**1,524,008**	**54**	**514,699**	**339,159**	**2,570**	**301**	**57**	**179,498**	**3,448**	**11**	2,563,805	**72,433**	**5,212**		**2,641,450**
	5.a.1 Surface water	**766,715**	**1**	**514,526**	**339,159**	**2,570**	**159**	**47**	**44,210**	**0**	**1**	1,667,388	**41,390**	**4,689**		**1,713,467**
	5.a.2 Groundwater	**81,951**	**2**	**167**	**0**	**0**	**0**	**5**	**135,288**	**3,201**	**9**	220,623	**20,695**	**523**		**241,841**
	5.a.3 Soil water	**675,342**	**51**	**6**	**0**	**0**	**142**	**5**	**0**	**247**	**0**	675,794	**10,348**	**0**		**686,142**
	5.b To other sources (e.g. sea water)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	**10,348**	**0**		**10,348**
6. Total supply of water (= 4+5)		1,524,008	21,362	515,516	339,159	2,570	12,972	62	179,498	3,448	11	2,598,607	82,781	5,212		**2,686,600**
7. Consumption (3-6)		12,073,090	1,067	151,490	17,850	50,970	3,700	14	45,008	862	133	12,344,183	134,113	1,303		**12,479,599**

Table D5 Physical Water Use for 2015, in 10^3 m^3

'000 m^3		Industries (by ISIC categories)										Total Production activities	Households	U. Activities of extraterritorial organizations and bodies	Rest of the world	Total
		A. Agriculture, forestry and fishing	B. Mining and Quarrying	C. Manufacturing	D. Electricity, gas, steam and air conditioning supply	E. Water supply (WASAC & AquaVirunga)	I. Accommodation and food service activities	K. Banking and insurance activities	P. Education	Q. Human health and social work activities	S. Other service activities (Religious & Burial)					
ISIC-Rev.4 Code:		1-3	6-8	10-13. 22, 32	35	36-38	55-56	64-66, 71-72, 75	85	86, 88	94, 96	Total	98	99		
From the environment	**1 - Total abstraction (=1.a+1.b = 1.i+1.ii)**	13,846,588	22,450	24,551	368,458	53,808	0	0	133	589	12	**14,316,588**	41,035	0		**14,357,623**
	1.a Abstraction for own use	13,846,588	22,450	24,466	368,458	3,213	0	0	133	589	12	14,265,908	41,035	0		14,306,942
	1.b Abstraction for distribution	0	0	86	0	50,595	0	0	0	0	0	50,681	0	0		50,681
	1 - Total abstraction (1.i+1.ii)	13,846,588	22,450	24,551	368,458	53,808	0	0	133	589	12	**14,316,588**	41,035	0		**14,357,623**
	1.i From water resources:	13,845,781	1,090	24,523	368,458	53,808	0	0	133	91	2	**14,293,886**	40,485	0		**14,334,370**
	1.i.1 Surface water	213,590	1,026	15,399	368,458	41,642	0	0	0	0	2	640,117	11,302	0		651,418
	1.i.1.a Lakes	14,950	0	0	0	0	0	0	0	0	0	14,950	5,040	0		19,990
	1.i.1.b Rivers	123,872	1,026	11,830	154,885	41,642	0	0	0	0	2	333,258	5,116	0		338,374
	1.i.1.c Reservoirs (Dams, ponds, ..)	53,411	0	0	213,572	0	0	0	0	0	0	266,983	12	0		266,995
	1.i.1.d Combined River & Reservoirs (Dams, ponds, ..)	21,357	0	3,568	0	0	0	0	0	0	0	24,926	1,134	0		26,060
	1.i.2 Groundwater	13,974	64	9,125	0	12,166	0	0	133	91	0	35,552	29,183	0		64,735
	1.i.2a From Boreholes	4,243	0	3,448	0	0	0	0	126	18	0	7,836	3,883	0		
	1.i.2b From Springs	9,731	64	5,676	0	12,166	0	0	7	73	0	27,716	25,300	0		
	1.i.3 Soil water (green water)	13,618,217	0	0	0	0	0	0	0	0	0	13,618,217	0	0		13,618,217
	1.ii From other sources	807	21,360	28	0	0	0	0	0	498	10	**22,703**	550	0		**23,253**
	1.ii.1 Collection of precipitation (rainwater harvesting; ..)	807	21,360	28	0	0	0	0	0	498	10	22,703	550	0		23,253
	1.ii.2 Abstraction from the sea	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Within the economy	**2. Use of water received from other economic units**	90,250	0	642,764	0	0	16,673	76	224,372	3,721	132	**977,987**	176,061	6,515		**1,160,563**
3. Total use of water (=1+2)		**13,936,838**	**22,450**	**667,315**	**368,458**	**53,808**	**16,673**	**76**	**224,505**	**4,310**	**143**	**15,294,576**	**217,096**	**6,515**		**15,518,186**

