RWANDA

State of Environment and Outlook Report 2021

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To obtain copies of this publication, please contact:

Rwanda Environment Management Authority (REMA)

P.O. Box 7436 Kigali, Rwanda

Tel: +250252580101

Fax: +250252580017

E-mail : info@rema.gov.rw

Twitter: @REMA_Rwanda

Website: www.rema.gov.rw

This report was prepared by the Environmental Pulse Institute, in collaboration with the Rwanda Environment Management Authority (REMA), supported by the United Nations Development Programme (UNDP) in Rwanda.

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A silverback gorilla (Gorilla gorilla beringei), Mr. Happy, from the Hirwa Group in the Volcanoes National Parc in Rwanda
Photo credit: MoneLoe/Flickr

Foreword

There has been significant progress in the quality of life of Rwanda's 12.9 million people in terms of human development indicators. Rwanda is the second fastest growing economy in Africa with 9.4 percent annual growth in GDP in 2019. Rwanda aspires to reach middle income country status by 2035 and high-income country status by 2050; and aims to do so while maintaining a green, climate-resilient, and low carbon economy. To achieve and maintain this, the country has put in place a strategic foundation that includes the Vision 2020 and Vision 2050 and respective implementation strategies - the Economic Development and Poverty Reduction Strategy (EDPRS I and II) and the National Strategy for Transformation (NST1 2017-2024) as well as the commitments to the Sustainable Development Goals.

The COVID-19 pandemic affected Rwanda's economic development prospects and the health and wellbeing of its people. In 2019, annual GDP growth was 9.4 percent and this had been projected to expand by 8 percent in 2020 before the pandemic. However, as the pandemic took a hold, GDP fell by 3.4 percent in 2020. The agriculture, tourism and mining sectors will all be central to the country's economic recovery. However, it is important to incorporate sustainability for building back better in the post pandemic period.

Vision 2050 identifies innovation, integration, agglomeration, and competitiveness as key drivers of growth that will accelerate momentum to propel the economy back into the pre-pandemic growth trajectory and towards its desired future. However, it is likely we will all have to 'rethink' the relationships between the economy, the environment, and the people. This report makes several recommendations on how this can be done, and it also highlights the resolve of the Government and people of Rwanda to ensure that knowledge, mindsets, and culture all combine to do so.

This is the sixth in the State of the Environment and outlook Report series. Rwanda Environment Management Authority (REMA) is commended on its commitment to meeting its statutory obligations of publishing scientifically credible information on the environment on a regular basis. The Government of Rwanda also acknowledges the support of our development partner UNDP towards production of this report. We are also grateful for the technical insights provided by policy analysts, technical experts, and scientists from stakeholder institutions. Congratulations to you all on this achievement!

Dr. Jeanne d'Arc Mujawamariya
Minister of Environment,
Republic of Rwanda

Preface

Rwanda is a leader in Africa (and beyond) in developing as a clean and green economy where the right to live in, protect and be informed of environmental issues is protected by the constitution in Articles 22 and 53.

This is the sixth in the State of the Environment and Outlook Report (SOER) series and it maintains the approach of integrating environment and natural resources management into national planning and development discussions. Rwanda has made great strides in mainstreaming environment into development planning at different levels of government. This role of 'regulatory champion' has allowed environment management to go beyond the sector or project level to line ministries taking active interest in and responsibility for their areas. High level government support and documentation has also supported policy innovation and home-grown solutions which have been the hallmark of Rwanda's success in turning around the environment.

Peer production and collaboration has been central to the process of making this SOER with the involvement of a broad spectrum of stakeholders. The well-known Driver-Pressure-State-Impact-Response (DPSIR) methodology and Sustainable Development Goals (SDGs) indicators underpins the analysis in the report, and case studies and photographic evidence have been used throughout the document to support the discussions.

The first SOER report Rwanda published in 2009 focused on environment and the economy and provided a baseline from which to reference progress. Other reports have focused on climate change and sustainable urban development among others. Each of these reports have independently, informed development strategies through compelling visual documentation of human activities and the impacts on the country's air, land, and water resources. This latest edition has been produced during the COVID-19 pandemic and is providing the opportunity for Rwanda to 'rethink' its strategic response to environmental management. It is clear from the impacts of the pandemic how integrated human lives are with the environment and the economy and how these linkages have impacted the quality of the natural resources around us.

This SOER 2021 provides a set of assessments of the current state of Rwanda's environment, its likely future state, what is being done and what could be done to improve it, and how global developments might affect future trends.

Juliet Kabera
Director General,
Rwanda Environment Management Authority (REMA)

Production and editorial teams

Rwanda Environment Management Authority:

Marie Laetitia Busokeye

UNDP Rwanda:

Bernardin Uzayisaba

Environmental Pulse Institute:

Ashbindu Singh, Peter Gilruth, Denis Rugege, H. Gyde Lund, Nadege Amizero, Albert Butare, Herman Musahara, Clever Mafuta, Elizabeth Gowa Kironde, Eugene Apindi Ochieng, Jayasurya Kalakkal, Mohammed Ameen Arimbra, Srilikhita Karedla.

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Akimpaye Beatha, REMA
Bahati N. Elysée, ICRAF
Bakundukize Dismas, RFA
Banamwana Marshall, Ministry of Environment
Bizima Joseph Anania, FAO
Buregeya Paulin, COPED Ltd
Cyubahiro Eric, REMA
Dukuze Marie Dalie, REMA
Gahigi Aimable, Meteo Rwanda
Gatete Benefique, REMA
Habimana Venant, RWB
Hakorimana Pierre Celestin, RHA
Hakuzimana Herman, REMA
Hitimana Janvier, ARCOS
Kamana Olivier, NIRDA
Kamando Stephanie, REMA
Kanyamibwa Sam, ARCOS
Karemera Vincent, ARECO-RWANDA NZIZA
Kubwimana Jean Paul, ARCOS
Maniragaba Abias, UNILAK
Mbera Olivier, Enviroserve Rwanda
Migambi B. Michel, REMA
Mudakikwa R. Eric, REMA
Mugabo Alex, REMA
Mugabo Fabrice, REMA
Mugisha Ange, REMA
Mugunga Canisius, UR- CAVM
Mukasibo Germaine, REMA
Mukiza Emile, REMA
Mukunzi Antoine, FDA
Munyaneza Leopard, RLMUA
Munyazikwiye Faustin, REMA
Murera Eric, Enviroserve Rwanda
Ndayisaba M. Lewis, RFA
Ngaboyamahina Theogene, REMA
Ngoga Télesphore, RDB
Ninziza Fidelite, REMA
Nkurunziza Philbert , REMA
Nsengiyumva Jacques, REMA
Nsengumuremyi Donat, RMB
Nshimiyimana Spridio, RFA
Nshizirungu Fabien, RSB
Nshutiyayesu Samuel, RICA
Nyagatare Guillaume , UR- CAVM
Nyirambangutse Brigitte, GGGI
Beth Kaplin, CoEB/ UR
Ruhamya Coletha, Independent
Rutikanga Adrien, UR
Ruzigana Pamela, RWB
Rwamukwaya Mediatrice, WSC
Rwanzunga Aimable, COPED Ltd
Ryumugabe Deogratias, Umusambi Village Ltd.
Tushabe Rachael, REMA
Ukwishaka David, REMA
Umugwaneza Janet, REMA
Umurungi Yvette, REMA
Uwijuru Christophe Michel, RLMUA

Acronyms

ANP	Akagera National Park
ASIP	Agriculture Sector Investment Plan
Au	Gold
BAU	Business-As-Usual
BEST	Biomass Energy Strategy
BOD	Biochemical Oxygen Demand
CBD	Convention on Biological Diversity
CIP	Crop Intensification Programme
COD	Chemical Oxygen Demand
CSA	Climate Smart Agriculture
DHS	Demographic and Health Survey
DPSIR	Driving Forces-Pressure-State-Impact-Response
DRC	Democratic Republic of the Congo
DRR	Disaster Risk Reduction
EAC	East African Community
EDPRS	Economic Development and Poverty Reduction Strategy
EESD	Environmental Education for Sustainable Development
EIA	Environmental Impact Assessments
EICV	Integrated Household Living Conditions Survey
ENR	Environment and Natural Resources
ESSP	Energy Sector Strategic Plan
EST	Environmentally Sound Technologies
FONERWA	Rwanda National Climate and Environment Fund
GACP	Gishwati Area Conservation Programme
GCF	Green Climate Fund
GEF	Global Environment Facility
GDP	Gross Domestic Product
GGCRS	Green Growth and Climate Resilience Strategy
GGGI	Global Green Growth Institute
GHGs	Greenhouse Gas(es)
GIS	Geographical Information System
GOR	Government of Rwanda
HHs	Households
IDP	Integrated Development Programme
IPCC	Intergovernmental Panel on Climate Change
IWI	Inclusive Wealth Index
IWRM	Integrated Water Resources Management
IWM	Integrated Waste Management
KCMP	Kigali City Master Plan
LPG	Liquefied petroleum gas
MINAGRI	Ministry of Agriculture of Rwanda
MINEDUC	Rwanda Ministry of Education
NAEB	Rwanda National Agriculture Export Board
NCA	Natural Capital Accounting
NISR	National Institute of Statistics of Rwanda
NLUMP	Rwanda National Land Use and Development Master Plan
NPDRR	National Platform for Disaster Risk Reduction
NPP	Nyungwe National Park
PSTA	Rwanda Strategic Plan for the Transformation of Agriculture
RDRC	Rwanda Demobilization and Reintegration Commission
RECP	Resource Efficient and Cleaner Production
REG	Rwanda Energy Group
REMA	Rwanda Environment Management Authority
ROR	Republic of Rwanda
RRA	Rwanda Revenue Authority
SAS	Seasonal Agricultural Survey
SE4ALL	Sustainable Energy for All
SEA	Strategic Environmental Assessments
SEOR	State of the Environment and Outlook Report
SEZ	Special Economic Zone
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VCM	Voluntary Carbon Marketing
VNP	Volcanoes National Park
WASAC	Rwanda Water and Sanitation Corporation
WAVES	Wealth Accounting and Valuation of Ecosystem Services

Introduction to the report

The constitution of the Republic of Rwanda of 2003 as revised in 2015, provides in its 22nd article, that everyone who lives in Rwanda has the right of living in a clean and healthy environment; in its 53rd article, it obliges everyone residing in Rwanda to protect, safeguard and promote the environment. In the same context, the Law n° 48/2018 of 13/08/2018 on Environment determining the modalities of protection, conservation and promotion of environment in Rwanda, emphasizes the importance of the right of every person to be informed of the "state of the environment" and to take part in the decisions and strategies aimed at protecting the environment. To date, Rwanda Environment Management Authority (REMA) has produced five State of Environment and Outlook reports since 2009.

This is the sixth report in the series. It aims to provide the required information on the current and future state of Rwanda's environment based upon the current trends and future impact of development. The assessment used the Drivers, Pressures, State, Impact and Response (DPSIR) approach to assess, measure, and provides a guide to managing the environment in Rwanda. The DPSIR assesses the environmental conditions and trends, the pressures on natural resources, the impacts of human activities on ecological goods and services and propose societal responses to environmental problems that both assist to prevent further environmental degradation and restore unhealthy ecosystems.

By 2050, Rwanda aspires to be a high income and jointly aims for a green, climate-resilient and low carbon economy. This calls for evidence-based benchmarking analysis of the state and trends of the country's environment to monitor and mitigate sustainability challenges. The present report of the Rwanda State of Environment and Outlook comes at a very crucial time when the government initiatives, aspirations and targets for sound environmental stewardship are being challenged by enormous uncertainties and impacts engendered by the current COVID-19 pandemic. The need to respond to the environmental challenges

2009 | 2011 | 2013 | 2015 | 2017

terracing and establishment of tree nurseries
Photo credit: Rugege D./EPI

represented by the evolving economic development and to support fundamental transitions to sustainability in Rwanda is now more important than ever. The assessment in this report lays the foundation for socio-environmental issues across relevant scales, examines the impact of COVID-19 on the environment, informs current and future challenges of Rwanda's environment with an integrated focus on major environmental issues such as pollution, ecosystem degradation, land degradation, exploitation of natural resources, deforestation, and waste management. This analysis will assist the government of Rwanda, non-government organizations and other stakeholders to take informed measures and actions to address, monitor progress towards the achievement of national environmental objectives, enable tracking of Sustainable Development Goal targets, and inform pathways and transitions towards sustainability. The step-by-step process and methodology used during the assessment and reporting is depicted in the Figure below:

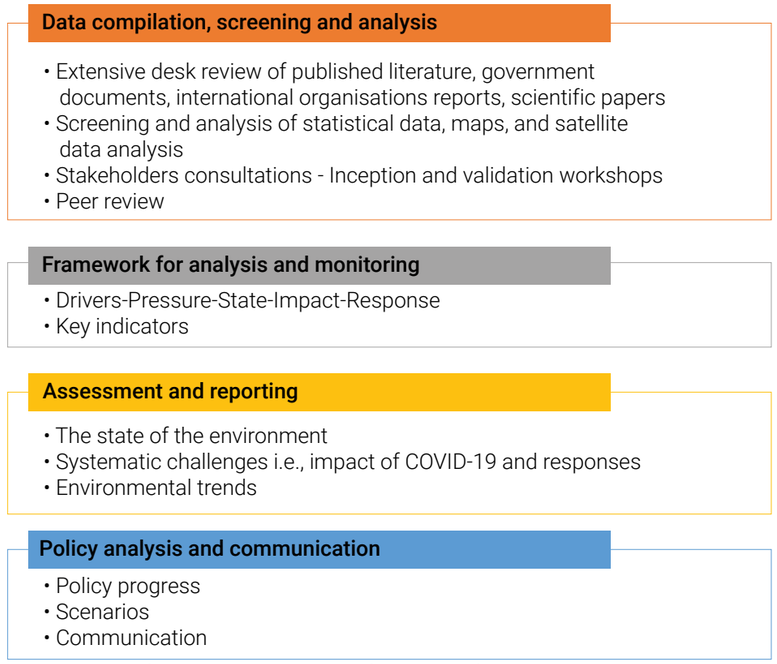


Figure : Analytical framework and methodology for the state of environment reporting.

Rwanda at a glance

Region: **Eastern Africa**	UN membership date: **18 September 1962**
Population ('000, 2021):**13,276**	Surface area (km²): **26,338**
Pop. density (per km², 2021): **538.2**	Sex ratio (m per 100 f): **96.7**
Capital city: **Kigali**	National currency - **Rwanda Franc (RWF)**
Capital city pop. ('000, 2020): **1,094.8**	Exchange rate (per US$): **972.5**

Indicator	2010	2021
Economic indicators		
GDP: Gross domestic product (Rwf billions)	3,569	9,746b
GDP growth rate (annual %, const. 2017 prices)	10.8	9.4
GDP per head (current US$)	614	820
CPI: Consumer Price Index (2010=100)	100	151b
Agricultural production index (2014-2016=100)	117	123
Major trading partners		**2020**
Export partners (% of exports)	Dem. Rep. of Congo 32.1, United Arab Emirates 29.6, Uganda 5.3	
Import partners (% of imports)	China 19.9, India 8.8, Kenya 8.7	
Social indicators	**2010**	**2021**
Urban population (% of total population)	16.9	17.3a
Urban population growth rate (average annual %)	2.6	-
Fertility rate, total (live births per woman)	4.8	4.1
Live expectancy at birth (females/males, years)	61.5/58.5	70.5/66.3b
Population age distribution (0-14/60+ years old, %)	41.5/4.1	39.2/5.3a
Refugees and others of concern to the UNHCR (000)	55.7	150.5c
Infant mortality rate (per 1,000 live births)	62.7	29.2c
Health: Current expenditure (% of GDP)	8.6	7.5d
Health: Physicians (per 1,000 pops.)	-	0.1b
Education: Government expenditure (% of GDP)	4.9	3.1b
Education: Primary gross enrol. ratio (f/m per 100 pop.)	150.1/146.4	130.0/132.7b
Education: Secondary gross enrol. ratio (f/m per 100 pop.)	31.6/31.6	47.0/41.6b
Education: Tertiary gross enrol. ratio (f/m per 100 pop.)	5.2/6.7	6.0/7.5c
Seats held by women in National Parliament (%)	56.2	61.3d
Environment and infrastructure indicators	**2010**	**2021**
Individuals using the Internet (per 100 inhabitants)	8.0	21.8a
Research & Development expenditure (% of GDP)	-	0.6a
Threatened species (number)	55	171
Energy production, primary (Petajoules)	76	87d
Energy supply per capita (Gigajoules)	8	8a,d
Tourist/visitor arrivals at national borders ('000)	504	932c
Important sites for terrestrial biodiversity protected (%)	51.7	51.7c
Net Official Development Assist. received (% of GNI)	16.92	11.92b

**a. projected estimate *b. 2019 data *c. 2020 data *d. data are as at 1 Jan of reporting year*

Source

UN. (2021). World Statistics Pocketbook 2021 edition. Department of Economic and Social Affairs. New York: United Nations (UN). Retrieved October 20, 2021, from https://unstats.un.org/unsd/publications/pocketbook/files/world-stats-pocketbook-2021.pdf

Chapter 1:

Socio-Economic Context

A snapshot of Kigali in 2021, illustrating commercial buildings and green spaces
Photo credit: The City of Kigali

1.1 Introduction

The environment is a broad subject that includes land, agriculture, atmosphere, water resources, chemicals, and minerals. It includes biodiversity and all forms of ecosystem services. In operational terms it includes forestry, water and wetlands, mining, green urban infrastructure, pollution, solid waste management, wastewater management and climate change (GoR, 2020a). The state of the environment is influenced by drivers such as demography, human settlement and rapid urbanization, structure of the economy and the social-development context (UNEP, 2019). This chapter focuses majorly on the economic, social, and developmental context influencing the state of the environment in Rwanda.

1.2 Economic context

Rwanda, the second fastest growing economy in Africa, aspires to reach Middle Income Country (MIC) status by 2035 and High-Income Country (HIC) status by 2050 (WB, 2021b). Along with a focus on economic growth, Rwanda has also shown a clear determination to protect the environment through its Economic Development and Poverty Reduction Strategy 2013-2018, Vision 2020, the commitments to the United Nations Sustainable Development Goals of 2015, the National Strategy for Transformation 1 for 2017-2024 and Vision 2050. According to Rwanda's Vision 2050, the future drivers of growth are innovation, integration, agglomeration, and competition (Figure 1-1).

The current COVID-19 pandemic has, however affected the country's economic development and prospects, and exacerbated the challenges to sustainable development mainly through economic and health shocks (NBR, 2020).

In 2019, before the COVID-19 pandemic, the country recorded 9.4 percent annual growth in GDP (GoR, 2020b). However, according to the 17th edition of the World Bank Rwanda Economic update of June 2021, the COVID-19 pandemic drove Rwanda's economy into its first recession since 1994, and GDP fell by 3.4 percent in 2020, compared to the 8 percent expansion projected before the pandemic (Figure 1-2).

As the country's economy recovers from the COVID-19 shock, it would be important to build back better with a green recovery plan, incorporating sustainability in all drivers of growth. The following sections describe key economic sectors in Rwanda such as agriculture, tourism, mining, and their environment linkages.

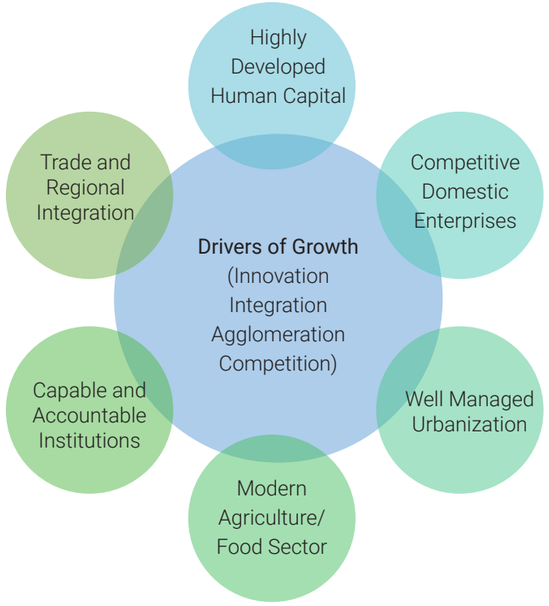


Figure 1-1: Future drivers of growth in Rwanda (WB, 2020)

Kigali International Convention Centre at night
Photo credit: erdbeernaut/Flickr

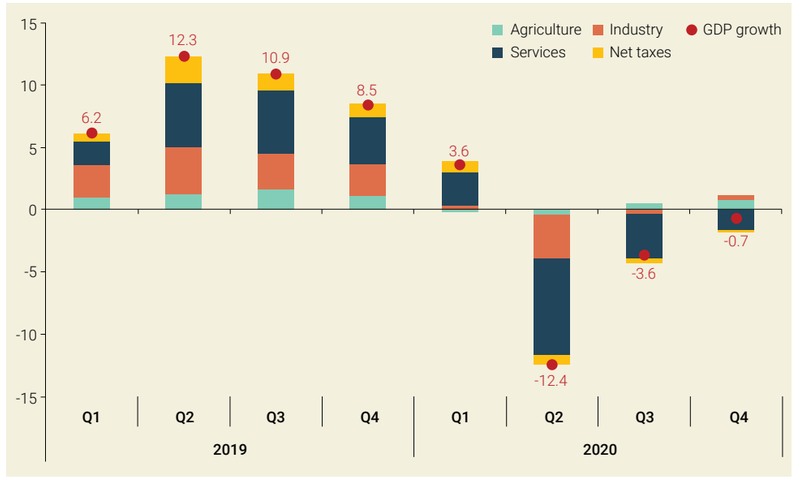


Figure 1-2: Rwanda's GDP during 2019-2020 (World Bank Group, 2021)

1.3 Key economic sectors and their environment linkages

Agriculture

The agriculture sector is the main economic activity in Rwanda with 64 percent of the working population employed in agriculture (Figure 1-3). GDP from agriculture grew from 418.14 billion Rwandan francs (Rwf) in 2006 to 570 billion in 2019 (GoR, 2020b), and accounted to 26 percent of the overall GDP in 2020 (NISR, 2021).

Tea and coffee are the major exports while plantains, cassava, Irish potatoes, sweet potatoes, maize, and beans are the most productive crops. Rwanda exports dry beans, potatoes, maize, rice, cassava flour, maize flour, poultry, and live animals within Eastern Africa. There are two main cultivable seasons – the first from September to January, and the second from February to June. In the marshlands, where water is abundant, there is also a third agricultural season for the cultivation of rice and vegetables (FAO, 2021).

Since 2006, Rwanda has been successfully implementing the Crop Intensification Programme (CIP) that has resulted in a dramatic increase in yield in the selected crops namely, maize, rice, wheat, cassava beans, soya beans. Food crops in the period between 2007 and 2019 following land use consolidation, provision of subsidised inputs and extension services resulted in yield increase by five times for maize; three times for wheat and cassava; two times for potatoes, soybeans, and beans; and 30 percent for rice (REMA, 2019). Figure 1-4 shows the increase in agricultural production in billions Rwf between 2009 and 2020 (GoR, 2020b).

To ensure sustainability, climate resilience and increase of production capacity in the agriculture sector, the Sustainable Agricultural Intensification and Food Security Project (SAIP) is being implemented in collaboration with World Bank, Food and Agriculture Organization (FAO), and other partners. Increasing agricultural productivity, market access, food security and enhancing climate-resilient agriculture in Rwanda has been the focus. The projects have various components including institutional strengthening, agricultural productivity enhancement, nutrition improvement, irrigation, and water use efficiency, creating market linkages and value addition investment support.

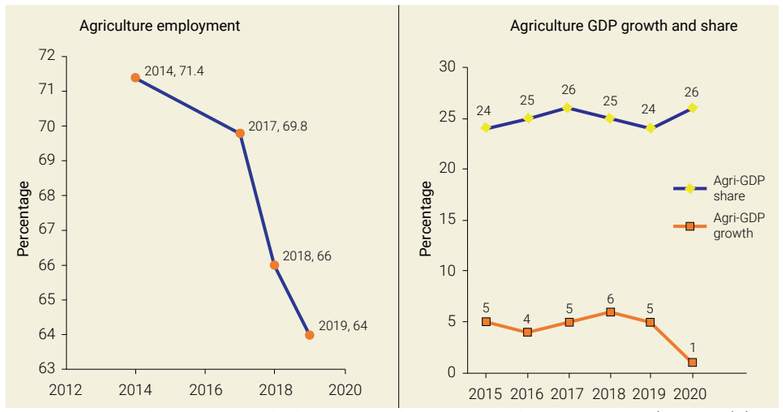


Figure 1-3: Agriculture employment rate and agriculture GDP share trends in Rwanda (WB, 2020) (NISR, 2021).

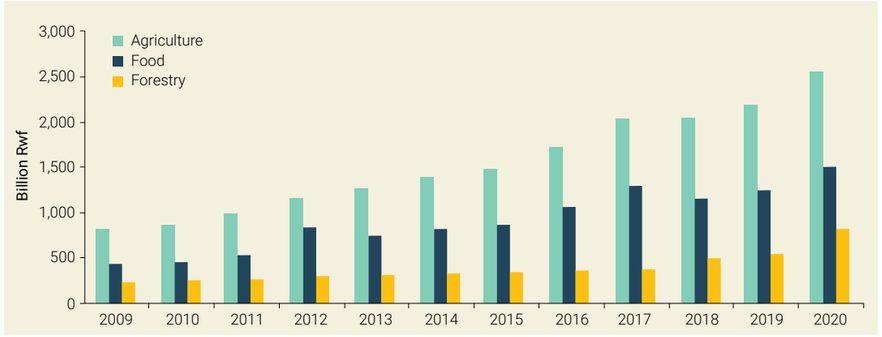


*Figure 1-4: **Agricultural production in billion Rwf (GoR, 2020b)***

Environmental impacts of the agriculture sector

The main agro-environmental problems are closely associated with the country's rapid and intensive agriculture and livestock farming. They include soil erosion and land degradation, water pollution and an increase in greenhouses gases emissions. According to the third National Communication report on climate change, the agriculture sector was the greatest contributor of greenhouse gas emissions in Rwanda accounting for 5,345.44 Gg CO_2-eq or 70.4 percent of the total national greenhouse gases (GHGs) emissions in 2015 (GoR, 2018). The livestock sector contributed less than 36 percent of the total agriculture GHG emissions, while the crop subsector, accounted for more than 67 percent of total agriculture GHG emissions. The major source of GHG emissions in the crop subsector in Rwanda is the use of mineral fertilizer through the application of urea. The increased use of mineral fertilizer in Rwanda has also been linked to soil degradation, leaching, chemical runoff, water contamination (Nkurunziza, 2021).

Quantification of the agro-environmental impacts at a national is often complex, given the magnitudes and spatial characteristics of current and long-term effects of agricultural practices on the environment. A list of key agro-environmental impacts in Rwanda are listed in Figure 1-5.

Most impacts from agriculture on the environment have been remediated by an appropriate mix of policies, strategies, regulations, and legal measures that promote sustainable land use and environmentally friendly farming practices. Some of them include Rwanda's Strategic Plan for Agricultural Transformation 2018-2024, Rwanda Livestock Master Plan 2018-2022, Rwanda National Agricultural Policy 2017 and the National Emergency Plan for Animal and Plant Diseases 2016.

The need for promoting green agriculture has also been embedded into strategy documents such as Vision 2050, Economic Development and Poverty Reduction Strategy (EDPRS) and the National Strategy for Transformation (NST1) 2017-2024.

Local farmers harvesting tea leaves at Kitabi Tea Farm
Photo credit: MINAGRI

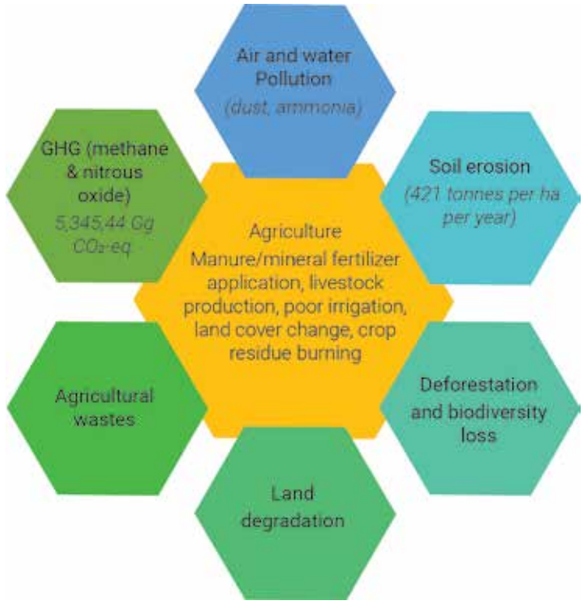


*Figure 1-5: **Environmental impacts from the agricultural sector in Rwanda based on studies by (Nahayo, et al., 2016), (Nambajimana, et al., 2019), (CGIS-UR, 2019)***

Industry and mining

Industry

The industrial sector in Rwanda is still small but it has been growing steadily (Figure 1-6). The industry sector contributed to 19 percent of the GDP in 2019-20. The sector majorly consists of the production and processing of wood, tobacco, cement, textiles, agricultural products, small scale beverages, soap, furniture, shoes, plastic goods, tea, and coffee. Others include chemicals, construction, printing, paper, engineering, and methane gas.

In line with National Strategy for Transformation (NST1) 2017-2024, the industrial policy prioritizes inclusive economic growth, job creation, and private sector-led development with a focus on high-value intensive agriculture and agro-processing, manufacturing, tourism, and knowledge-based services and ICT.

Since the adoption of the National Industrial policy in 2011; several critical policy interventions and strategies have been developed such as the Made in Rwanda policy, Entrepreneurship Development Policy (EDP), Special Economic Zone (SEZ) policy, the Domestic Market Recapturing Strategy (DMRS), the SMEs strategy, the National Export Strategy and Cross Border Trade Strategy.

To increase the local domestic and foreign supply of manufactured goods, the GoR has put in place the special economic zone and 9 industrial parks in Bugesera, Rwamagana, Muhanga, Nyagatare, Musanze, Huye, Nyabihu, Rusizi, and Kicukiro (RDB, 2018b). Industrialization is also part of the Vision 2050 as one of the ways of leading Rwanda into middle-income status by 2035. Under these policies, the aim is to raise the contribution of industry to GDP from 19 to at least 24 percent by 2024 (GoR, 2020b).

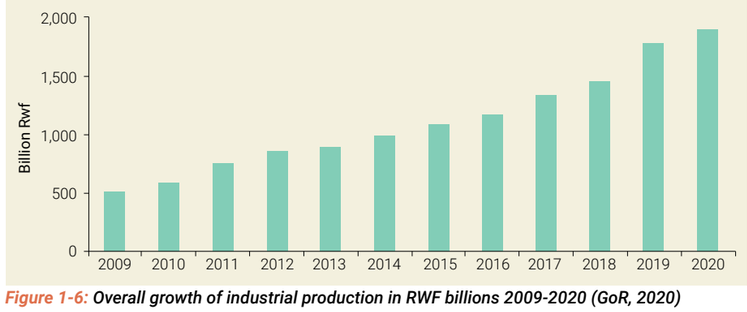


*Figure 1-6: **Overall growth of industrial production in RWF billions 2009-2020 (GoR, 2020)***

These two sattelite images show the re-emergence of Masaka wetland, within Kigali, between 2010 and 2020. In the top image, the wetland had all but dried up with no visible water while the bottom image indicates a return of water in the wetland.
Source: The images were aquired by Maxar Technologies and accessed through Google Earth.

Mining

The mining sector is considered one of Rwanda's key sectors. Rwanda's mineral potential includes the traditional minerals of cassiterite, coltan, wolfram, and gold with additional minerals like beryl, and industrial minerals or construction materials. The country is now home to two refineries for gold and tin, both of which have the capacity to process large amounts of minerals from within the country and the region (REMA, 2019).

To transform the mining subsector into a key driver of the economy, the government has put in place a raft of legal, policy, and institutional frameworks. In 2017, the GoR restructured the mining sector and created a new public entity, the Rwanda Mines, Petroleum and Gas Board (RMB), to deal with all mining, petroleum, and gas matters and steer the implementation of the Mining Policy, Law, and Strategies. The RMB was vested with the mandate to re-design the mining subsector to deliver higher-level results. According to the RMB, the mining sector generated around US $412 million from mineral exports in 2019 and in 2020 it contributed to 1 percent of GDP. The sector aims to contribute 3.6 percent of Rwanda's GDP by 2024 and up to 4 percent by 2050. Towards this target, the mining subsector aims to earn US $1.5 billion annually by 2024 (GoR, 2019).

As pointed out in the ENR-SSP 2018-2024, the mining subsector still performs below its capacity. Against the 5.27 percent contributions to the National GDP targeted in EDPRS 2 the mining subsector recorded only 2 percent, equivalent to US $161 million compared to US $400 million targeted. Some of the challenges as noted in the ENR-SSP include the lack of updated data and records on the country's mineral resources due to limited exploration in mines and quarries. Additionally, the limited implementation of legal framework and access to international and local finance, obsolete technology and processes, shortages of skilled-labour and limitations in infrastructure and services, inadequate assessment and management of environmental impacts, illegal mining, and trading are some of the key constraints hindering the development of the subsector.

In line with the NST1 Priority Area *'to promote industrialisation and attain a structural shift in the export base to high value goods and services with the aim of growing exports by 17 percent annually'*, the ENR-SSP set out a specific objective of catalyzing responsible development and improved performance in the mining subsector to spur sustainable economic development of the country. This objective is to be achieved through four ENR-SSP outputs (i) Support exploration of minerals, petroleum, and gas; (ii) Increase productivity of mines through consolidating small mines into bigger mining blocks for joint efforts to meet best practices; (iii) Increase mineral and quarry value addition; and (iv) Increase compliance with mining standards (Environment protection and occupational health and safety).

Different instruments have been adopted to support and guide the implementation of the national vision of developing and improving the performance of the mining subsector. These include the:

- National Land Use and Development Master Plan (2020)
- Updated Nationally Determined Contributions (2020)
- Prime Minister's Order n° 079/03 of 26/07/2019 determining the structure and functioning of the committee in charge of assessment of applications for licences and disputes related to mining and quarry operations
- Mining Safety Standards (2017)
- Environmental Audit guidelines for mining projects (2014)
- EIA guidelines for mining projects in Rwanda (2012)

In addition, there are seven RMB CEO Regulations published in 2019 to regulate the exploration and exploitation operations for mining, petroleum, and gas resources.

Environmental impacts from the industry and mining sectors

Although the mining activities and industries are key economic sectors for Rwanda, they nonetheless contribute to environmental degradation, and can have significant and irreversible impacts on the natural assets of the country. The industrial processes have a wide range of negative environmental impacts, associated with pollution and greenhouse gases emissions (REMA, 2018). These include pollution, insufficient waste disposal measures, outdated and less energy-efficient technologies, and lack of efficient planning for industries.

According to a study by Cyesa (2019) on water and waste management technologies in the mining sector, the environmental impact of inefficient mining and processing in Rwanda include:

- Impacts on land use and quality through mining-related disturbance and unmanaged disposal of mineral wastes.
- Discharge of sediment-loaded processing water and ongoing erosion of disturbed land and mineral wastes from multiple mining sites.
- Downstream contamination and loss of water use potential and water quality within the wider water catchment.

These environmental impacts pose multiple risks to human health, livelihoods, and economic development. Figure 1-7 lists the environment impacts of the mining sector in Rwanda, based on results from the Rwanda Natural Capital Accounts on minerals resource flows.

Recommendations for greening the mining subsector

As the mining sector grows, there is urgent need to reform and promote environmentally friendly mining. The Rwanda Mineral and Petroleum and Gas Board (RMB) needs to consider various policy recommendations, to promote the greening of the subsector including the need to strengthen environmental and social assessment and monitoring and promoting environment protection through resource efficiency in the mining subsector (REMA, 2020). Figure 1-8 outlines the key issues that need to be addressed.

Tourism

In the last decade, there has been a major effort from the government to promote Rwanda as a tourist destination, focusing on its rich flora and fauna around the national

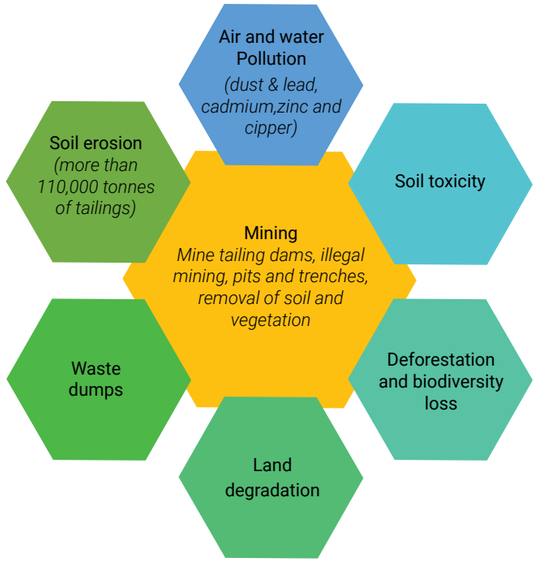


Figure 1-7: ***Environment impacts of the mining sector in Rwanda (GoR, 2019).***

A semi-industrialised Tungsten mine in Rwanda
Photo credit: Fairphone/Flickr

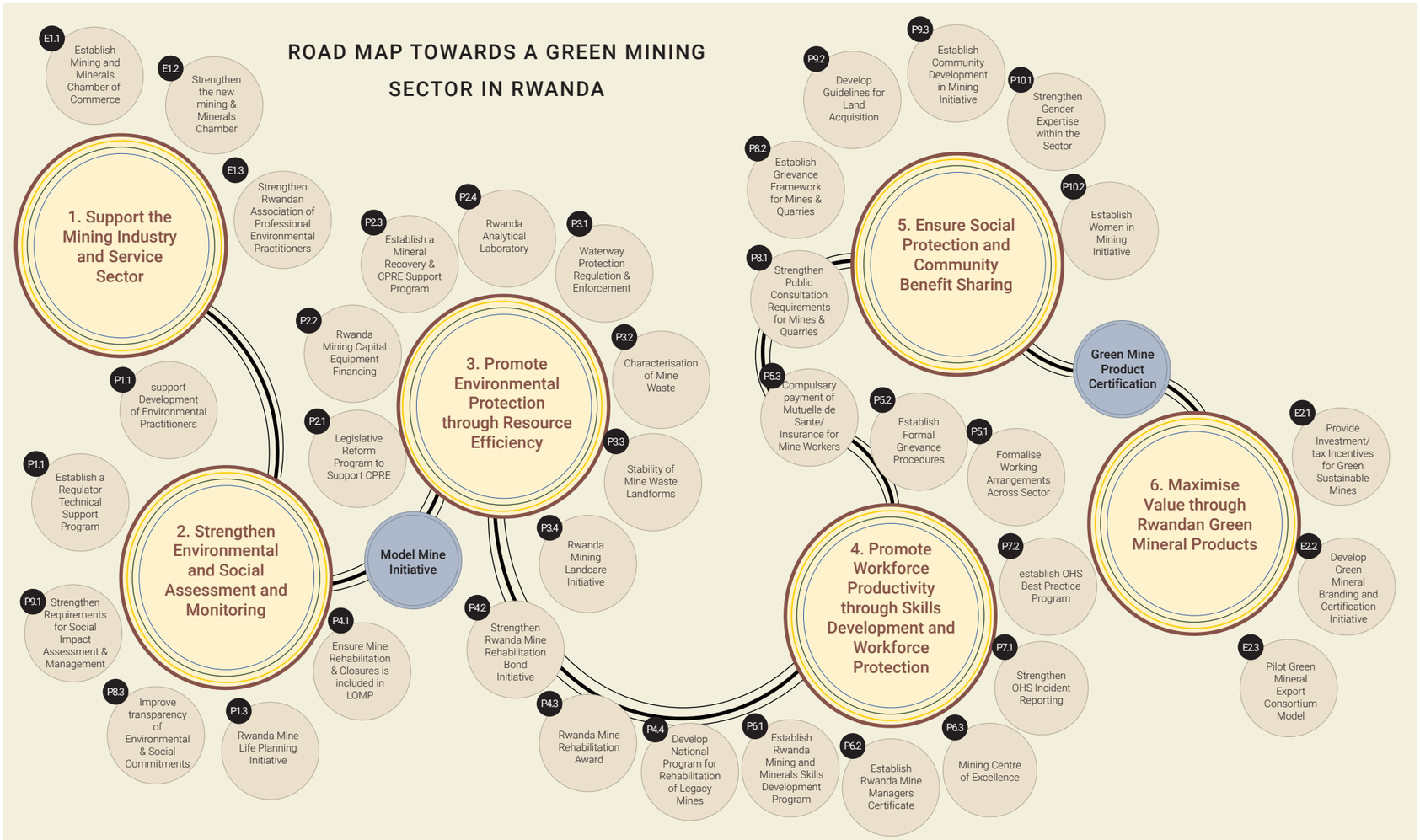


Figure 1-8: ***Rwanda's roadmap towards green mining sector (REMA, 2020)***

Washing Tungsten, Rwanda
Photo credit: Fairphone/Flickr

parks. As part of this, Rwanda Development Board initiated a national tourism campaign known as 'Visit Rwanda'. As a result of these efforts, tourism revenues amounted to US $498 million in 2019 (a 17 percent increase from 2018) contributing to 50.1 percent of all service exports. In the same year, 110,000 visits were registered to national parks (an increase of 13.4 percent from 2018) and generated US $29 million in revenue (a 31.8 percent increase from the previous year) (RDB, 2021). However, in 2020, tourism was among the worst hit sectors in Rwanda as shown in Figure 1-9 and Figure 1-10. Tourism revenues in 2020 were US $121 million, a decline of 76 percent decline from the 2019 figure due to the COVID-19 pandemic. The government's support for the sector through the Economic Recovery Fund (ERF) will go a long way in aiding its recovery. About 50 percent of the Rwf 100 billion recovery fund has been dedicated to the tourism and hospitality sector (WV, 2021).