Table D6 Physical Water Supply for 2015, in 10^3 m^3

'000 m^3		Industries (by ISIC categories)											Households	U. Activities of extraterritorial organizations and bodies	Rest of the world	Total
		A. Agriculture, forestry and fishing	B. Mining and Quarrying	C. Manufacturing	D. Electricity, gas, steam and air conditioning supply	E. Water supply (WASAC & AquaVirunga)	I. Accommodation and food service activities	K. Banking and insurance activities	P. Education	Q. Human health and social work activities	S. Other service activities (Religious & Burial)					
		1-3	6-8	10-13. 22, 32	35	36-38	55-56	64-66, 71-72, 75	85	86, 88	94, 96	Total	98	99		
Within the economy	**4. Supply of water to other economic units**	0	21,327	817	0	0	12,671	6	0	0	0	34,821	0	0		**34,821**
	4.a Reused water	0	21,327	346	0	0	12,671	2	0	0	0	34,347	0	0		**34,347**
	4.b Wastewater to sewerage	0	0	471	0	0	0	3	0	0	0	474	0	0		**474**
To the environment	**5. Total returns (= 5.a+5.b)**	1,557,982	54	514,699	350,035	2,570	301	57	179,498	3,448	11	2,608,655	82,781	5,212		**2,696,648**
	5.a To water resources	1,557,982	54	514,699	350,035	2,570	301	57	179,498	3,448	11	2,608,655	72,433	5,212		**2,686,300**
	5.a.1 Surface water	783,702	1	514,526	350,035	2,570	159	47	44,210	0	1	1,695,251	41,390	4,689		**1,741,330**
	5.a.2 Groundwater	81,951	2	167	0	0	0	5	135,288	3,201	9	220,623	20,695	523		**241,841**
	5.a.3 Soil water	692,329	51	6	0	0	142	5	0	247	0	692,781	10,348	0		**703,129**
	5.b To other sources (e.g. sea water)	0	0	0	0	0	0	0	0	0	0	0	10,348	0		**10,348**
6. Total supply of water (= 4+5)		1,557,982	21,382	515,516	350,035	2,570	12,972	62	179,498	3,448	11	2,643,476	82,781	5,212		**2,731,469**
7. Consumption (3-6)		12,378,856	1,068	151,799	18,423	51,238	3,700	14	45,008	862	133	12,651,100	134,315	1,303		**12,786,717**