Environment impacts of tourism

Although Rwanda's tourism activities are concentrated in protected areas, particularly in the national parks, some tourism activities, and developments such as nature trails creation, canopy walk during tourist seasons, and hiking and camping activities may impact the environment. Some impacts from these activities are associated with land degradation or erosion, environmental pollution, and depletion of natural resources (Bizimana & Kambogo, 2016). To date no specific study has been conducted to quantify the environment impact from tourism sector in Rwanda, however, the government has put effort into promoting eco-tourism in the country.

Eco-tourism

With the tourism sector booming, the Government of Rwanda has been doing an excellent job over the last decade to promote eco-tourism and sustainable tourism in the country (Ahmed, 2018). Figure 1-11 summarizes some of the key initiatives.

1.4 Social and development context

Rwanda's strong economic growth was accompanied by substantial improvements in living standards, with a two-thirds drop in child mortality and near-universal primary

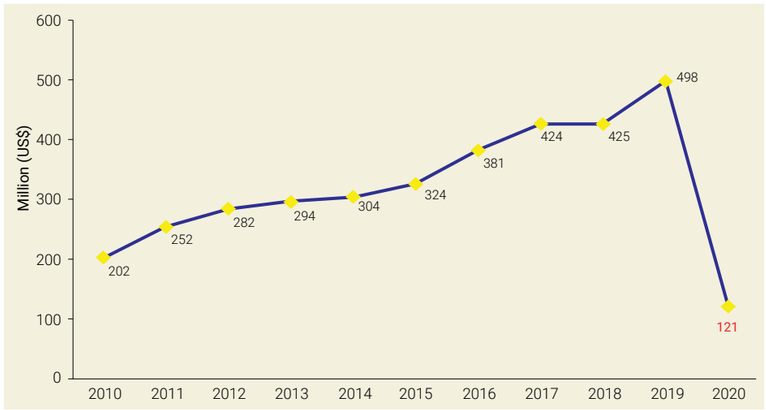


Figure 1-9: Tourism revenue generated (in US $million) 2010-20 (RDB, 2021)

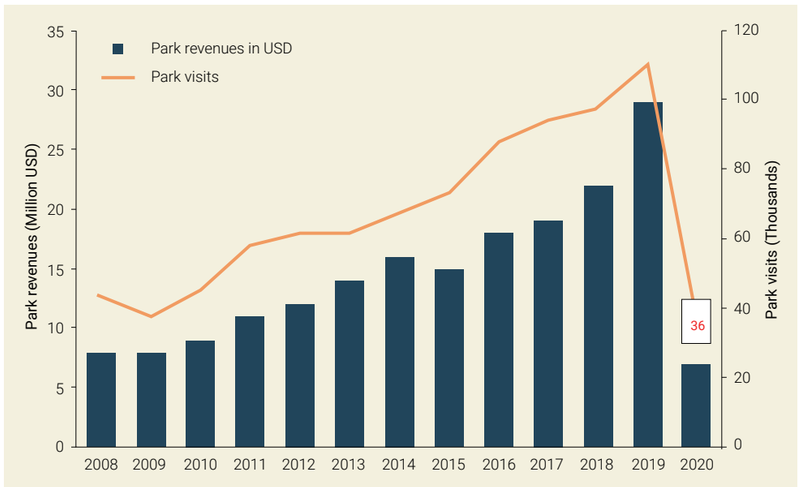


Figure 1-10: Revenue generated from National Park and number of visitors 2008-20 (RDB, 2021)

Eco-tourism activities	Several improvements have been made, and new activities have been introduced to enhance the eco-tourism experience in Rwanda. Examples include, promoting conservation in Rwanda and increasing the number of protected areas, improvement of eco-friendly facilities and infrastructure, responsive customer care and marketing Rwanda as an eco-tourism destination in international exhibitions and fairs.
National Legislation and Policy	In the past decade, Rwanda has undertaken several legislative and policy measures to create an environment suitable for a thriving sustainable eco-tourism industry. These include: Biodiversity Policy 2011, Biodiversity Law 2013, Rwanda Vision 2020 Development Strategy, Rwanda Wildlife Policy (2013), Rwanda Protected Areas Concessions Management Policy (2013), National Industrial Policy (2011), National Strategy for Climate Change and Low Carbon Development (2011), and Rwanda Tourism Policy (2009).
Greater Virunga Transboundary Collaboration (GVTC)	GVTC brings together Rwanda, Uganda, and the DRC for the purpose of conservation and management of Mountain gorilla populations and their habitat. GVTC is a strategic management system for the Greater Virunga landscape. Through trans-boundary and collaborative mechanisms, GVTC addresses both conservation and socio-economic issues, in a landscape defined by ecosystems rather than administrative boundaries
Revenue sharing and promoting sustainable livelihood	The government in several national parks, such as Nyungwe National Park and Volcanoes National Park, is allocating a certain percentage of the income generated from eco-tourism, to fund socio-economic activities which benefit local communities living around the national parks. Similarly, through eco-tourism, the government has been providing sustainable livelihoods to local people. For example, instead of felling trees in the Nyungwe National Park, which is the traditional way to harvest honey from natural beehives, local people have been trained in income-generating beekeeping and have formed cooperatives.

Figure 1-11: Initiatives by Government of Rwanda to promote sustainable tourism (Ahmed, 2018)

Impalas (Aepyceros M.) in Akagera National Park.
Photo credit: RDB/ Flickr

school enrollment. A strong focus on homegrown policies and initiatives contributed to significant improvement in access to services and human development indicators. The Human Development Index (HDI) value improved from 0.248 in 1990 to 0.543 in 2019 as highlighted in Table 1-1.

Measured by the national poverty line, poverty declined from 58.9 percent in 2001 to 38.2 percent in 2017, while life expectancy at birth improved from 29 in the mid-1990s to 69 in 2019. The adult literacy rate increased to 73 percent in 2018 (see Figure 1-12) (WB, 2020). The maternal mortality ratio fell from 1,270 per 100,000 live births in the 1990s to 290 in 2019. The official inequality measure, the Gini index, declined from 0.52 in 2006 to 0.43 in 2017 (GoR, 2020b). However, the country still has one of highest inequality rate compared to its East African neighbours.

Health and WASH sector interlinkages to environment

Health has been a priority social sector in all country plans and strategies including Vision 2020, Vision 2050, NST1 and SDG 3. It is important for human development and human capital accumulation. The Rwanda Health Sector Performance Report 2019/2020 and the Rwanda Demographic and Health Survey 2020 show remarkable achievements in terms of quality of life, access to health services, prevention of diseases among adults and children, services to mothers and support to vulnerable groups. Figure 1-13 shows the status of the health infrastructure in the country.

However, the current health trends are complex with the COVID-19 pandemic likely to shift the short- and medium-term priorities. For example, health indicators such as infant and maternal mortality ratio decreased considerably in the last decade and are expected to reduce further by 2024 (Figure 1-14) (NISR, 2020b).

However, some of the other indicators have been improving. For instance, the number of births in a health center rose from 28 percent in 2005 to 93 in 2019/2020. Maternal mortality declined from 750 in 2005 to 203 per 1,000 women in 2019/2020, while children receiving basic vaccination reached 96 percent in 2019/2020 up from 75 percent in 2005 (NISR, 2020b).

Improving access to water, sanitation, and hygiene (WASH) is an important environmental factor contributing to good health, contributing to livelihoods and helping to create resilient communities living in healthy environments. Drinking unsafe water impairs health through illnesses such as diarrhea. Untreated excrements contaminate ground and surface waters polluting water used for drinking, irrigation, bathing and other household purposes. WASH is a priority in Rwanda. The government has set and reinforced the target of universal access to WASH services in all planning documents, including Vision 2020, Vision 2050, the National Strategy for Transformation (NST1, 2018-2024) and the Water and Sanitation Sector Strategic Plan (2018-2024)

Table 1-1: Rwanda's HDI trends based on consistent time series data (UNDP, 2020).

Year	Life expectancy at birth	Expected years of schooling	Mean years of schooling	GNI per capita (2017 PPP$)	HID Value
1990	33.4	5.7	1.8	933	0.248
1995	31.0	6.2	2.0	749	0.231
2000	48.6	7.2	2.3	860	0.341
2005	55.3	9.4	2.8	1,137	0.413
2010	63.4	11.1	3.8	1,497	0.492
2015	67.5	11.5	4.0	1,846	0.526
2016	67.9	11.1	4.1	1,904	0.527
2017	68.3	11.5	4.3	1,909	0.535
2018	68.7	11.4	4.3	2,021	0.540
2019	69.0	11.2	4.4	2,155	0.543

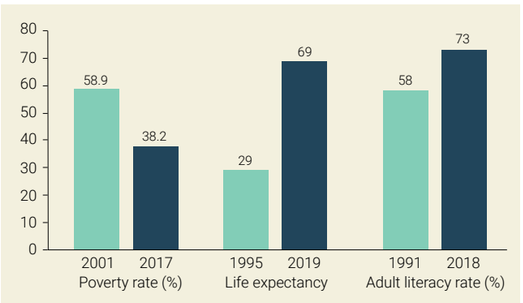


Figure 1-12: Positive trends in social indicators, Rwanda (WB, 2020).

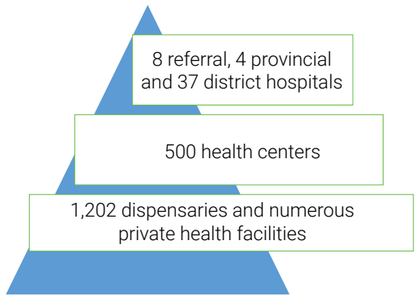


Figure 1-13: Health facilities in Rwanda (MoH, 2021).

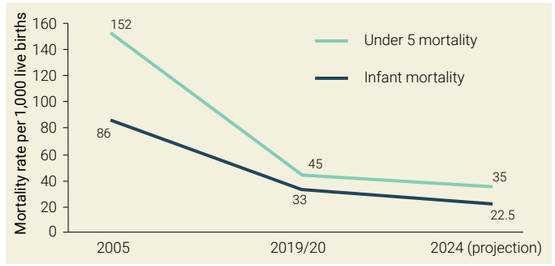


Figure 1-14: Infant and under-5 mortality rate in Rwanda (2005-2024) (NISR, 2015a) (NISR, 2020b).

(UNICEF, 2020).

Impact of COVID-19 on social and health indicators

Currently, the COVID-19 crisis is dramatically increasing poverty, and threatening public health achievements in Rwanda. The headcount poverty rate is likely to rise by 5.1 percentage points (more than 550,000 people) in 2021, compared to the no-COVID scenario. The combination of poorer nutrition, limited health services, learning losses from school closures, and the likelihood that some children (particularly adolescent girls and children from poor households) may never return to school because of the COVID-19 pandemic have the potential to threaten decades of progress in human capital development (WB, 2021a). However, rapid steps to contain the pandemic have resulted in relatively few cases, more recovery and lower deaths compared to other countries (RBC, 2021). Rwanda reported its first COVID-19 case in mid-March. As of October 2021, there were 98,839 confirmed cases and 1,311 deaths, still less than 1 per 100,000 people. So far, 2,621,889 persons (representing more than 20 percent of the population) had the first dose, whereas 1,702,654 persons (representing more than 13 percent of the population) had been fully vaccinated. But this has meant increased expenditure in the health sector and away from other health services to procure equipment, test, and handle COVID-19 cases. Despite the heavy burden to the health sector and the economy caused by COVID-19, it is becoming clear that there are innovations such as advances in the technological approach in the health and service sectors, that are gradually emerging out of the efforts to contain the pandemic in the country and the region.

Gender and environment

Gender is a cross-cutting issue; and globally, gender equality is recognized as a critical factor for achieving sustainable development. Rwanda has ratified and adheres to international and regional conventions and declarations, each of which has a gender action plan with commitments for mainstreaming the gender-environment and climate change nexus into national strategies and policies.

In fact, in Rwanda gender mainstreaming takes its roots from the National Constitution of June 2003 which provides for higher levels of representation to previously marginalized groups such as women, youth and people living with a disability. As a result, Rwanda is a global leader in gender equality and ranks number 1 globally in terms of the number of women in parliament positions (Okwach, Byabagambi, Nyiransabimana, & Dusabe, 2018). Women in parliament, senate and cabinet constitute more than 60 percent or double the 30 percent guaranteed by the constitution.

Gender and environment have been cross-cutting issues in all planning blueprints of Rwanda from the Poverty Reduction Strategy Paper (PRSP) 2000-2003, Economic Development and Poverty Reduction Strategy 1 and 2 (2013-2018) and National Strategy for Transformation 1 (2017-2024). Rwanda's effort in mainstreaming gender in environment, energy and climate change policies, strategies and actions are summarized in Figure 1-15.

Further, the gender budgeting programme (gender budget statement) adopted by the Ministry of Finance and Economic planning is an important tool in the process of institutionalizing gender-responsive budgeting and gender mainstreaming process in central and local government institutions. The "Checklists for Mainstreaming Environment and Climate Change in Sectors and Districts' Development Strategies" also plays a crucial role in the process of integrating gender, environment and climate change (E&CC) in priority sectors. There are also gender statistics issued by the National Institute of Statistics which clearly shows the position of women in relation with the environment (GoR, 2019).

Environment and Climate Change Policy (2019)	In the Environment and Climate Change Policy (2019) gender is enshrined in the principles aiming at fostering inclusiveness. This Policy urges and encourages effective involvement of women and youth in E&CC management, intervention, and decisionmaking as essential.
Green Growth and Climate Resilience Strategy (GGCRS)	The Green Growth and Climate Resilience Strategy (GGCRS) states the need to conduct a robust gender analysis assessment for informing gender-responsive approaches in its implementation
National Strategy for Transformation (NST1, 2017-2024)	NST1 urges sectors to mainstream gender and family promotion and ensure women and men's equal access, control, and equitable benefits in terms of responsibility and sustainable production and consumption
Gender mainstreaming in energy, infrastructure and WASH strategies	Gender is mainstreamed in National Energy Policy 2015, Infrastructure Gender Mainstreaming Strategy 2017-2022, Energy Strategic Plan 2013/14-2017/18, 2018/19-2023/24 and the Water and Sanitation Sector SP 2013-2018

Figure 1-15: ***Gender mainstreaming in national level policies and strategies in Rwanda (Hakuzimana, 2020).***

A young lady gets ready to plant her tree during the launch of the 2018/19 Tree Planting Season.
Photo credit: Ministry of Environment - Rwanda/Flickr

1.5 Demographic profile and urbanization

Trends in total population

The population in Rwanda by July 2021 was 12.9 million (NISR, 2021), a 2.3 percent increase from the previous in 2020 (Figure 1-16).

In the last 60 years, Rwanda's population has risen by more than 5 times. The population in 1960 was 2.6 million, and reached 8.2 million in 2002, 9.6 million in 2008 and 10.5 million in 2012. With a current annual growth rate of 2.4 percent (between 300,000-400,000 new annual population), the population in Rwanda may reach 25.8 million in 2050, with gross density approaching 1,000 people/sq.km, the highest in Africa (Figure 1-17) (GoR, 2020a).

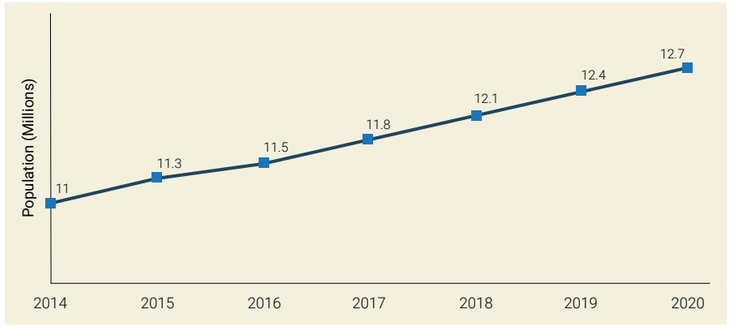


Figure 1-16: ***Total population in Rwanda, 2014-2020 (NISR, 2021)***

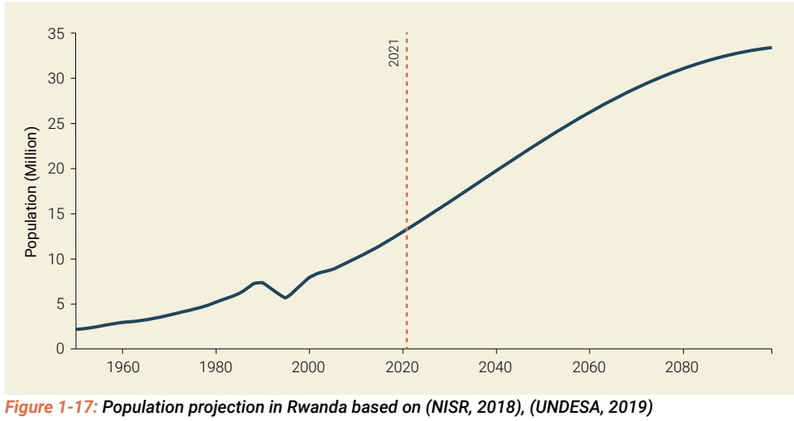


Figure 1-17: ***Population projection in Rwanda based on (NISR, 2018), (UNDESA, 2019)***

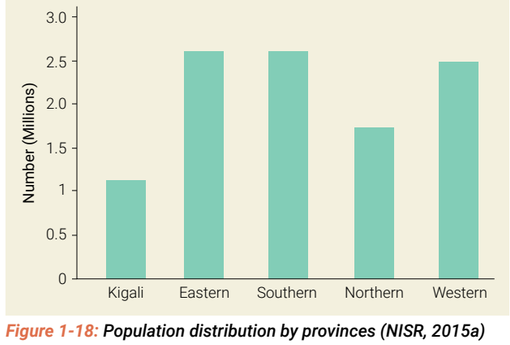


Figure 1-18: ***Population distribution by provinces (NISR, 2015a)***

Population distribution, composition, and demographic dividend

From Rwanda's Fourth Population and Health Census in 2015, 52 percent of the population were men and 48 percent women. The highest number of people resided in the Eastern Province, while the lowest was in the Northern Province (Figure 1-18), and (83 percent) resided in rural areas.

Similarly, between 1980 and 2015, there has been a remarkable decline in the Total Fertility Rate, or the average number of children per woman, from 8.4 children per woman in 1980 to 4.2 children per woman in 2015. The use of modern contraceptive methods increased from 10 percent in 2005 to 45 percent in 2010 and then rose slightly to 48 percent in 2015. In recent years, the country has invested in family planning and behavior change and provided training

on long acting and permanent contraceptive methods. As a result, the fertility rate has declined. This trend implies a better opportunity for economic growth if combined with the promotion of equitable and good quality education, the right investments in health, job creation, and good governance.

Urbanization

As indicated earlier in this chapter, urbanization and agglomeration have been identified as future drivers of growth and economic transformation in Rwanda (WB, 2020). Planned growth of the urban population is a broad concept that goes beyond having urban structures but includes employment conditions, composition of residents and the production conditions of firms. For instance, there have been major efforts to promote urbanization, as a strategy to reduce the dependency on the agricultural sector for employment, while minimizing the effects of environmental hazards and health problems that may accompany unplanned cities.

In EICV 5, the number of people living in urban areas was estimated to be 1,678,786 while rural residents were estimated to be 8,899,235 (NISR, 2015b). As per the latest data available, 17.5 percent of the population of Rwanda is urban (2,215,085 people in 2019). This falls short of the 35 percent initially planned by Vision 2020 (RoR, 2013). Figure 1-19 and Figure 1-20 highlight some of these trends.

There is currently in place an Urbanization and Rural Settlement Sector Strategic Plan for NST 1 2018/2019 -2023/24, the national urbanization policy with a vision of urbanization as an engine of economic development and sustainable human settlement. Additionally, Vision 2050 aims to achieve 70 percent urbanization from all types of urban settlements - Kigali, satellite cities to Kigali, peripheral or secondary cities, district towns, and urban and emerging centers. An annual growth rate of 6.8 percent is needed to reach this target in 30 years. It will also require encouraging in situ urbanization and prioritizing investments in the rural system to form real clusters of settlements. In this regard, there will also be need to ensure a sustainable and environmentally friendly approach to transformative urbanization (REMA, 2017).