ANNEX E: Physical Water Asset Table for 2013, 2014 and 2015

Table E1 Physical Water Asset for 2013, in 10^6 m^3

Units in Million Cubic Meters	Surface water			Soil water	Groundwater	Total	Internal Renewable water resources	Total Renewable water resources
	Lakes	Rivers and streams	Artificial reservoirs					
Opening stock water resources	257,690	1,264	63	3,389	62,127	324,532		
Additions to stock								
Returns of water	1	349	0	147	1	499		
Precipitation	2,105	2,623	107	27,100		31,935	31,935	31,935
Inflows from other territories	0	850	0		0	850		850
Inflows from other inland water resources	1,636	4,863	319	911	3,644	11,373		
Total additions to stock	3,742	8,685	426	28,159	3,646	44,657	31,935	32,785
Reductions in stock								
Abstraction of water	20	333	295	0	64	712		
Actual Evaporation and transpiration	1,401	56	17	20,982		22,456	22,456	22,456
Outflows to other territories		6,439	0		0	6,439		
Outflow to the sea		0	0		0	0		
Outflow to other inland water resources	2,762	1,857	108	7,177	3,582	15,486		
Total reductions in stock	4,183	8,685	420	28,159	3,646	45,093	22,456	22,456
Closing stock water resources	257,248	1,264	68	3,389	62,127	324,096	9,479	10,329

Table E2 Physical Water Asset for 2014, in 10^6 m^3

Units in Million Cubic Meters	Surface water			Soil water	Groundwater	Total	Internal Renewable water resources	Total Renewable water resources
	Lakes	Rivers and streams	Artificial reservoirs					
Opening stock water resources	257,248	1,264	68	3,389	62,127	324,096		
Additions to stock								
Returns of water	1	353	0	149	1	505		
Precipitation	2,107	2,623	107	27,130		31,966	31,966	31,966
Inflows from other territories	0	850	0		0	850		850
Inflows from other inland water resources	1,636	4,859	323	911	3,645	11,374		
Total additions to stock	3,744	8,685	430	28,191	3,646	44,695	31,966	32,817
Reductions in stock								
Abstraction of water	20	338	299	0	64	721		
Actual Evaporation and transpiration	1,286	51	15	19,538		20,891	20,891	20,891
Outflows to other territories		6,439	0		0	6,439		
Outflow to the sea		0	0		0	0		
Outflow to other inland water resources	2,879	1,857	106	8,653	3,582	17,076		
Total reductions in stock	4,185	8,685	420	28,191	3,646	45,128	20,891	20,891
Closing stock water resources	256,807	1,264	77	3,389	62,127	323,664	11,075	11,925

Table E3 Physical Water Asset for 2015, in 10^6 m^3

Units in Million Cubic Meters	Surface water			Soil water	Groundwater	Total	Internal Renewable water resources	Total Renewable water resources
	Lakes	Rivers and streams	Artificial reservoirs					
Opening stock water resources	256,807	1,264	77	3,389	62,127	323,664		
Additions to stock								
Returns of water	1	357	0	151	1	510		
Precipitation	2,110	2,623	107	27,187		32,027	32,027	32,027
Inflows from other territories	0	850	0		0	850		850
Inflows from other inland water resources	1,636	4,861	337	911	3,644	11,389		
Total additions to stock	3,747	8,692	443	28,248	3,646	44,777	32,027	32,877
Reductions in stock								
Abstraction of water	20	342	302	0	65	729		
Actual Evaporation and transpiration	1,331	53	16	20,220		21,621	21,621	21,621
Outflows to other territories		6,439	0		0	6,439		
Outflow to the sea		0	0		0	0		
Outflow to other inland water resources	2,837	1,857	101	8,028	3,581	16,404		
Total reductions in stock	4,189	8,692	419	28,248	3,646	45,194	21,621	21,621
Closing stock water resources	256,365	1,264	102	3,389	62,127	323,247	10,406	11,256