Population growth, urbanization, and the environment in Rwanda

It is important to monitor the population dynamics, urbanization, and their linkages to environment as they evolve in Rwanda's development trajectory. Environmental management depends on sustainable construction of settlements and waste management facilities, reuse of fuels and improved access to water. The country's current rapid population growth and the resultant dwindling size of landholdings have pushed more people onto landscapes unsuited for agriculture, grazing and settlements such as steep hillslopes and urban watersheds. Between 2009 and 2020, the frequency of floods and natural disasters has been increasing (WVR, 2020). With the challenge of high population growth and density, one of the responses has been evolving policies that strongly encourage population to take care of their environment through environmental awareness campaigns since 2009. From EICV 5 it was shown that about 81 percent of Rwandans received environmental information. However, there is still room for improvement in building environmental awareness among the growing population especially as secondary cities are being developed as hubs of future economic growth (REMA, 2017). By region, environmental education ranged from a high of 89 percent in Eastern Province to the Western regions with the lowest rate of 75 percent (GoR, 2016/17)

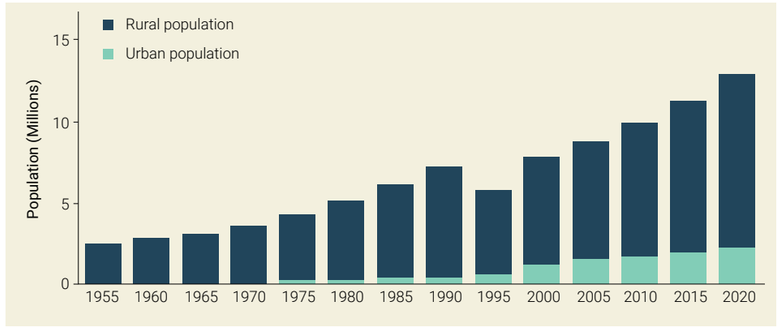


Figure 1-19: Urbanization trend in Rwanda (UNDESA, 2019),(NISR, 2020b)

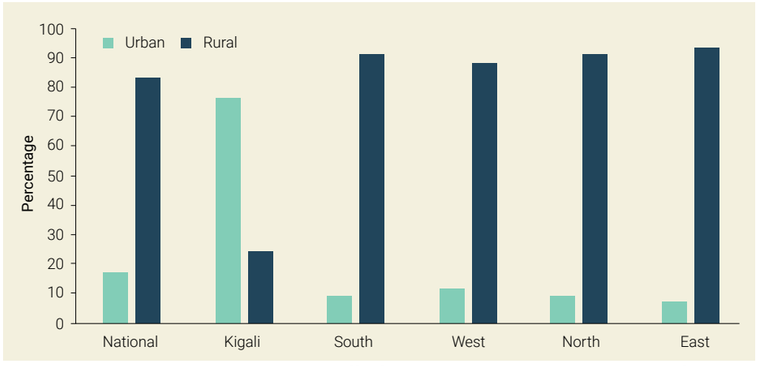


Figure 1-20: Residence in urban areas also differ from province to province and the City of Kigali (NISR, 2015b)

Green jobs

Rwanda has made remarkable progress in putting in place green growth policies and strategies. In the coming decades, with an increasingly youthful population, it will be important to provide the country's large, young, and energetic workforce with productive employment to benefit from the demographic dividend. To ensure this and promote long-term sustainable development in the country, the creation of green jobs will be a key factor (Figure 1-21).

The ILO defines green jobs as decent jobs that contribute to, preserve or restore the environment, either in traditional sectors such as manufacturing and construction or in, emerging green sectors such as renewable energy and energy efficiency. In summary green jobs:

- Improve energy and raw materials efficiency
- Limit greenhouse gas emissions
- Minimize waste and pollution
- Protect and restore ecosystems
- Support adaptation to the effects of climate change (ILO, 2016)

In Rwanda, the Green Fund (FONERWA) is the engine of green growth. It is the primary promoter of green investment and the largest in Africa. It has invested in more than 40 projects involving 21,798 hectares of land and creating 144,858 green jobs, permanent and contractual as shown in Figure 1-22 (FONERWA, 2021).

However, there is a need to create more green jobs in the country, with increasing green infrastructure and investment opportunities. Recently, Rwanda unveiled an US $11 billion (Rwf 10.2 trillion) plan to combat climate change and build adaptation to its effects in the next 10 years. Pipeline activities such as Rwanda's green investment facility, green bank and greening districts development plans are also expected to generate more green jobs in the agriculture and industry sectors, among others.

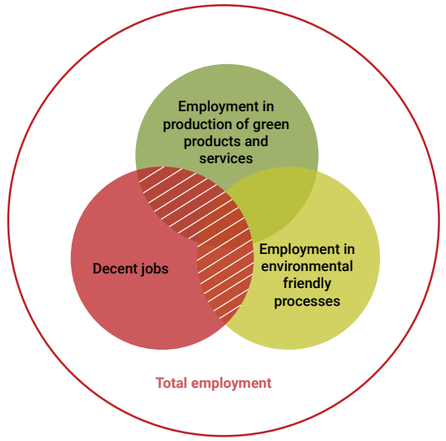


Figure 1-21: Green jobs (ILO, 2016)

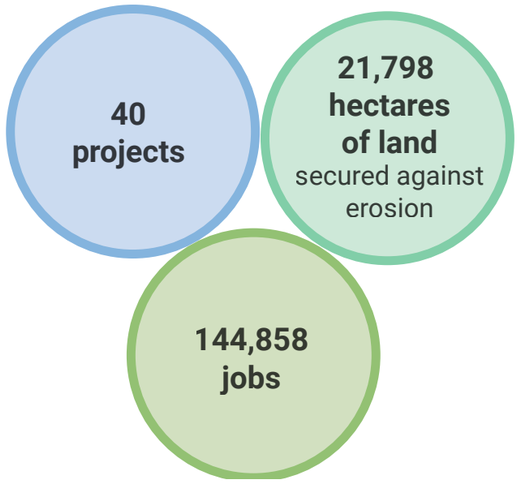


Figure 1-22: Green growth under the Rwanda Green Fund (FONERWA, 2021)

1.6 Conclusion and recommendations

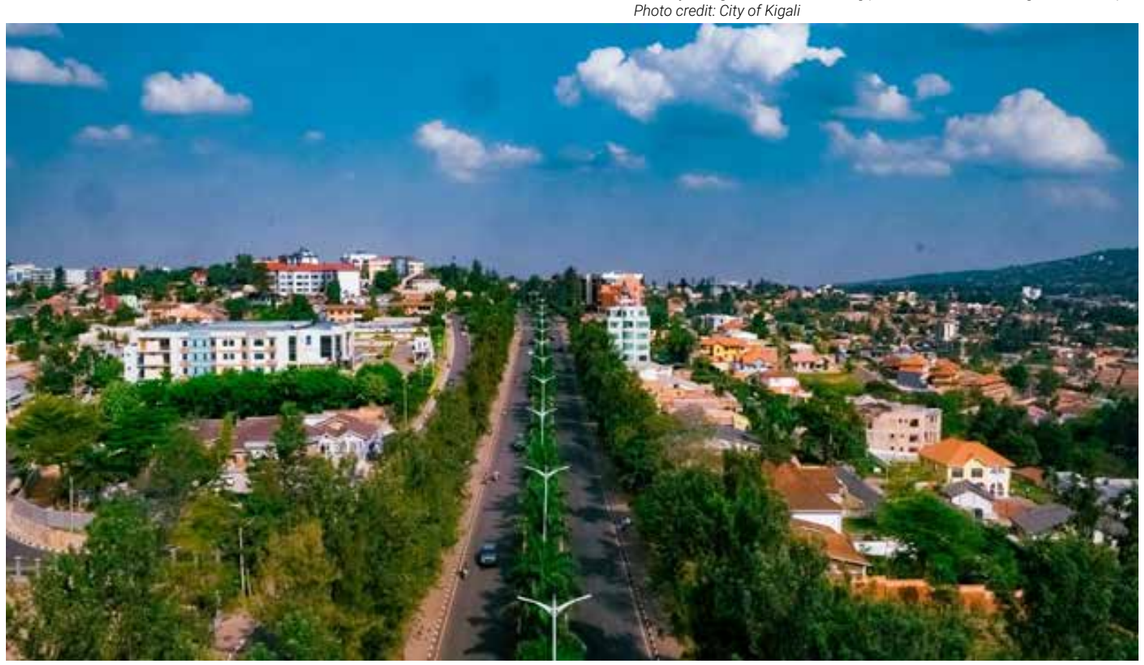
In the last 10 years from 2009 Rwanda has made notable strides in economic growth at the macroeconomic level and at sectorial levels particularly agriculture, industry, mining, and tourism. Before the breakout of the COVID-19 pandemic, Rwanda was growing at an average of over 7.2 percent (9.4 percent in 2019 alone).

There is data and evidence of policy initiatives and institution that have aimed at promoting sustainable development in Rwanda through protecting the environment and supporting the implementation of the SDGs. However, there is still a lot to do in terms of managing and protecting the environment as part of the National Strategy for Transformation and through Vision 2050. Indeed, along with the SDGs, it is important to have a clear monitoring mechanism on how policies and strategies on environment and sustainability are handled.

Rwanda is developing as a clean and green economy. This is commendable and bodes well for health and sustainable development. But there is need for further efforts to mitigate and adapt to the effects of climate change. The latter effort needs further mobilization of resources and involvement of all sectors of the economy.

Despite the progress in the economic and environmental spheres, Rwanda like other countries in the region has been impacted by COVID-19. The pandemic is still on and is coming in different waves. While vaccination has been embarked on as one way forward there is still the gargantuan task facing Rwanda like other countries of building back better and propelling the economy back onto the pre-pandemic growth trajectory.

The City of Kigali in 2021 illustrating planned settlement and green landscape
Photo credit: City of Kigali



References

ADB. (2020). Rwanda Economic Outlook. k. Washington: African Development Bank (ADB)). Retrieved June 26, 2021, from https://www.afdb.org/en/countries/east-africa/rwanda/rwanda-economic-outlook

Ahmed, H. (2018). Eco tourism; Rwanda's Fastest growing sector. Kigali: NABSAP Forum. Retrieved June 24, 2021, from http://www.nbsapforum.net/knowledge-base/best-practice/eco-tourism-rwanda%E2%80%99s-fastest-growing-sector#:~:text=Biodiversity%20makes%20a%20substantial%20and%20direct%20contribution%20to,and%20has%20shown%20significant%20potential%20for%20future%20growt

CGIS-UR. (2019). Rwanda Atlas: Environment, Agriculture and Livelihood Options. University of Rwanda . Centre for Geographic Information Systems of the University of Rwanda (CGIS-UR) & Wildlife Conservation Society (WCS). https://www.researchgate.net/publication/342888933_Rwanda_Atlas_Environment_Agriculture_and_Livelihood_Options

Cyesa, G. (2019). Investing in Water and Waste management technologies in the mining sector. 4 th Annual IWRM Conference. IWRM Conference. https://waterportal.rwb.rw/sites/default/files/2019-04/4.6.b%20Investing%20in%20water%20and%20waste%20management%20technologies%20in%20mining%20sector.pdf

FAO. (2021). Rwanda at a glance. Rome: Food and Agriculture Organization of the United Nations (FAO). Retrieved June 24, 2021, from FAO: http://www.fao.org/rwanda/our-office-in-rwanda/rwanda-at-a-glance/en/

FONERWA. (2021, May 18). www.fonerwa.org. Retrieved May 18th, 2021, from www.fonerwa.org: www.fonerwa.org

GoR. (2020a). National Land Use and Development Master Plan 2020-2050. Kigali: Republic of Rwanda. Retrieved June 24, 2021, from https://www.environment.gov.rw/fileadmin/user_upload/Moe/Publications/Policies/National_Land-Use_and_Development_Master_Plan_2020-2050.pdf#:~:text=The%20National%20Land%20Use%20and%20Deve%20lopment%20Master,Rurban%20Settlements%2C%20Rural%20Settlements%2C

GoR. (2020b). Rwanda National Accounts. Kigali: NISR. Retrieved June 24, 2021, from https://www.statistics.gov.rw/publication/gdp-national-accounts-second-quarter-2020

GoR. (2018). Third National Communication: Report to the United Nations Framework Convention on Climate Change. Kigali, Rwanda: Government of Rwanda (GoR). http://climateportal.rema.gov.rw/node/136

GoR (2019). Rwanda Natural Capital Accounts -Minerals resource flows. Government of Rwanda. Kigali.

Hakuzimana, H. (2020). Rwanda 's experience in Mainstreaming gender into climate change policy, strategies, plans and actions. Kigali: Rwanda Environment Management Authority (REMA). Retrieved June 26, 2021, from https://unfccc.int/sites/default/files/resource/RWANDA%20Herman%20Hakuzimana.pdf

ILO. (2016). What is a green job? Retrieved from ILO: https://www.ilo.org/global/topics/green-jobs/news/WCMS_220248/lang--en/index.htm#:~:text=Green%20jobs%20are%20decent%20jobs,renewable%20energy%20and%20energy%20efficiency.

KPMG. (2017). Rwanda Economic Snapshot. PMG Services Pty Ltd. Retrieved June 24, 2021, from KPMG: https://assets.kpmg/content/dam/kpmg/za/pdf/2017/12/KPMG_Rwanda_2017_V2.pdf

MINAGRI. (2019). Annual Report 2019-2020. Kigali: Ministry of Agriculture and Animal Resources. Retrieved June 26, 2021, from https://www.minagri.gov.rw/fileadmin/user_upload/Minagri/Publications/Annual_Reports/Annual_report_2019-20_FY_.pdf

MoH. (2021, May 18). Ministry of Health. (Ministry of Health (MoH)) Retrieved May 18th, 2021, from MOH: https://www.moh.gov.rw/

Nahayo, L., Karamage, F., Zhang, C., Ndayisaba, F., Shao, H., Kayiranga, A., . . . Tian, G. (2016). Extent of Cropland and Related Soil Erosion Riskin Rwanda. Sustainability. doi:10.3390/su8070609

Nambajimana, J. d., He, X., Zhou, J., Justine, M. F., Li, J., Khurram, D., . . . Nsabimana, G. (2019). Land Use Change Impacts on Water Erosion in Rwanda. Sustainability. doi:10.3390/su12010050

NBR. (2020). Economic Recovery Fund. Kigali: National Bank of Rwanda (NBR). Retrieved June 24, 2021, from https://www.bnr.rw/browse-in/economic-recovery-fund/

NBR. (2021). Economic Recovery Fund. Kigali: National Bank of Rwanda (NBR). Retrieved June 24, 2021, from https://www.bnr.rw/browse-in/economic-recovery-fund/

NISR. (2015a). Demographic and Health Survey 2014/15. Kigali: National Institute of Statistics of Rwanda. Retrieved June 26, 2021, from http://statistics.gov.rw/datasource/108#:~:text=The%202014-15%20Rwanda%20Demographic%20and%20Health%20Survey%20%28RDHS5%29,and%20prevalence%20of%20HIV%20among%20the%20adult%20population.

NISR. (2015b). Integrated Household Living Conditions Survey (EICV) 4. Kigali: National Institute of Statistics Rwanda (NISR). Retrieved June 26, 2021, from http://www.statistics.gov.rw/datasource/integrated-household-living-conditions-survey-4-eicv-4#:~:text=The%20Fourth%20Integrated%20Household%20Living%20Conditions%20Survey%20or,housing%20conditions%2C%20household%20consumption%2C%20among%20others%20in%202

NISR. (2018). Rwanda - Integrated Household Living Conditions Survey (EICV5), 2016-2017. Kigali: National Institute of Statistics Rwanda (NISR). Retrieved June 26, 2021, from http://statistics.gov.rw/file/7276/download?token=TERG2for

NISR. (2020a). GDP National Accounts. National Institute of Statistics of Rwanda. Kigali: NISR. Retrieved June 24, 2021, from https://statistics.gov.rw/file/9568/download?token=JlQj_O8Y

NISR. (2020b). Rwanda Demographic and Health Survey 2019/20 Key Indicators. Kigali: National Institute of Statistics of Rwanda (NISR). Retrieved June 24, 2021, from https://www.statistics.gov.rw/file/9331/download?token=ixNg9145

Okwach, A., Byabagambi, A., Nyiransabimana, V., & Dusabe, S. (2018). The joint programme "advancing and sustaining gender equality gains in Rwanda". Kigal: UNWOMEN. Retrieved June 26, 2021, fromfile:///C:/Users/Owner/Downloads/Final%20Evaluation%20Report_JP%20GEWE%20in%20Rwanda.pdf

RBC. (2021). daily reports. Kigali: Rwanda Biomedical Centre (RBC) . Retrieved June 26, 2021, from https://www.rbc.gov.rw/index.php?id=707

RDB. (2018b). Overview. Kigali: Rwanda Development Board (RDB). Retrieved June 2021, 2021, from RDB: https://rdb.rw/investment-opportunities/manufacturing/

RDB. (2020). Annual report 2020. Kigali: Rwanda Development Board (RFB). Retrieved June 24, 2021, from https://www.minagri.gov.rw/fileadmin/user_upload/Minagri/Publications/Annual_Reports/Annual_report_2020_FY_.pdf

REMA. (2017). State of Environment and Outlook Report 2017 . Rwanda Environment Management Authority (REMA). https://www.researchgate.net/publication/327041096_Rwanda_State_of_Environment_and_Outlook_Report_2017_-_Achieving_Sustainable_Urbanization

REMA. (2019). Rwanda Compendium of Environment Statistic, 2018. Kigali: Rwanda Environment Management Authority (REMA). Retrieved June 26, 2021, from https://unstats.un.org/unsd/environment/Compendia/Compendium%20of%20Environment%20Statistics%20of%20Rwanda%202018.pdf

REMA. (2020). Greening the Economic Recovery Plan. ENR JSR Meeting - 26 June 2020. Kigali, Rwanda, Rwanda: UNDP.

RMB. (2020). Rwanda: Africa's Emerging Mining Destination. Rwanda Mines, Petroleum and Gas Board (RMB). https://www.rmb.gov.rw/fileadmin/user_upload/Mining_Investment_Pitchbook_April_2020.pdf

RoR. (2012). Vision 2020. Kigali: Republic of Rwanda. Retrieved June 24, 2021, from https://kigalicity.gov.rw/fileadmin/templates/Documents/policies/Rwanda_Vision_2020__revised_2012_.pdf

RoR. (2013). Vision 2020 Revised version. Kigali: Republic of Rwanda (RoR). Retrieved June 26, 2021, from https://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/RWANDA%29%20Vision%202020%20%28Revised%202012%29.pdf

UNCTAD. (2017). Science and Technology and Innovation Policy Review. Rwanda. UNCTAD. United Nations Conference on Trade and Development (UNCTAD). Retrieved June 24, 2021, from https://unctad.org/system/files/official-document/dtlstict2017d8_en.pdf

UNDESA. (2019). World Population Prospects 2019: Volume I: Comprehensive Tables. Retrieved from United Nations, Department of Economic and Social Affairs, Population Division: https://population.un.org/wpp/Publications/Files/WPP2019_Volume-I_Comprehensive-Tables.pdf

UNDP. (2020). The Next Frontier: Human Development and the Anthropocene. UNDP. Retrieved June 24, 2021, from http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/RWA.pdf

UNEP. (2019). GEO 6- Healthy Planet Healthy People. Cambridge: United Nation Environment Programme (UNEP). Retrieved June 24, 2021, from https://wedocs.unep.org/bitstream/handle/20.500.11822/27539/GEO6_2019.pdf?sequence=1&isAllowed=y

UNICEF. (2020). WASH Budget Brief: Investing in water, sanitation and hygiene for child 2020/21. Kigali: United Nations Children's Fund (UNICEF) Rwanda. Retrieved June 26, 2021, from https://www.unicef.org/rwanda/media/2786/file/WASH-Budget-Brief-2021.pdf

WB. (2017). Doing Business Report 2018 - Reforming to Create Jobs. Washington: World Bank. Retrieved June 24, 2021, from https://www.doingbusiness.org/content/dam/doingBusiness/media/Annual-Reports/English/DB2018-Full-Report.pdf

WB. (2020). Rwanda Future Drivers of Growth: Innovation, Integration, Agglomeration, and Competition. Washington D.C.: World Bank. Retrieved June 24, 2021, from https://documents1.worldbank.org/curated/en/522801541618364833/pdf/Future-Drivers-of-Growth-in-Rwanda-Innovation-Integration-Agglomeration-and-Competition.pdf

WB. (2021a, March 21). Rwanda Overview. Retrieved from World Bank (WB): https://www.worldbank.org/en/country/rwanda/overview

WB. (2021b). The Republic of Rwanda Country Partnership Framework FY21-FY26. World Bank Group. Retrieved June 24, 2021, from https://openknowledge.worldbank.org/bitstream/handle/10986/34109/Rwanda-Country-Partnership-Framework-for-the-Period-of-FY21-FY26.pdf?sequence=4&isAllowed=y

World Bank Group. (2021). Rwanda Economic update- 17th edition . World Bank Group, Rwanda. https://www.railwaysafrica.com/news/17th-edition-of-rwanda-economic-update

WVR. (2020). Rwanda Annual Report - Our Impact Update. Kigali: World Vision Rwanda (WVR). Retrieved June 24, 2021, from https://www.wvi.org/sites/default/files/2021-03/2020%20Rwanda%20Annual%20Report.pdf

A fisherman catches fish with his net in Lake Kivu
Photo credit: Ian Masias/IFPRI/Flickr

Chapter 2:

Inclusive Wealth and Natural Capital Account

A section of Gishwati Natural Forest - A UNESCO World Heritage Site
Photo credit: Rugege D./EPI

2.1 Introduction

The current COVID-19 pandemic is a reminder that humans, animals and the environment are intimately connected. The transmission pathways of emerging infectious diseases, such as COVID-19, from wildlife and domesticated animals to humans highlight the extent to which human activity is placing increasing pressures on the health of our biosphere with damaging consequences to the society. The post-crisis recovery process cannot follow business-as-usual pathways as this would further increase pressure on ecosystems such as increasing carbon emissions, biodiversity loss and land degradation. As governments develop strategies towards "building back better", they should ensure that the health of ecosystems and their capacity for providing natural resources are protected without undermining people's well-being. "Building back better" requires better measurement and management of assets that underpin human, environmental, institutional, and economic progress.