ANNEX F: Calculations and assumptions for PSUT tables

	Abstraction of water, Production of water, Generation of return flows							
	Agriculture	**Manufacturing**	**Electricity**	**Water supply**	**Sewerage**	**other industries + Mining +commercial**	**Households**	**Flow from the environment**
Physical Supply Table								
Sources of abstracted water								
Surface Water								150570 from Master plan and other from our own data collection whereby we have excluded them here to avoid double counting. Mainly big amount of water abstracted is from REG data at rate of 2487248.72m3 and abstracted for mining 1.309.610m3 and 51738m3 for households
Ground water								128610m3 from Master plan and other 50010m3 from our own data collection in different institutions. with 523m3 abstracted by households
Green water								Calculated based on Land use change matrix and considering ET and Rainfall of 2012
Rainwater harvesting								807m3 from Master Plan and other from our own survey whereby we have excluded them here to avoid double counting. 550m3 harvested by households
Abstracted Water for distribution				279180m3 from Master Plan and 36963m3 from WASAC &AquaVirunga whereby we have excluded them here to avoid double counting				
Abstracted Water for own use	807m3 from Master Plan and other from our own survey	From Rubavu retreat after data collection from industries. Need to put data on the whole country coverage. Done	784m3 from Master Plan and remaining Data from REG	3212.9m3 Data from WASAC &AquaVirunga and 52811m3 from households data as collected from NISR	Data from our own survey	From our own data collected for mining and other sectors		
Wastewater	9106m3 from master plan and 471m3 from our data collected	6866m3 from Master plan			from Master Plan	3406m3 from Master plan and 471m3 from our data collected	46564m3 equal to 90% of abstracted by household from different sources by own as reported by NISR (51.738m3) and this amount was substracted from 149652m3 collected from Master plan to avoid duplication	
Reused water	from master plan	1212m3 from master plan and 346m3 from our collected data				601m3 from master plan and 1244060m3 from our collected data	From Master plan	
Return flows of water to inland water resources					from Master Plan	24584m3 from our collected data	46564m3 equal to 90% of abstracted by household from different sources by own as reported by NISR (51.738m3) and this amount was substracted from 149652m3 collected from Master plan to avoid duplication	
Evaporation of abstracted water and transpiration	We assumed that 5% of water abstracted by agriculture sector for own use evaporated	From Master Plan	We assumed that 3% of water abstracted by electricity sector for own use evaporated	From Master Plan	We assumed that 85% of water abstracted by sewarage sector for own use evaporated			
Losses			We assumed that 10% of water abstracted by electricity sector for own use lossed					

	Abstraction of water, Production of water, Generation of return flows							
	Agriculture	**Manufacturing**	**Electricity**	**Water supply**	**Sewerage**	**other industries + Mining +commercial**	**Households**	**Flow from the environment**
Water incorporated to products	We assumed that 15% of water abstracted by agriculture sector for own use were incorporated	We assumed that 5% of water abstracted by manufacturing sector for own use were incorporated	We assumed that 10% of water abstracted by electricity sector for own use were incorporated	We assumed that 10% of water abstracted by water utility sector for own use and distribution were incorporated	We assumed that 10% of water abstracted by sewerage sector for own use were incorporated	24584m3 from our collected data		
Return flows	We assumed that 15% of water abstracted by agriculture sector for own use were returned to environment	We assumed that 5% of water abstracted by manufacturing sector for own use were returned to environment	The same as water returned to inland water resources	The same as water returned to inland water resources	85% of water returned to inland water resources	The same as water returned to inland water resources	46564m3 equal to 90% of abstracted by household from different sources by own as reported by NISR (51.738m3) and this amount was substracted from 149652m3 collected from Master plan to avoid duplication	
Physical Use Table								
Sources of abstracted water								
Surface Water			784m3 from Master Plan and remaining Data from REG	We assumed that 60% of water abstracted by water utility sector for own use and distribution were abstracted from surface water		From our own data collected for mining and other sectors	From our own data collected for households and NISR publication	
Ground water				We assumed that 60% of water abstracted by water utility sector for own use and distribution were abstracted from Groundwater				
Green water	The same as green water							
Rainwater harvesting	Master Plan						Master Plan	
Abstracted Water for Distributed water	From Master Plan which is wrong value because even both WASAC &AquaVirunga do not supply such amount a year! Maybe to assess for other private operators if they are supplying water to agriculture sector!	8078m3 from Master Plan and other from our own survey	from NWRMP	36963m3 data from WASAC and AquaVirunga and other from Private operators		From Master Plan	fromMaster Plan. Maybe supplied by other private operators beyond WASAC and AquaVirunga! To assess later	
Abstracted Water for own use	807m3 from Master Plan and other from our own survey	From Rubavu retreat after data collection from industries. Need to put data on the whole country coverage. Done		3213m3 data from WASAC and AquaVirunga and other from Private operators				
Wastewater					The same as total wastewater			
Reused water	From Master Plan	1212m3 from Master plan and remaining from other data collected				The same as reused water	from master plan	

ANNEX G: Calculations and assumptions Physical Water Asset table

	Surface water				
	Lakes	**Rivers and streams**	**Artificial reservoirs**	**Soil water**	**Groundwater**
Opening stock water resources Versus closing stock	Stock 2012 from Master Plan Stock Change from area lakes times measured change in water level at 1^{st} of January	Stock 2012 From Master Plan Stock Change from area rivers &water level change1^{st} of January	From RNRA report on water storage per capita (REF) Total inventory of storage capacity Level in reservoirs at 1^{st} of January	Calculated based on area from Land use change matrix and considering ET and Rainfall of 2012 as collected from Rwanda Meteo	For reference stock from master plan For changes in stock, any measurement on groundwater tables or spring levels
Returns of water	Returns of water to inland water resources, we assumed that 20% from … … (NOT from ET) goes back to lakes	Returns of water to inland water resources, we assumed that 60% from (NOT ET) goes back to rivers	Returns of water to inland water resources, we assumed that 5% from … goes back to Artificial Reservoir	Returns of water to inland water resources, we assumed that 10% goes back to Soil Water	Returns of water to inland water resources, we assumed that 5% goes back to GW
Precipitation	Calculated based on rainfall data collected from Rwanda Meteo and considering surface area of Rwanda lakes	Calculated based on rainfall data collected from Rwanda Meteo and considering surface area of rwanda rivers	Calculated based on rainfall data collected from Rwanda Meteo and considering surface area of Rwanda artificial reservoirs (see the report of RWFA on National Water storage per capita, 2016)	Consider that an important share of total rainfall became infiltrated water to soil zone The rest either evaporates directly from surface or is lost via runoff?	
Inflows from other territories		Data from RWFA as measured at 3 rivers mainly Ruvubu river from Burundi; Muvumba river from Uganda at Kabare; and at Rusumo River from Uganda at Butaro station (Kinyababa river)			
Abstraction of water	40% of surface water abstraction stem from lakes	60% of surface water abstracted is from rivers	We considered here water harvested, both small-scale (rooftop, etc) and large scale for hydro and agriculture	from green water (soil water)	as abstracted from GW according to figures totaled from the PSUT
Evaporation and transpiration	Master plan shows ET of 2012 yr is 860 mm and rainfall is 1274 mm meaning 67.5% of abstracted water are evaporated	67% of precipitation	67% of precipitation	Around 67% of soil water evapo-transpirated though different types of crops	
Outflows to other territories		Data from RWFA as measured at 4 rivers (Akagera river at Rusumo, Rusizi river at Kamanyora and Ruhwa and Muvumba river before entering to Akagera river and at Akanyaru river to Burundi at Butare-Ngozi OUTFLOW to Lake Kivu			Estimation?

The WAVES Global Partnership, through the World Bank, supported Rwanda in the preparation of these natural capital accounts for land. The WAVES program aims to mainstream natural capital in development planning and national economic accounts in support of sustainable development.

WAVES core implementing countries include developing countries—Botswana, Colombia, Costa Rica, Guatemala, Indonesia, Madagascar, the Philippines and Rwanda—all working to establish natural capital accounts. WAVES also partners with UN agencies—UNEP, UNDP, and the UN Statistical Commission—that are helping to implement natural capital accounting.

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