Natural capital is a term to describe the world's stocks of natural assets. It includes geology, soil, air, water and ecosystems generally. The depreciation and degradation of natural capital is closely related to negative externalities resulting from development of various sectors of the economy, particularly those involving non-renewable resources.

2.2 The Inclusive Wealth Index (IWI)

Policy and investment decisions made in the post-COVID 19 recovery process should be guided by the understanding and the measurement of the wealth of nations rather than focusing on GDP and income alone. The Inclusive Wealth paradigm shows that future economic possibilities depend on the current management of all forms of wealth. This includes human health and skills, physical infrastructure (e.g., transport, housing, utilities and ICT), sustainable natural resource and ecosystems management (including air quality, biodiversity, and climate systems), trust and the strength of social relationships, and the quality of democratic institutions. Combined, these assets form the building blocks for achieving the Sustainable Development Goals (SDGs).

Frameworks for the complex task of measuring natural capital have been steadily improving, with the United Nations launching the System of Environmental Economic Accounting-Ecosystem Accounting (SEEA-EA) in 2021. SEEA-EA sets out a comprehensive framework which guides the setting of appropriate indicators of ecosystem health and function for their systematic inclusion into natural capital accounts.

The Inclusive Wealth Index (IWI) concept was first shared at the Rio+20 conferences in the IWI report (IWR) that was released in 2012 by UNEP. The IWI compared the decline or increase of natural capital against two other areas: produced capital and human capital. Results indicated that it is possible to trace the changes of the components of wealth by country and link these to economic growth by highlighting that the impact of declines or increases in natural capital can be significant to the economic productive base (Figure 2-1). The second report, the IWR 2014, expanded the study significantly, to cover 140 countries. The IWR 2014's main theme was Human Capital with a focus on Education. It provided valuable insights into investment strategies of countries on education and potential returns from future investments into education. The report demonstrated the use of the Inclusive Wealth Index as a key indicator for sustainable, stronger, and more peaceful development. In the 2018 edition of IWR, health was considered in the calculation of human capital, and fisheries were added to the stocks of natural capital.

The recent *Dasgupta Review* (Dasgupta, 2021), commissioned by the Her Majesty's Treasury UK points out that the global economy has grown due to sacrificing natural capital. What is routinely celebrated as 'economic growth' – GDP – is no longer an appropriate proxy for sustainable growth and is deeply problematic.

What is crucial now is that the wealth accounting framework is useful for policy-making decisions. GDP growth rates are important performance measures, but if the main aim is to look at the progress of the economy in terms of sustainability, then it is important to mainstream inclusive wealth metrics in planning and strategies. Noteworthy is that the Inclusive Wealth measurement includes the physical capital and human capital change elements as well. To date, Rwanda and other countries in the region have tended to depend only on an income accounting framework. It is also clear that an inclusive wealth accounting framework overcomes the classical limits of measuring progress by GDP per capita alone.

Secondly, by including the components of inclusive wealth in measurement of sustainability, it is possible to focus on the importance of natural resources. If there are diminishing returns to the natural resource base, then it would be imperative to invest in renewable natural capital in the case of Rwanda.

The IWI demonstrates that assessing and valuing natural capital and the change in per capita inclusive or comprehensive wealth over time has the potential to keep track of progress on most Sustainable Development Goals (SDGs). It totals up the value of an economy's stock of manufactured capital, human capital, and natural capital (Figure 2-1). The changes in the inclusive wealth of 140 countries are calculated by annual average growth rates over the past 25 years, with 1990 as the base year. The results show that the growth of inclusive wealth is positive for a considerable number of countries. The IWR 2018 found that 44 out of the 140 countries in the sample had experienced a decline in (inclusive) wealth per capita since 1998, even though GDP (read, 'income') per capita increased in all but a handful of them.

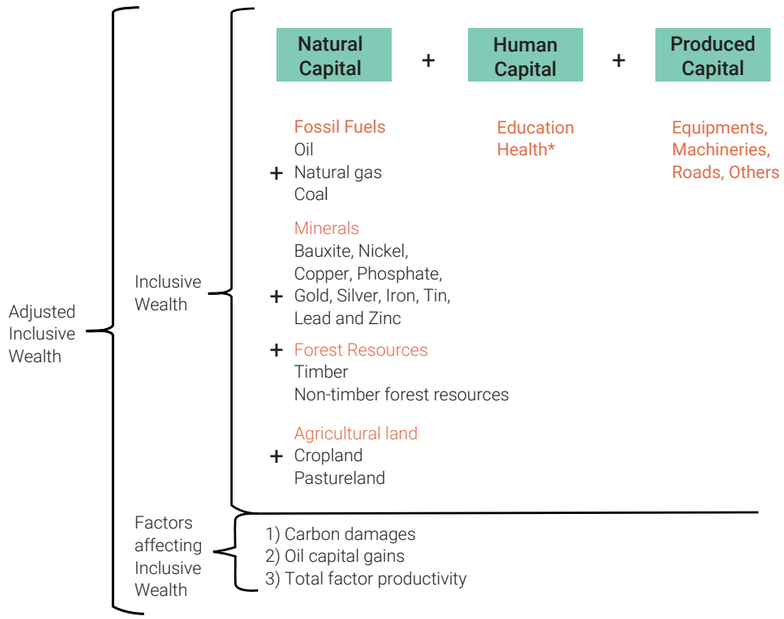


Figure 2-1: Assets accounted for in the Inclusive Wealth Index 2018 (UNEP, 2018)

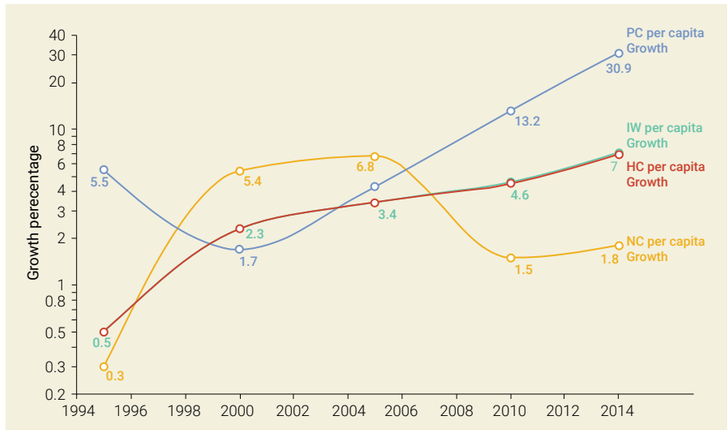


Figure 2-2: Rwanda Inclusive Wealth Growth per capita (UNEP, 2018)

In the case of Rwanda, the country scored 3.3 per capita for the Inclusive Wealth growth rate compared to the 14.2 per capita GDP growth rate from 1992 to 2015. Figure 2-2 illustrates Rwanda's performance in the three components of Inclusive Wealth (Produced Capital, Human Capital, and Natural Capital). The natural capital per capita trendline shows fluctuation and is trending upward. Rwanda's human capital per capita and produced capital per capita show similar trendlines with the rest of the world (see Figure 2-3). Figure 2-4 displays the growth rates of the inclusive wealth capitals in Rwanda, and the Natural Capital growth rate per capita is trending upward again. The inclusive wealth of Rwanda is above average compared to other African countries (see Figure 2-5).

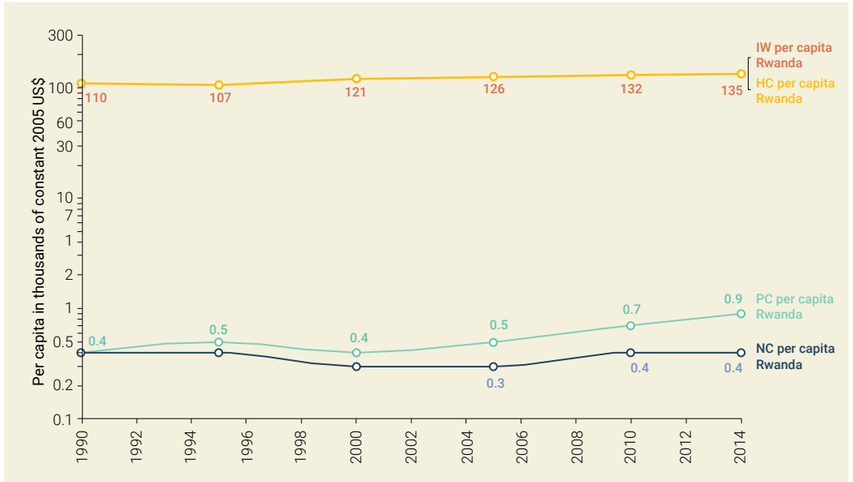


Figure 2-3: Inclusive Wealth per capita in thousands of constant 2005 US$ (Rwanda) (UNEP, 2018)

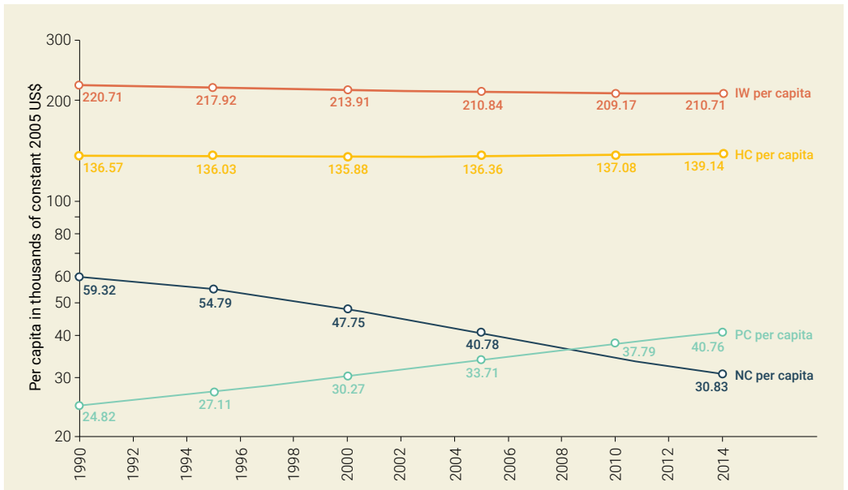


Figure 2-4: Global Inclusive Wealth per capita in thousands of constant 2005 US$ (UNEP, 2018)

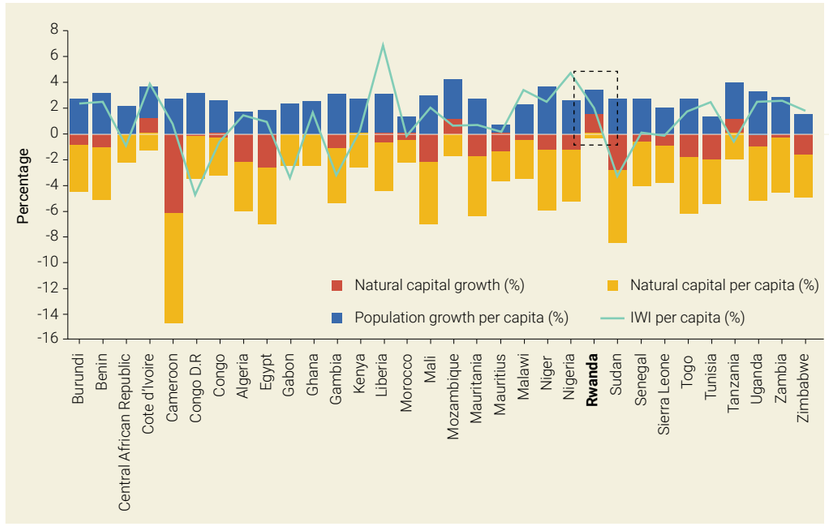


Figure 2-5: Changes in natural capital in African countries: average annual growth (UNEP, 2018)

A l'Hoest's monkey (Cercopithecus lhoesti) in the wild
Photo credit: Alex Zanuccoli/Flickr

2.3 Natural capital accounts of Rwanda

Ecosystems services

According to the United Nations Millennium Ecosystems Assessment (MEA, 2005), an ecosystem is a dynamic complex of plant animal and microorganism communities and the non-living environment interacting as a functional unit. Humans are part of the ecosystem. Ecosystems comprise agro-ecosystems, forest ecosystems, grassland ecosystems and aquatic ecosystems. Ecosystem services are the benefits provided to humans through the transformation of resources (or environmental assets including land, water, vegetation, and atmosphere) into a flow of essential goods and services such as clean air and water (Figure 2-6) (MEA, 2005).

Economic values of ecosystem services in Rwanda

The valuation of Ecosystem Services has become popular using the Total Economic Valuation (TEV) Approach (IUCN, 2004). The economic value of ecosystems and biodiversity is the sum of their use and non-use values. The use values include direct use values such as good and services from the ecosystems for consumption and for other uses. The indirect use values that ecosystems provide to humans are regulating, cultural and support services (Figure 2-6). The Total Economic Value of Ecosystem Services is also defined as the value that natural capital contributes now and in the future. The non-use values of ecosystem services are those that are just valued for their existence. The first attempt to estimate the value of global ecosystem services was pegged at US $347 trillion per year (Constanza, et al., 1997).

Studies of the total economic value of ecosystem services in Rwanda are listed below and in Box 2-1:

- The economic value of Nyungwe montane forest was US $4.80 billion in 2014 (RoR, 2020).
- The TEV of Rugezi wetland was US $375 Million in 2014 (RoR, 2020).
- The TEV of Mukura Landscape was estimated US $1,468,211 per year. The monetary benefits from the Mukura landscape translate into a value of US $817 per hectare per year, which is comparable to the most productive forest landscapes (RoR, 2020).
- The total value of the Akagera Wetland Complex includes a stock value (carbon storage) of US $1.1 billion, and an annual flow value of US $11.9 million (RoR, 2020).

For more detailed inputs to the natural capital accounting, further studies are needed not only to calculate the estimated and relative values of natural resources but also to monitor trends.

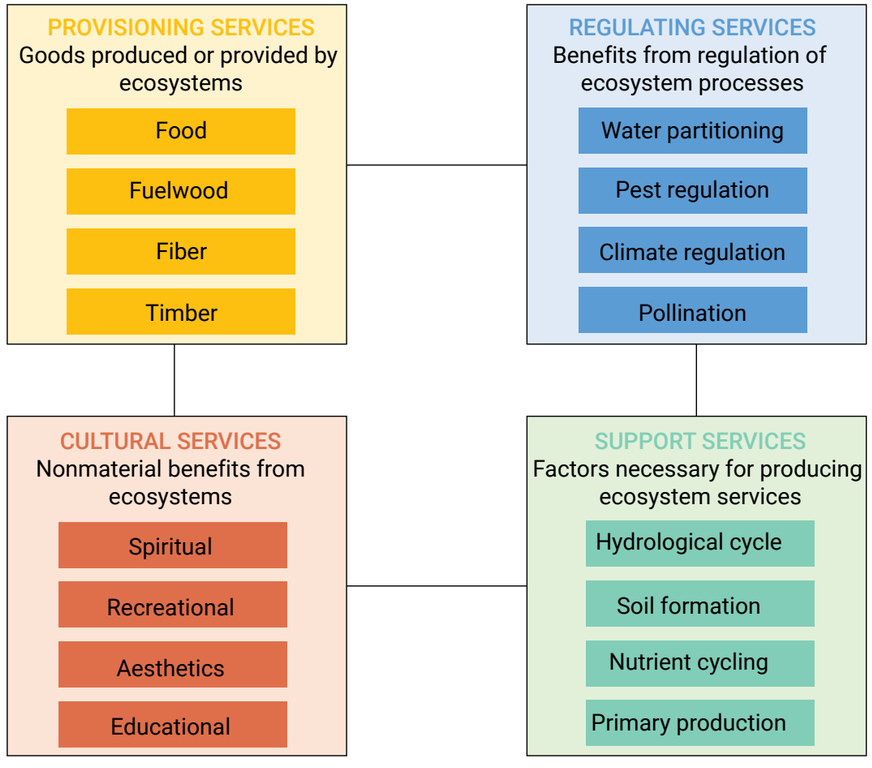


Figure 2-6: Classification of Ecosystem Services (MEA, 2005)

Box 2-1: Economic valuation of ecosystem services of Kigali City and Rweru-Mugesera wetland complexes in Rwanda (ARCOS, 2021a) (ARCOS, 2021b)

According to a recent joint study by the ARCOS network, REMA and IUCN, the Kigali city and the Rweru-Mugesera wetland complexes generate several ecosystem services of local, national, and international importance.

Kigali City's wetland complexes provide four important provisioning ecosystem services, namely crop framing, papyrus and papyrus products, grass harvesting, and valuable brick with a total economic value of just under US $22 million per year. This wetland also generates regulatory and cultural services such as climate change mitigation, habitat for biodiversity, sediment control, and water quality improvement worth over US $51 million.

The Rweru-Mugesera wetland complex provides a multitude of ecosystem services to more than 48,000 households (about 194,000 individuals) with an estimated economic value of over US $52 million. In addition, the Rweru-Mugesera wetland complex generates regulatory services valued at over US $403 million.

If the status quo (business as usual) is maintained, the wetland complexes of the city of Kigali will accumulate a net present value loss in terms of ecosystem services worth more than US $1.8 billion by 2050. While the implementation of the Kigali City Wetlands Master Plan would surpass the status quo by generating a net present value benefit of over US $1.9 billion by 2050, generating an additional US $155 million per year more than the status quo.

Towards Development of Natural Capital Accounts (NCA) in Rwanda

Rwanda joined the Wealth Accounting and Valuation of Ecosystems Services (WAVES) programme which is spearheaded by the World Bank. Its goal is to enhance the mainstreaming of natural capital into development planning and national economic accounting systems. WAVES is implemented in line with the System for Environment and Economic Accounts (SEEA) adopted by the United Nations Statistical Commission. Lead agencies in spearheading WAVES were the Rwanda Natural Resources Authority (RNRA), Rwanda Environment Management Authority (REMA) and the Ministry of Finance and Economic Planning.

The data was consolidated from diverse sources as captured in the 2019 publication "*Towards ecosystem accounts for Rwanda: Tracking 25 years of change inflows and a potential supply of ecosystem services Report*". It was noted that ecosystem conditions, potential supply and ecosystem services flows degraded substantially over the 25-year period due to the conversion of forests to croplands (see Figure 2-7 and Box 2-2). Declines in the forest cover trends did not include recovery noted in the 2010-2015 period, especially of dense cover in protected areas (Bagstad, et al., 2019).

In addition, the National Capital Accounts revealed several challenges. Firstly, there are capacity building needs. The natural capital accounting depended on external expertise and few experts are available in Rwanda to conduct in depth analytical studies. Secondly, current data availability is still a challenge. In the initial study, land cover maps were dated 2010. Information about ecosystems show the situation up to 2015 only. Finally, it was noted that the accounting process requires more financial resources to fully execute analyses.

Box 2-2: Findings of the WAVE programme for the years 1990-2015 (Bagstad, et al., 2019)

Over a 25-year period, it was found that all ecosystem services declined, strongly driven by conversion of forests to cropland. Declines were most pronounced between 1990-2000 and 2010-2015. Ecosystem services were relatively stable from 2000 to 2010 (except for nutrient exports to water bodies, which jumped most sharply between 2000 and 2010). From 2010 to 2015, over 42 percent of Rwanda's water-use sites (representing 9 percent of the nation's hydroelectric generation capacity and 59 percent of its water treatment capacity) had upstream increased in sediment export. Half of Rwanda's water treatment plants had upstream phosphorus export.

WAVE results quantify country-wide ecosystem services trends, their implications for key water dependent industries, and the importance of protected areas in safeguarding ecosystem services flows and potential supply in Rwanda. They also provide data that can be integrated with existing land, water, and economic accounts for Rwanda, as well as a baseline to inform development strategies that better link economic and environmental goals.

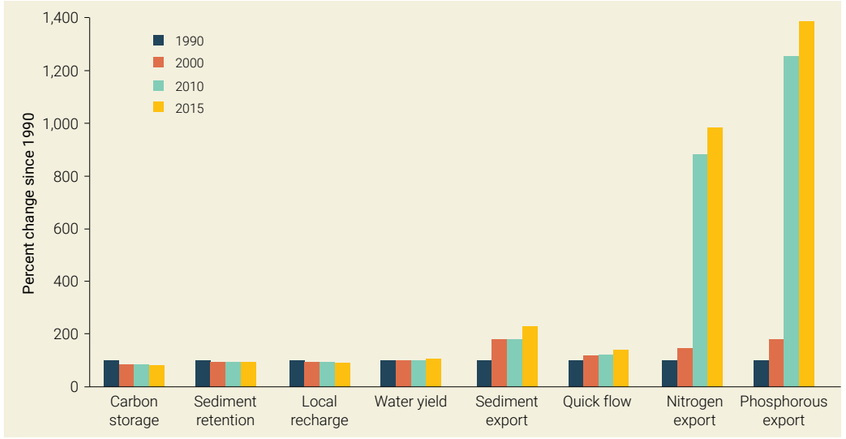


Figure 2-7: Ecosystem service trends for Rwanda, 1990–2015 (Bagstad, et al., 2019)

2.4 Nature-based solutions

Nature-based solutions are designed to address major societal challenges such as food security, climate change, water security, human health, disaster risk, and social and economic development (Box 2-3 and Figure 2-8) (IUCN, 2021). They are essential for addressing global challenges such as reducing carbon emissions and protecting biodiversity.

Box 2-3: Description of Nature-based Solutions (IUCN, 2021).

Nature-based Solutions (NbS) are defined by the International Union for Conservation of Nature (IUCN) as *"actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits"*.

Figure 2-8: The benefits of Nature-based Solutions (Dasgupta, 2021)

There are several nature-based actions that can boost rural livelihoods while building ecosystem resilience to environmental change. Many of them involve improving land-use sustainability, which provides ecosystem services and supports over millions of livelihoods in farming, fishing, and forestry industries. Rwanda has initiated several nature-based solutions to protect, conserve or manage ecosystems and natural resources. One such case is Rugezi Marshlands (Box 2-4).

Box 2-4: Rugezi Marshland Restoration (REMA, 2006)

Rugezi is regarded as a highland wetland at an altitude of 2005 meters above sea level in Northern Rwanda near the border with Uganda. It is a wetland that is important nationally, regionally and globally now as a RAMSAR site. It has become an example of how a crisis of national grid electricity supply, unsustainable use of the wetlands, and livelihood of resource depended population is answered by a solution based on harnessing nature and restoring the ecosystem functions.

In early 2000s, Rwanda was hit by a major shortage in hydroelectricity to an extent that diesel generators had to be purchased for which the government had to pay almost $60,000 per day. The main cause was that the water reservoir – Rugezi Marsh and ecosystems for Lake Burera and Ruhondo had been mismanaged. The linked watershed had been degraded due to converting forest slopes into farmlands. Through poor drainage, unsustainable agriculture, and uncontrolled fishing, the water flowing from Rugezi to Lake Burera was drastically reduced. As a result, water falling into Ruhondo through Ntaruka to generate electricity was not sufficient and very often electricity outages and black outs were experienced around 2003 and 2004. By 2003, it is estimated that 56 percent of the wetlands had been destroyed by unsustainable practices. A nature-based solution was initiated by the government. The government halted drainage activities, agricultural and pastoralist activities in the marshlands. As a result, livelihoods of people dependent on the wetlands were immediately affected. To address the problem, people were mobilized to take care of the nature around them by planting trees around the hills, bamboos and grass around the wetlands and improved farming methods that did not affect the watershed and wetlands. Improved cook stoves were introduced to the surrounding communities; alternative income activities far from the wetlands such as beekeeping were started. There is opportunity for using nature-based solutions in many spots in Rwanda where ecosystem functions need to be restored.

By 2010, water levels had been restored, electricity shortage ended, and livelihoods of surrounding communities safeguarded and improved. As much as there is concern for degradation of ecosystems and biodiversity, the case builds confidence in possible restoration.

2.5 Conclusion and recommendations

Many of the assets that are critical for maintaining the productive base for the economy of Rwanda are either not priced or are priced at much lower levels than they should rightly be. This is especially true for natural capital. Natural capital assets such as forests and water bodies have only been valued for the products they provide for the market. These include timber and aquatic products such as fish. However, these ecosystems offer a much larger suite of services such as water purification, water regulation, habitat provisioning for species among many others. Furthermore, the asset side of the national balance sheet should be expanded to include human and natural capital. Improvements in natural resource accounting would be great leap forward towards measuring the dependence of humans on nature.

The government has already taken steps for developing natural capital accounts. In the age of sustainability and inclusion, the use of Inclusive Wealth in informing current and future development will be helpful and need to be considered in natural capital accounting and assessment. The following recommendations should be considered:

- REMA may consider approaching UNEP for a country study of Inclusive Wealth of Rwanda using the latest data.
- The Strategic Plan for the Environment and Natural Resources Sector 2018-2024 recommends the "*Adoption of Natural Capital Accounting (NCA) practices to track the Total Economic Value of natural capital to the Rwandan economy focusing on land, water, forests, wetlands and mining, thereby accounting for gains and losses relative to GDP growth*" (REMA, 2017). This recommendation should be implemented using the latest statistics.

References

ARCOS. (2021a). Economic Valuation of Ecosystem Services of Kigali City Wetland Complex in Rwanda. Kigali, Rwanda: Albertine Rift Conservation Society (ARCOS). Retrieved from http://arcosnetwork.org/uploads/2021/10/Econimic_Valuaton_Ecosystem_Services_Kigali_City_Wetlands_complex.pdf

ARCOS. (2021b). Economic Valuation of Ecosystem Services of Rweru-Mugesera Wetland Complex in Rwanda. Kigali, Rwanda: Albertine Rift Conservation Society (ARCOS). Retrieved from http://arcosnetwork.org/uploads/2021/10/Economic_Valuaton_Rweru-Mugesera_Wetland_Complex.pdf

Bagstad, K., Ingram, J., Lang, G.-M. M., Ancona, Z., Bana, M., Kanabo, D., . . . Uwera, C. (2019, December 9). Towards ecosystem accounts for Rwanda. Tracking 25 years of change inflows and potential supply of ecosystem services. People and Nature, 2(1), 163-198. doi:https://doi.org/10.1002/pan3.10062

Constanza, R., Arge, D., deGroot, R., Farber, S., Grasso, M., Hannon, B., . . . Sutton, P. V. (1997, May 15). The value of the World's Ecosystem services and natural capital. Nature, 387, 253-260. Retrieved June 5, 2021, from https://www.nature.com/articles/387253a0

Dasgupta, P. (2021). The Economics of Biodiversity-The Dasgupta Review. Final Report. London: GOV.UK HM Treasury. Retrieved June 5, 2021, from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/962785/The_Economics_of_Biodiversity_The_Dasgupta_Review_Full_Report.pdf

IUCN. (2004). How much is an ecosystem worth? Assessing the economic value of conservation. Washington, DC: The International Bank for Reconstruction. Retrieved June 5, 2021, from https://documents1.worldbank.org/curated/en/376691468780627185/pdf/308930PAPER0Ecosytem0worth01public1.pdf

IUCN. (2021, May 19). Nature based solutions Commission on Ecosystem management. Retrieved June 5, 2021, from IUCN: https://www.iucn.org/commissions/commission-ecosystem-management/our-work/nature-based-solutions

MEA. (2005). Guide to the Millennium Assessment Reports. Millennium Ecosystem Assessment (MEA). Retrieved June 6, 2021, from https://www.millenniumassessment.org/en/index.html

REMA. (2006). Economic Analysis of Natural Resource Management in Rwanda. Kigali: Rwanda Environment Management Authority (REMA). Retrieved June 6, 2021, from https://wedocs.unep.org/bitstream/handle/20.500.11822/26513/Rwanda-Economic-Analysis.pdf?sequence=1&isAllowed=y

REMA. (2017). Strategic Plan for the Environment and Natural Resources Sector 2018 – 2024. Kigali: Rwanda Environment Management Authority (REMA). Retrieved June 5, 2021, from https://www.rwamagana.gov.rw/fileadmin/user_upload/Strategic_plan_for_the_environment_and_natural_resources_sector_2018-2024.pdf

RoR. (2020). Rwanda 6th National Report to the Convention on Biological Diversity. Kigali: Republic of Rwanda (RoR). Retrieved June 5, 2021, from https://www.cbd.int/doc/nr/nr-06/rw-nr-06-en.pdf

SIDA. (2019). Rwanda Environment and Climate Change Analysis– 2019-06-05. Swedish International Development Cooperation Agency (SIDA). Retrieved February 3, 2021, from https://sidaenvironmenthelpdesk.se/digitalAssets/1748/1748556_environment-and-climate-change-analysis-rwanda-2019-06-05.pdf

UNEP. (2018). Inclusive Wealth Report. Nairobi: United Nations Environment Programme (UNEP). Retrieved June 5, 2021, from https://wedocs.unep.org/bitstream/handle/20.500.11822/27597/IWR2018.pdf?sequence=1&isAllowed=y

WAVES. (2015). Wealth Accounting and the Valuation of Ecosystem Services. Washington, DC: Wealth Accounting and the Valuation of Ecosystem Services (WAVES). Retrieved June 6, 2021, from https://www.wavespartnership.org/en/rwanda

A bamboo forest loccated on the way to the Susa group, Parc National des Volcans
Photo credit: Garret Ziegler/Flickr

Chapter 3:

Environmental Governance

Orientation meeting, Ministry of Agriculture and Animal Resources 2021
Photo credit: MINAGRI

3.1 Rwanda's changing development context

Rwanda's Vision 2020 and the Vision 2050 provide the overarching blueprint for the country's economic growth and ambition to achieve middle, upper middle and ultimately high-income status by 2050. The global Sustainable Development Goals provide a holistic framework for ensuring Rwanda's growth is sustainable as it implements this blueprint.

Subsequently, the Economic Development and Poverty Reduction Strategy (EDPRS) identified environment and natural resources as cross cutting issues and set targets to be achieved. Currently, Rwanda is implementing Vision 2050 through the National Strategy for Transformation (NST), with the first phase NST 1 as a 7-Year Government programme, covering the period 2018 -2024. Priorities and targets were informed by the National Green Growth and Climate Resilience Strategy (GGCRS) of 2011. The GGCRS also informed the updated Rwanda's Nationally Determined Contributions to the Paris Agreement on Climate Change submitted to the UNFCCC in 2019 that commit Rwanda to a development pathway that is low-emission and climate resilient. Overall, the high-level Government commitment has paved the way for the development of the policy and legal framework for achievement of the SDGs and its Vision 2050. Figure 3-1 highlights the evolution of environmental governance in Rwanda.

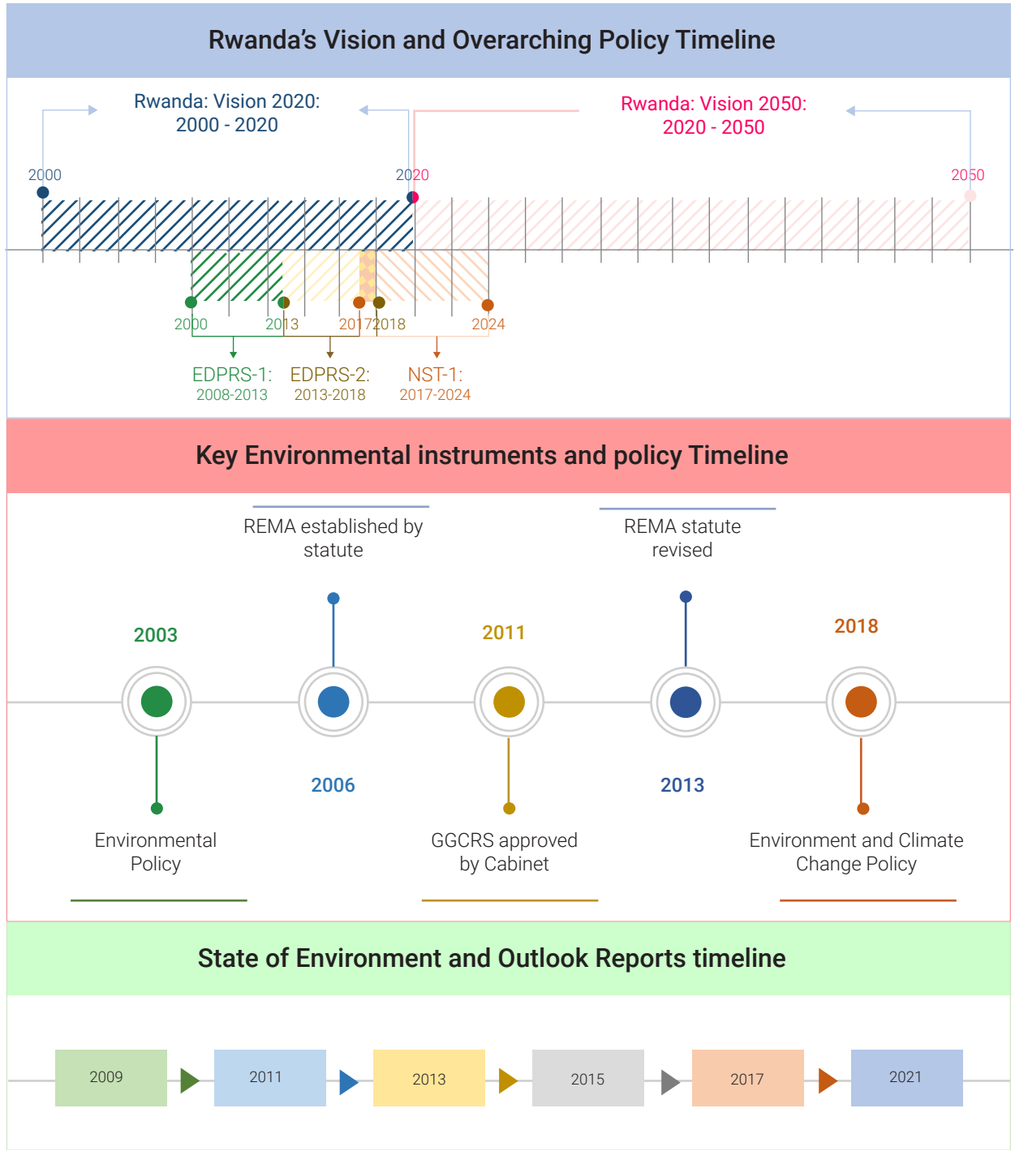


Figure 3-1: Evolution of environmental governance in Rwanda

3.2 Institutions related to Environment and Natural Resources (ENR)

Institutional and organisational linkages

The Ministry of Environment (MoE) is the lead ministry in charge of protection of the environment and sustainable management of natural resources in Rwanda. MoE provides overall coordination as Chair of Sector Working Group (SWG) which is a formal forum that facilitates dialogue, ownership, and accountability of the development agenda by all stakeholders at the sector level. It brings together central and local government institutions, Development Partners, Civil Society, and the Private Sector involved in the sector or with an interest in the sector's development. For the Environment and Natural Resources (ENR) sector, roles, and responsibilities of the SWG include the following:

- Developing sector strategies that contribute to the thematic priorities of Vision 2050 and NST1, and which are effectively prioritized based on available financing for the sector.
- Giving guidance to districts on emerging sector priorities to guide the development of district strategies.
- Understanding the needs of districts and actively incorporating their priorities into the sector strategic plans.
- Developing sector Monitoring and Evaluation frameworks in line with sector strategies.

The ENR sector comprises the environment and climate change, land, water, forest, meteorology and mining sub-sectors that are responsible for the respective implementation of the ENR sector strategic plan. Implementation of sector priorities is undertaken by the six national agencies (Table 3-1).

Table 3-1: Key national agencies related to environment and their responsibilities (MoE, 2017)

National Agencies	Responsibility
Rwanda Water Resources Board (RWB)	Rwanda Water Resources Board was established by the law N° 71/2019 of 29/01/2020 with the mission of ensuring the availability of adequate and well managed water resources for sustainable development.
Rwanda Forestry Authority (RFA)	Rwanda Forestry Authority (RFA) has the mandate to ensure growth of forest resources, their management and protection for sustainable development purposes.
Rwanda Land Management and Use Authority (RLMUA)	Rwanda Land Management and Use Authority (RLMUA) is responsible for putting in place and operationalizing an efficient system of land administration, use and management that secures land ownership, promotes investment in land for socio-economic development and poverty reduction.
Rwanda Meteorological Agency (Meteo Rwanda)	Meteo Rwanda was established in November 2011, under Law N°54/2011. Formerly within the Ministry of Infrastructure, Meteo was transferred to the Ministry of Environment in 2015. The purpose of the Rwanda Meteorology Agency is to provide accurate weather and climate information services for safety of life and property and socio-economic development.
Rwanda Environment Management Authority (REMA)	REMA established in 2006, is supervised by the Ministry of Environment, as per Law N°63/2013 of 27/08/2013 determining the mission, organization and functioning of Rwanda Environment Management Authority (REMA). REMA is vested with the legal mandate for national environmental protection, conservation, promotion, and overall management, including an advisory role to the Government on all matters pertinent to the environment and climate change. REMA is designated as the national competent authority for all international environmental treaties and agreements on environment. REMA is also the National Designated Authority (NDA) for Green Climate Fund (GCF).
Centre of Excellence in Biodiversity and Natural Resources Management (CoEB)	CoEB has been established by the Rwandan Government under the University of Rwanda as a centre of excellence in biodiversity with the mission to enhance the knowledge of biodiversity and natural resource management for sustainable development. The centre acts as clearing house for data and information on biodiversity and natural resources for Rwanda and as a hub for capacity building and knowledge generation on biodiversity conservation and natural resources management in the country.
Rwanda Mining, Petroleum and Gas Board (RMB)	The Rwanda Mines, Petroleum and Gas Board was established by Law N°07/2017 in February 2017 to redesign the minerals sector to deliver higher-level results. Accordingly, the RMB has responsibility to redesign the sector to transform mining resources into key drivers of Rwanda's growth during the NST-1 period and beyond.

Stakeholders

Since the ENR is a cross cutting issue, it intersects with areas agriculture, energy, tourism, housing, health, macroeconomic management, gender, and social development, among others. In this context, a key priority of the sector strategies is improved coordination among partners in terms of programming, activity implementation and funding. At the Central Government level, key ministerial stakeholders include:

- Ministry of Agriculture, Animal Resources (MINAGRI) and affiliated agencies: Rwanda Agricultural Board (RAB) and National Agricultural Export Development Board (NAEB)
- Ministry of Infrastructure (MININFRA) and affiliated agencies: Water and Sanitation Corporation (WASAC) and Rwanda Energy Group (REG)
- Ministry of Trade and Industry (MINICOM)
- Rwanda Development Board (RDB)
- Ministry of Local Government (MINALOC)
- Ministry of Health (MoH)
- Ministry of Education (MINEDUC)
- Ministry of Foreign Affairs and Cooperation (MINAFFET)
- Ministry of Finance, Planning and Economic Development (MINECOFIN)
- Rwanda Utilities Regulatory Agency (RURA)
- Rwanda Standards Board (RSB)

Given that the majority of implementation takes place at the local level, the Central Government must enhance integration with all stakeholders including local government, private, non-governmental, development partner, academic and media.

3.3 The Environmental legal and policy landscape

Environmental policies

Over the years the government of Rwanda has formulated relevant policies and revised them to capture changing national priorities and international commitments related to different sectors some of which are listed in Table 3-2.

Selected laws and guidelines

Rwanda has a rich legacy of sound legal frameworks and has promulgated several laws, regulations, and guidelines for protection of environment and conservation of natural resources. A selected list is given in Table 3-3 and Table 3-4.

The Government of Rwanda has issued extensive guidelines for conducting Strategic Environmental Impact Assessments in different sectors and Environmental Impact Assessments of projects.

Table 3-2: Rwanda's key national environmental policies (REMA, 2018)

Policies	Year
National Environment Policy 2003, Revised National Environment and Climate Change Policy	2019
National Policy & Strategy for Water Supply and Sanitation Services	2010
Rwanda Biodiversity Policy	2011
Rwanda Wildlife Policy	2013
National Forest Policy 2013, Revised National Forest Policy	2018
National Land Policy 2004 revised in 2019	2019

Table 3-3: Rwanda's Laws enacted for the environment (REMA, 2018); (Bizimana, 2018); (RoR, 2020)

Law No.	Date	Topic	Year
58/2008	10/09/2008	Law determining the organization and management of aquaculture and fishing in Rwanda	2008
62/2008	10/09/2008	Law putting in place the use, conservation, protection, and management of water resources regulations	2008
31/2009	26/10/2009	Law enforces protection of Intellectual Property Rights	2009
20/2011	21/06/2011	Law governing human habitation	2011
10/2012	02/05/2012	Law governing urban planning and building in Rwanda	2012
16/2012	22/05/2012	Law determining the organization, functioning and mission of the National Fund for Environment (FONERWA)	2012
46/2013	16/06/2013	Law established the Rwanda Development Board (RDB) with the mandate to fast-track development activities and facilitate the Government and private sector to undertake an active role.	2013
47/2013	28/06/2013	Law determining the Management and Utilisation of Forests in Rwanda	2013
55/2013	02/08/2013	Law on Mineral Tax	2013
57/2013	10/08/2013	Law authorising the accession of Rwanda to the International Union for Conservation of Nature and Natural Resources (IUCN)	2013
58/2013	10/08/2013	Law authorising the ratification of the Treaty of 05 February 2005 on the conservation and sustainable management of forest ecosystems in Central Africa and establishing the Central African Forests Commission (COMIFAC)	2013
59/2013	10/08/2013	Law authorising the accession of Rwanda to the Regional Centre for Mapping of Resources for Development (RCMRD)	2013
63/2013	27/08/2013	Law determining the mission, organization and functioning of Rwanda Environment Management Authority (REMA)	2013
70/2013	02/09/2013	Law governing biodiversity in Rwanda	2013
13/2014	20/05/2014	Law on Mining and Quarry Operations	2014
41/2015	29/08/2015	Law relating to disaster management	2015
45/2015	15/10/2015	Law establishing the Gishwati -Mukura National Park	2015
18/2016	18/05/2016	Law Governing the preservation of air quality and prevention of air pollution in Rwanda	2016
14/2017	14/04/2017	Law established the Rwanda Agriculture and Animal Resources Development Board (RAB) with the mission of developing agriculture and animal resources through research, agricultural and animal resources extension to increase agricultural and animal productivity	2017
39/2017	16/08/2017	Law establishing the National Fund for Environment and determining its mission, organisation, and functioning	2017
48/2018	13/08/2018	Law on Environment	2018
17/2019	10/08/2019	Law relating to the prohibition of manufacturing, importation, use and sale of plastic carry bags and single-use plastic items	2019
71/2019	29/01/2020	Law establishing Rwanda Water Resources Board (WRB) with the mandate to ensure availability of enough and well managed water resources for sustainable development.	2020
72/2019	29/01/2020	Law establishing Rwanda Forestry Authority (RFA) with the mandate to ensure growth of forest resources, their management and protection for sustainable development purpose	2020
27/2021	10/06/2021	Law governing land	2021

Table 3-4: Rwanda's selected Ministerial Orders and Instructions (REMA, 2018); (Bizimana, 2018); (RoR, 2020). Note: This is not an exhaustive list.

Order/ Instruction No.	Date	Ministerial Order/Instruction	Year
57/2004	18/02/2004	Ministerial Instruction on the use and manufacturing of plastic bags in Rwanda	2004
002/2008	01/04/2008	Ministerial Order determining modalities of land registration	2008
004/2008	15/08/2008	Ministerial Order establishing the list of works, activities and projects that must undertake an environment impact assessment.	2008
005/2008	15/08/2008	Ministerial Order establishing modalities of inspecting companies or activities that pollute the environment	2008
006/2008	15/08/2008	Ministerial Order regulating the importation and exportation of ozone layer depleting substances products and equipment containing such substances	2008
007/2008	15/08/2008	Ministerial Order establishing the list of protected animal and plant species	2008
26/03	23/10/2008	Prime Minister's Order determining the list of chemicals and other prohibited pollutants	2008
27/03	23/10/2008	Prime Minister's Order determining a list of prohibited drugs unless authorized or temporary permitted	2008
004/ MINICOM/2010	14/09/2010	Ministerial Order determining the modalities of environment conservation in mining and quarry extraction	2010
005/Minifom	14/09/2010	Ministerial Order determining the procedures of requesting licences, the conditions, classification of mineral substances and the procedures for licence limits on mining and quarry extraction	2010
003/ Minifom/2010	14/09/2010	Ministerial Order on requirements for granting the licence for purchasing and selling mineral substances in Rwanda	2010
006/Minifom	14/09/2010	Ministerial order determining taxes applicable to mines and quarries	2010
003/16.01	15/07/2010	Ministerial Order preventing activities that pollute the atmosphere	2010
004/16.01	15/07/2010	Ministerial Order governing the importation and exportation of wild animals	2010
005/16.01	15/07/2010	Ministerial Order determining the list of prohibited plains to constructions -	2010
006/16.01	15/07/2010	Ministerial Order establishing special regulations relating to burying toxic wastes	2010
007/16.01	15/07/2010	Ministerial Order determining the length of land on shores of lakes and rivers transferred to public property	2010
126/03	25/10/2010	Prime Ministerial Order determining the responsibilities, organization and functioning of committees in charge of the environment conservation and protection	2010
008/16.01	26/11/2010	Ministerial Order establishing rules and procedures for Rwanda environment management authorities	2010
002/16.01	24/05/2013	Ministerial Order Determining the Procedure for Declaration, Authorisation and Concession for the Utilisation of Water	2013
004/16.01	24/05/2013	Ministerial Order determining the list of water pollutants	2013
005/16.01	24/05/2013	Ministerial Order determining the organisation and functioning of hydrographic basin committees	2013
006/16.01	24/05/2013	Ministerial Order determining the organization of water resources data collection, treatment, management, exploitation, and communication	2013
007/16.01	24/05/2013	Ministerial Order determining the main management visions of water resources in the main hydrographic basins in Rwanda	2013
37/ 16.09	30/07/2013	Ministerial Instructions relating to the Management and exploitation of used paper	2013
005/03	27/12/2013	Prime Minister's Instructions preventing Air Pollution caused by vehicular emissions and machines using petroleum products in Rwanda	2014
006/ MINIRENA/2015	18/06/2015	Ministerial Order determining the management of protected state forests not managed by Special laws	2015
006/03	30/01/2017	Prime Minister's Order drawing up a list of swamp lands, their characteristics and determining modalities of their use, development and management.	2017
001/ 2019	15/04/2019	Ministerial Order establishing the list of projects that must undergo environmental impact assessment, instructions, requirements, and procedures to conduct environmental impact assessment	2019

Plans and strategies

Over the years the country has developed several strategic plans for sound management of natural resources incorporating changing priorities and emerging issues as highlighted in Table 3-5.

Table 3-5: Rwanda's Strategic Plans (REMA, 2018)

Strategy	Year
National Strategy and Action Plan for the Conservation of Biodiversity in Rwanda	2003
Five-Year Strategic Plan for the Environment and Natural Resource Sector 2009-2013	2009
Environment Sub-Sector Strategic Plan 2010-2015	2010
Rwanda Environmental Education for Sustainable Development Strategy: A Strategy and Action Plan for 2010-2015	2010
The Green Growth and Climate Resilience Strategy (GGCRS) with a vision for Rwanda to be a developed, climate-resilient, and low-carbon economy by 2050	2011
Environment and Climate Change Sub-sector strategic Plan 2013/14- 2017/2018	2012
National Biodiversity Strategy and Action Plan (NBSAP II) (2016-2020)	2016
National Cooling Strategy	2020
National Land Use and Development Master Plan	2020

A delegation from Rwanda attending the 25th Conference of the Parties to the United Nations Framework Convention on Climate Change taking place in Madrid, Spain.

Photo credit: Rwanda Green Fund/Flickr

3.4 Multilateral Environmental Agreements (MEAs)

A multilateral environmental agreement (MEA) is a legally binding agreement between three or more nations which allows them to reach an environmental goal. The agreements, primarily created by the United Nations, cover subjects related to atmosphere, freshwater, hazardous waste and substances, the marine environment, nature conservation, noise, and nuclear safety (UNCCD, 2016). MEAs could be broadly grouped into three clusters - Nature, Climate and Pollution (chemicals and waste) clusters. Some of the MEAs that Rwanda is a member of are listed in Table 3-6.

*Table 3-6: **Rwanda's Multilateral Environmental Agreements (UN, 2021)***

Treaty		Ratification
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora	20 Oct 1980
	United Nations Convention on the Law of the Sea	10 Dec 1982 (Simple signature)
	Convention on Biological Diversity	29 May 1996
	United Nations Framework Convention on Climate Change	18 Apr 1998
	United Nations Convention to Combat Desertification	22 Oct 1998
	Cartagena Protocol on Biosafety	22 Jul 2004
	Montreal Protocol on Substances that deplete the Ozone Layer	11 Oct 2001
	The Vienna Convention for the Protection of the Ozone Layer	11 Oct 2001
	Stockholm Convention on Persistent Organic Pollutants	5 Jun 2002
	Basel Convention on Hazardous waste	7 Jun 2004
	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides	7 Jan 2004
	Kyoto Protocol on climate change	22 Jul 2004
CMS	Convention on Migratory Species	1 Jan 2005
Ramsar	Ramsar Convention on wetlands	1 Apr 2006
	Nagoya Protocol	28 Feb 2011
AEWA	Agreement on the Conservation of African-Eurasian Migratory Waterbirds	1 Sep 2014 (Entry into force)
	Paris Agreement on Climate Change	6 Oct 2016
	Minamata Convention on Mercury	29 Jun 2017
UN environment	Bamako Convention on ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa	4 Dec 2018

Reporting on the MEAs

Each State party is required to report on the status of implementation of the respective MEA to the responsible Secretariat according to an agreed schedule. The reporting requirements and time frame varies depending upon each convention. Rwanda has been regularly reporting its obligations under various international agreements. Rwanda's performance is an indicator of the importance the government assigns to MEAs. REMA is mandated to oversee the implementation of all MEAs. However, the institutions fulfilling the reporting requirements may vary across the conventions. REMA reports on the conventions related to climate, chemicals and waste, wetlands, and biological diversity. The Rwandan Development Board (RDB) is responsible for reporting on CITES and the Ministry of Sports and Culture for the World Heritage Convention.

Recently a research study analysed six conventions - four related to biodiversity and another two related to chemicals and waste clusters- and compared reporting rates for Rwanda, Africa, and the world (Figure 3-2). The study found that Rwanda has complied fully with the reporting obligations for the Ramsar Convention on Wetlands, the Basel convention on transboundary movement of hazardous waste and the World Heritage Convention (Ivanova, Escobar-Pemberthy, & Dubrova, 2019).

Based on this analysis, Rwanda has submitted only one out of the four required reports for the Stockholm Convention on Persistent Organic Pollutants and has not submitted any reports for CITES. Despite this, Rwanda has been actively engaged in cooperation with Uganda, and DRC and established the Greater Virunga Transboundary Collaboration (GVTC) in 2015, which comprises a council of ministers with representatives from each country to promote cooperation and reduce illegal trade in endangered species in the landscape (Ivanova, Escobar-Pemberthy, & Dubrova, 2019).

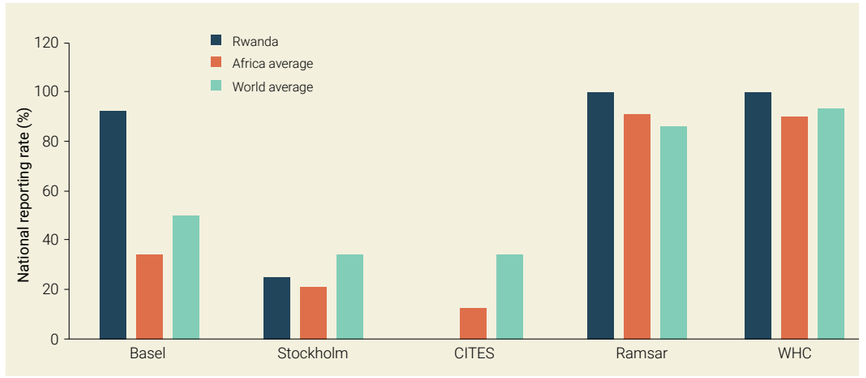


*Figure 3-2: **National Reporting Rates to Global Environmental Conventions (Average 2001-2015) (Ivanova, Escobar-Pemberthy, & Dubrova, 2019)***

*Table 3-7: **Summary findings of best practices and challenges of five conventions implemented in Rwanda (Ivanova, Escobar-Pemberthy, & Dubrova, 2019)***

	Basel	Stockholm	Ramsar	CITES	WHC
Best practices	• Comprehensive legislation, regulatory and institutional framework • International and regional cooperation • Plastic bags ban • E-waste management • Vision 2020 and a set of other environmental policies	• Legislative and regulatory framework • Policy framework • Managing some persistent organic pollutants	• Comprehensive legislation • Cultural and historical sustainable approach to wetlands management • International recognition of conservation efforts • Effective bureaucratic processes and regulations	• Awareness raising • Regional cooperation • National conservation programs • Stakeholder engagement in conservation through poverty reduction programs	• Recognition and interest in heritage sites protection
Challenges	• Reducing volume of hazardous waste • Absence of adequate recycling infrastructure • Information gaps	• Lack of reporting resulting in low public awareness and stakeholder engagement • Lack of data and poor management of pesticides and contaminated sites	• Funding for engaging local communities • Relocating infrastructure • Wetland's protection in the context of climate change	• Inconsistent reporting • Incoherent legislation	• Lack of instruments supporting the Convention • Lack of world heritage sites inscription

Progress toward eliminating lead paint

The elimination of lead exposure at source is the single most effective action to protect people from the harmful effects of lead. Most industrialized countries adopted laws or regulations to control the lead content of residential and decorative paints in the 1970s and 1980s, based on clear findings that lead-contained in household paint is a major source of lead exposure in children. However, the continued use of lead in paint in many parts of the world remains an important source of exposure. To protect human health, laws, regulations, or enforceable standards are needed in every country to stop the manufacture, sale and import of lead-containing paints.

Six countries in Africa have lead paint laws. These are Algeria, Cameroon, Ethiopia, Kenya, South Africa, and Tanzania. Benin, Sierra Leone, and Tunisia are in the process of drafting lead paint laws. Rwanda is in the final stages of approving a regulation to implement an East African Community (EAC) regional standard. Zambia has finalized a voluntary standard limiting lead content to 90 ppm to be incorporated later into a lead paint law.

Climate change

Rwanda has recently updated its first Nationally Determined Contributions (NDCs) that was submitted to the UNFCCC in 2015 to 2020 for mitigation and adaptation up to 2030 The 6th National Report to the Convention on Biological Diversity was submitted in 2020.

The Sustainable Development Goals

Furthermore, **Rwanda** volunteered to conduct and present its **Voluntary National Review** (VNR) report on implementation of the **SDGs** in 2019. The lessons learned included:

- Visionary leadership, effective governance and accountability are critical for achievement of SDGs.
- Home-Grown Solutions rooted in the Rwandan culture are resource-efficient and play a major role in enhancing ownership and accelerating development outcomes.
- A full integration of SDGs in the national planning and monitoring framework is critical for effective implementation (UN, 2019).

3.5 Conclusion and recommendations

In Rwanda, like in many other countries, several government agencies are dealing with the different facets of the environment. The **Ministry of Environment (MoE)** is the nodal Ministry for formulation of relevant policies and laws regulating the protection of the environment. Under the direction of the ministry, **Rwanda Environment Management Authority (REMA)** is to promote and ensure the protection of the environment and sustainable management of natural resources. However, **Rwanda Development Board (RDB)** is tasked to conserve the rich biodiversity of the Protected Areas and to develop a sustainable tourism; **Rwanda Land Management and Use Authority (RLMUA)** is mandated to promote and enforce proper management and use of land; **Rwanda Water Resources Board (RWB)** is implementing policies, laws, strategies research and programmes that improve the quality and productivity of water resources; **Rwanda Forestry Authority (RFA)** is to ensure growth of forest resources, their management and protection for sustainable development purpose. Unfortunately, responsibilities, coordination mechanisms and communication channels among these institutions remain overlapping and difficult to implement. This is particularly the case for RDB and REMA. This confusion leads to wastage of already scarce resources and duplication of efforts (USAID, 2019).

Rwanda's commitments in implementation and reporting under various MEAs offer an excellent example for many countries in Africa and beyond to follow. Rwanda has also provided leadership in global environmental governance being the birthplace of **Kigali Amendment to the Montreal Protocol**. In October 2016, during the 28th Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer in Kigali/Rwanda, more than 170 countries agreed to amend the Protocol targeting at protection of the climate and the ozone layer. The Kigali Amendment aims for the phase-down of hydrofluorocarbons (HFCs) by cutting their production and consumption. Given their zero impact on the depletion of the ozone layer, HFCs are currently used as replacements of hydrochlorofluorocarbons (HCFCs) and chlorofluorocarbons (CFCs), however they are powerful greenhouse gases. With the Kigali Amendment, the Montreal Protocol will be an even more powerful instrument against global warming" (UNIDO, 2021).

References

Bizimana, I. (2018). Final Country Report of the LDN Target Setting Programme in Rwanda. Kigali: Ministry of Lands and Forestry. Retrieved May 6, 2021, from https://knowledge.unccd.int/sites/default/files/ldn_targets/2019-01/Rwanda%20LDN%20TSP%20Country%20Report.pdf

Ivanova, M., Escobar-Pemberthy, N., & Dubrova, A. (2019). National Implementation of Global Environmental Agreements in Rwanda. Center for Governance and Sustainability. Boston: University of Massachusetts. Retrieved June 14, 2021, from https://789c2bcb-2f10-4a1b-9807-566a4b86a576.filesusr.com/ugd/8fed65_af4a19c6a4d4479297a25e9db2867740.pdf

MoE. (2017). Strategic Plan for the Environment and Natural Resources Sector 2018 – 2024. Kigali: Rwanda Ministry of Environment. Retrieved June 7, 2021, from https://www.rwamagana.gov.rw/fileadmin/user_upload/Strategic_plan_for_the_environment_and_natural_resources_sector_2018-2024.pdf

REMA. (2018). Compendium of Environment Statistics, Rwanda, 2018. Kigali: Rwanda Environment Management Authority (REMA). Retrieved February 11, 2021, from https://unstats.un.org/unsd/environment/Compendia/Compendium%20of%20Environment%20Statistics%20of%20Rwanda%202018.pdf

RoR. (2020). Rwanda 6th National Report to the Convention on Biological Diversity. Kigali: Republic of Rwanda (RoR). Retrieved February 6, 2021, from https://www.cbd.int/doc/nr/nr-06/rw-nr-06-en.pdf

UN. (2019). Rwanda. Retrieved June 14, 2021, from Knowledge Platform: https://sustainabledevelopment.un.org/memberstates/rwanda

UN. (2021). Rwanda. Retrieved February 11, 2021, from InforMEA: https://www.informea.org/en/countries/RW/parties

UNCCD. (2016). Glossary. Retrieved June 13, 2021, from Multilateral Environmental Agreements (MEA): https://knowledge.unccd.int/lib-unccd-terminology-and-glossary/lib-unccd-terminology-and-glossary-142

UNEP. (2020). 2020 Update on the Global Status of Legal Limits on Lead in Paint. Kigali: United Nations Environment Programme. Retrieved June 14, 2021, from https://wedocs.unep.org/bitstream/handle/20.500.11822/35105/GS-2020.pdf.sequence=1&isAllowed=y

UNIDO. (2021). The Montreal Protocol Evolves To Fight Climate Change. United Nations Industrial Development Organization (UNIDO). Retrieved June 13, 2021, from https://www.unido.org/sites/default/files/2017-07/UNIDO_leaflet_07_MontrealProtocolEvolves_170126_0.pdf

USAID. (2019). Rwanda Tropical Forests and Biodiversity Analysis. Washington, DC: United States Agency for International Development (USAID). Retrieved June 12, 2021, from https://pdf.usaid.gov/pdf_docs/PA00X8HV.pdf

Chapter 4:

Forests and Biodiversity

A snapshot of part of the Nyungwe Afromontane dense rainforest in Rusizi district, 2019
Photo credit: RDB

4.1 Introduction

Forests cover about 31 percent of the global land area. They are home to most of the terrestrial plant and animal species known to science (FAO, 2020). Communities that live within or directly adjacent to forests rely directly on forest biodiversity for their lives and livelihoods, using products derived from forest resources for food, fodder, shelter, energy, medicine, and income generation. Forests and biodiversity benefits much of humanity through their role in the carbon, water, and nutrient cycles and through links with food production, including seed dispersal and crop pollination. However, globally natural ecosystems are declining at an accelerating rate as huge swathes of natural habitat such as forests, grasslands savannas and wetlands are converted to agriculture and settlements to meet the growing demand for food, animal feed, fiber, and shelter. It also threatens the achievement of the SDGs, including those seeking to protect life on land and under water, eliminate poverty and hunger, and promote climate action and health.

The recent COVID-19 pandemic proves that ecosystem health also plays an important role in the emergence of zoonotic diseases - transmissible between animals and humans. Drastic ecological transformations, including the loss of entire ecosystems and wildlife habitat, have taken place during the 20th century, and along with industrial farming and livestock producing systems, wildlife trade and consumption, certain hunting practices, rising demand for meat consumption and live animal markets, have contributed to increased human-animal contact creating opportunities for pathogens to pass from wild and domestic animals to people (IPBES, 2020). In fact, *zoonoses account for 70 percent of emerging infectious diseases and nearly all known pandemics and there has been a global increase in emerging zoonotic diseases or zoonoses* (IPBES, 2020). Zoonoses are caused by pathogens that become Emerging Infectious Diseases (EIDs) when anthropogenic environmental changes alter the population structure of their reservoir hosts and bring wildlife, livestock, and people into contact, as illustrated in Figure 4-1. These interactions can alter the transmission dynamics of microbes within their hosts, lead to interspecies spread of pathogens, spillover to livestock and people and result in the emergence of novel diseases. Animals host millions of "undiscovered" viruses, some of which have the potential to become EIDs (IPBES, 2020).

Rwanda is endowed with rich biological resources comprised of a great diversity of plants, animals and habitats which make the country unique. The forests in Rwanda have historically played a significant role in the economy and livelihoods of its population. However, these plus the country's other natural ecosystems including, wetlands, rivers, and lakes, together with the biodiversity they host have been degraded by deforestation, encroachment from expansion of agricultural activities, human settlements, grazing, illegal logging, and charcoal production (RoR, 2020b).

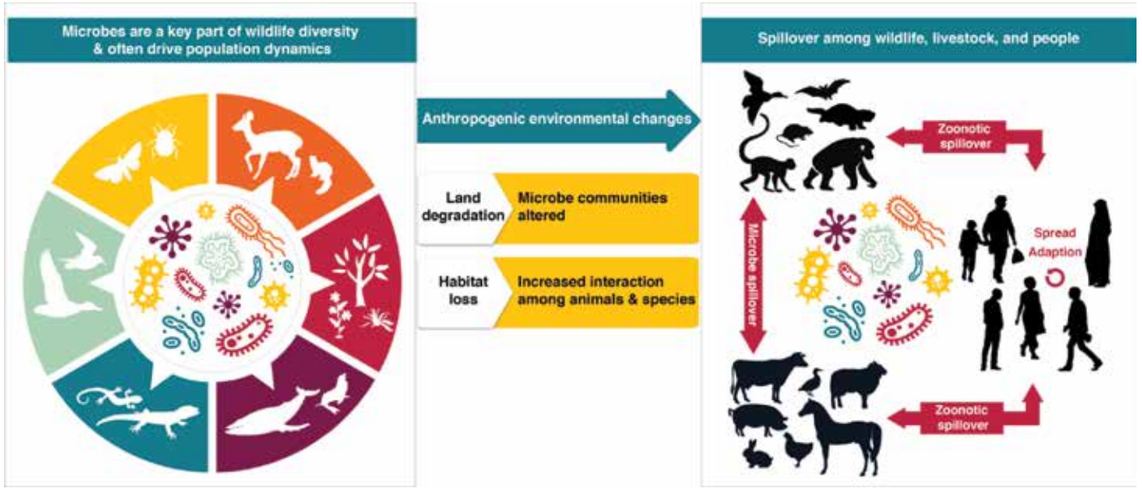


Figure 4-1: The origins and drivers of emerging zoonotic diseases and pandemics (IPBES, 2020).
Note: Microbes (left) become emerging infectious diseases (EIDs) when human changes to the environment bring wildlife, livestock, and people into contact (centre), thus changing the population structure of the species and the pathogens they host. These interactions disturb the dynamics of microbial transmission, leading to the spillover from one species to another, including from wildlife to livestock and people, resulting in the emergence of novel diseases (right).

4.2 Status and trends of forests

The forests in Rwanda have historically played a significant role in the economy and livelihoods of its population. In 2020, the forestry sector contributed 6 percent to the country's GDP and supported agriculture which accounted for 26 percent of GDP (NISR, 2021). In addition, forests provided around 86 percent of the primary energy source mainly as domestic cooking energy; and held the base for the country's tourism opportunities, which in 2020 generated US $121 million (targeted to increase to over US $800 million by 2024). Forested catchments supply a high proportion of the water for domestic, agricultural, industrial, urban, and ecological needs in both upstream and downstream areas (MoE, 2020).

Forest cover

Forest cover has been steadily increasing over the years from 618,000 ha in 2011 to over 725,000 ha in 2019 as shown in Figure 4-2 (MoE, 2019b). Much of this has been through agroforestry on farmlands and other open spaces to reach the target of restoring 2 million ha of degraded or deforested land. Forests now occupy about 30.4 percent of the total land area of which 387,425 ha (53.5 percent) are plantations, 130,850 ha (18.1 percent) are natural mountain rainforests, 161,843 ha (22.3 percent) are wooded savannah, and 43,963 ha (6.1 percent) are shrubs. Bamboo stands occupy only 613 ha (0.1 percent).

About 318,434 (44 percent) ha of Rwanda's forests are very dense, 234,004 ha (32 percent) are moderately dense, 146,222 ha (20 percent) are sparse, and 26,035 ha (4 percent) are quite degraded (MoE, 2019b). Figure 4-3 shows the distribution of forests based upon density or canopy cover. Dense forests are important as they help to retain and recharge the groundwater table, provide green cover and support local biodiversity and clean air.

An analysis by province shows that Eastern Province alone has almost 40 percent of Rwanda's total forests with a total of 274,630 ha. Northern Province contains only 85,688 ha of forest as shown in Figure 4-4.

Nyaruguru with 55 percent (55,759 ha) of its land occupied by forests is the top forested district. It is followed by Rusizi district with 48,255 ha (53 percent), Nyamagabe with 54,018 ha (50 percent) and Nyamasheke districts with 45,935 ha (48 percent percent). Savannah woodland of the East makes Gatsibo and Kayonza districts the most afforested districts with 43 percent (66,985 ha) of Gatsibo and 45 percent (80,545 ha) of Kayonza districts covered by savannah woodland.

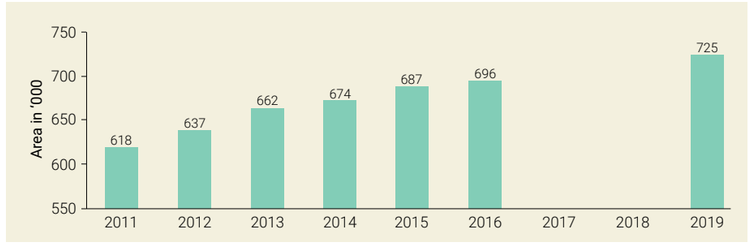


Figure 4-2: Forest cover trend, 2011-2019 (MoE, 2019b)

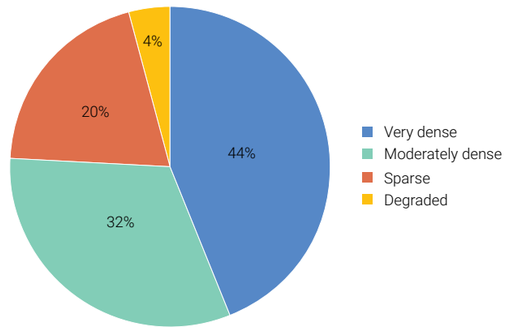


Figure 4-3: Distribution of forest cover density in Rwanda Key: high or very dense >70% canopy cover medium or moderately dense = 40%- 70% cover, low or sparse density = 10%-40% cover and very low or degraded cover <10% canopy cover (MoE, 2019b).

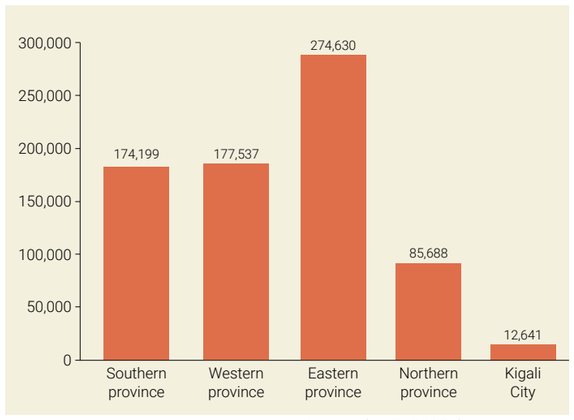


Figure 4-4: Forest area in provinces of Rwanda (MoE, 2019b).

Changes to forest cover

During the 2009-2019 period about 105,713 hectares were deforested (a loss of 15.7 percent). In 2019, however, 139,674 ha of trees were planted increasing forest cover by 20.7. This is equivalent to an afforestation rate of about 5 percent over a 10-year period or 0.5 percent of forest area being added each year (MoE, 2019b). Figure 4-5 and Figure 4-6 show the distribution Rwanda's forest cover in 2019 and changes between 2009 and 2019 (MoE, 2019b).

Forest cover varies across the country with afforestation and deforestation rates proceeding differently. For instance, in the Eastern province the deforestation is over 20 percent and according to the Rwanda Forest Cover Mapping Report of November 2019 by the Ministry of Environment, this is the only province where deforestation exceeds reforestation. The underlying driving forces are social processes, such as agricultural expansion (cultivation and animal husbandry with clear cutting practices of trees native to the savannah) (MoE, 2019b). This data is highlighted in Table 4-1 and Figure 4-7.

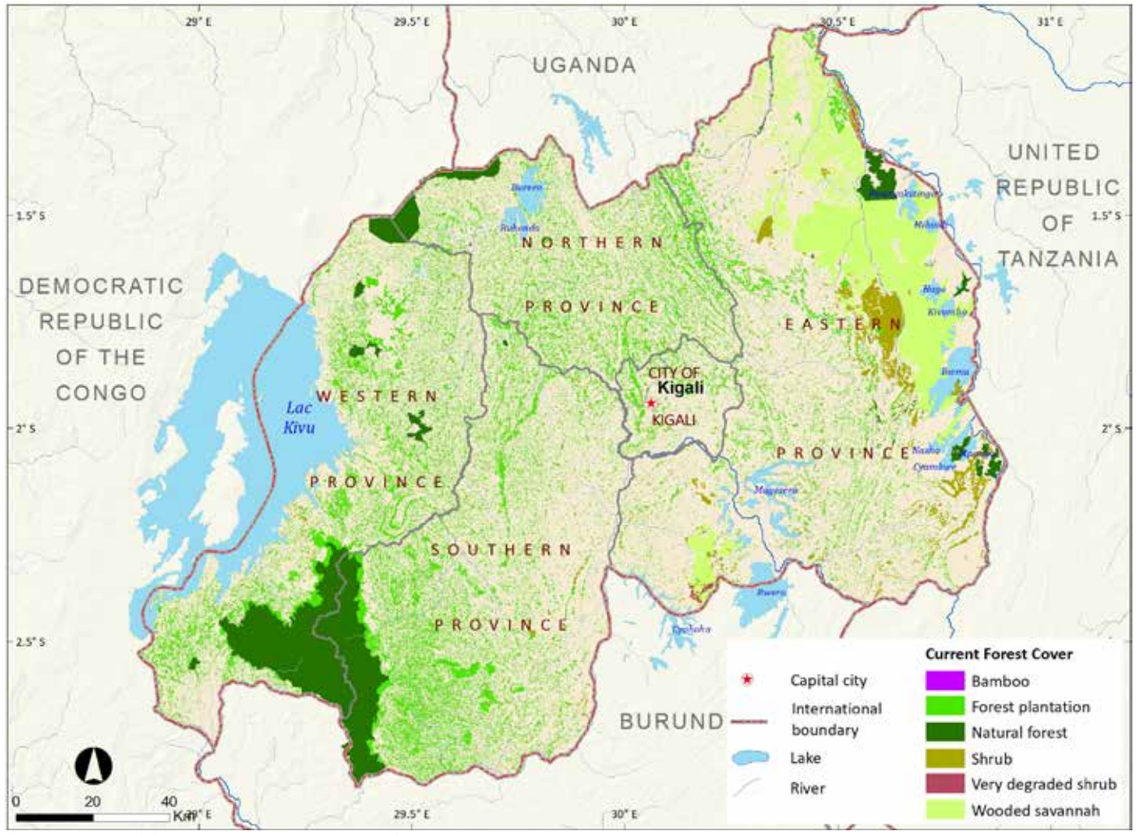


Figure 4-5: Rwanda's forest cover, 2019 (MoE, 2019b)

Nyungwe rainforrest
Photo credit: François Terrier/Flickr

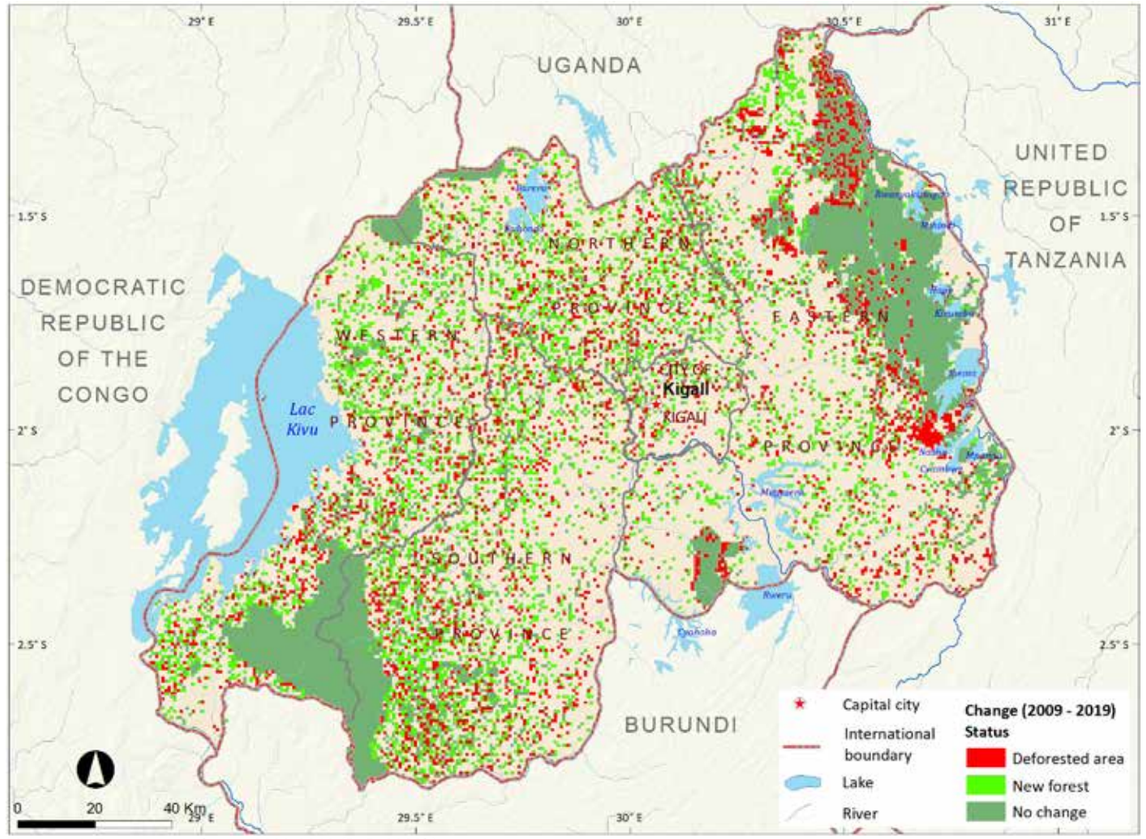


Figure 4-6: Forest cover change 2009-2019 (RoR, 2020b)

Table 4-1: Deforestation and afforestation status by province (MoE, 2019b)

Province	Forest cover (ha)		Deforested area (ha)	Afforested area (ha)	No Change (ha)
	2019*	2009			
Kigali	11,783	11,400	2,626	3,009	8,774
East	271,156	296,234	65,807	40,729	230,427
North	81,691	66,529	5,518	20,679	61,011
South	173,471	153,196	17,205	37,480	135,991
West	169,364	146,145	14,557	37,777	131,588
Total	707,465	673,504	105,713	139,674	567,791

** Plots of less than or equal to 0.25ha are excluded in the 2019 forest statistics to allow for comparison with the forest statistics of 2009.*

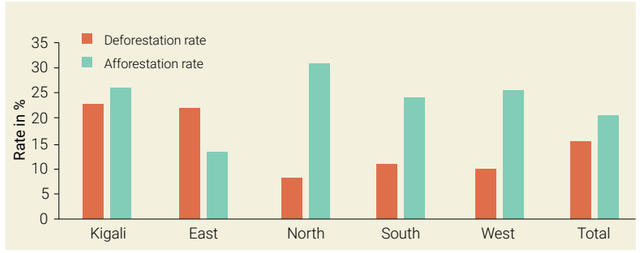


Figure 4-7: Deforestation and afforestation rate (%) by province (MoE, 2019b)

Forest plantations

People have traditionally planted some indigenous tree species including *Ficus thoningii, Euphorbia tirucalli, Erythrina abyssinica, Vernonia amygdalena, Dracaena afromontana* around household compounds.

In recent decades, Rwanda has embarked upon massive tree planting efforts. The major species found in woodlots and plantations include E*ucalyptus grandis, E. saligna, E. globulus, E. camaldulensis, E. tereticornis, E. microcorys, E. maculata,* and *E. maidenii* (MoE, 2019a). However, weak extension services do not allow for effective follow up of planted seedlings resulting in extremely poor survival rates as well as unprofessional management of forest plantations (both public and private) and extremely low forest productivity. The Forestry Strategic Plan 2017-2021 aims to address these issues by boosting forest productivity and ensuring sustainable forest management (RWFA, 2017).

Forest stock

Despite a decline in forest stock between 1990-2000, the decade between 2010 and 2020 registered a slight increase in forest growing stock and carbon stock (Table 4-2).

The most recent National Forest Inventory conducted in 2016 indicated following stockings (Personal communication from RFB 2021):

- 127.48 m^3/ha for public plantation forests.
- 25.72 m^3/ha for district plantation forests
- 17.32 m^3/ha for private individual plantation forests
- 105.99 m^3/ha for private institutional plantation forests.

The low stock could be due to poor management which involves lack of adherence to silvicultural guidelines, early harvesting, poor selection of species and planting material and poor site matching.

Wood supply and demand

Rwanda currently suffers from a severe imbalance between wood supply and demand, with low productivity exacerbating this problem. Although private forests were the biggest supplier of wood in 2015 (Figure 4-8), they seldom deliver their full potential due to poor species-user-site matching, limited management, and premature cutting. Public plantations have a very narrow range of species, low stocking, and stagnated growth due to damage from fire and illegal cutting with a limited management and protection.

An analysis of the wood demand and supply shows that the demand to supply ratio is 2:1 and the shortage is projected to increase unless alternative sources of wood energy are identified. The consumption of fuelwood for Rwandan households is estimated at 2.7 million tonnes per year and charcoal making accounts for about 50 percent of total fuelwood used. The Business-as-Usual scenario on wood supply/demand, estimated the deficit between wood supply and demand to be 4.3 million tonnes (oven dry weight) in 2017, and this is projected to increase to 7.5 million tonnes by 2026. This is due to a high increase demand for firewood and wood for charcoal. The implications are that already low stocked forests will be subject to over-exploitation (RWFA, 2017).

Table 4-2: ***Forest growing stock and carbon (1990-2020) (FAO, 2020)***

Feature	1990	2000	2010	2020
Growing stock (million m^3 over bark)	31.56	29.48	27.86	29.33
Carbon stock in biomass (tonnes/ha)	82.87	84.37	85.84	86.22
Total carbon stock (tonnes/ha)	131.97	133.47	134.94	135.32

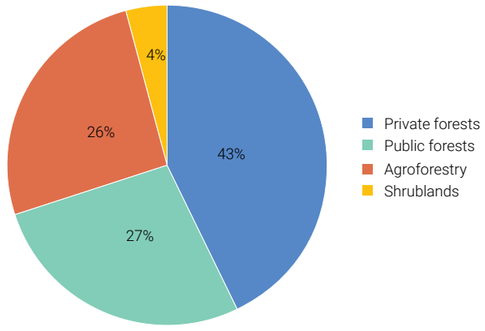


Figure 4-8: ***Source of current wood supply 2015 – WISDOM Report (RWFA, 2017)***

Forest management and restoration

Conservation of Rwanda's primary forest has been key to maximising biodiversity and the provisioning of ecosystem services to the wider populations, locally, nationally and internationally (SIDA, 2019). The status of forest management is given in Table 4-3.

To address these issues, the National Forestry Policy 2018 is being implemented. Currently, the management of public forests is being transferred to private operators for better management. So far, 36 percent of public forest area has been brought under this management system and it is continuing. Small private forests are also being consolidated or grouped into Private Forest Management Units (PFMUs) which are being managed under a simplified forest management plan. To date, 870 ha have been brought under this process and it is ongoing.

There has also been commendable action taken to rehabilitate degraded landscapes within and outside forest areas (as discussed in Chapter 5 on Soil Erosion and Land Degradation Neutrality). Recently Rwanda joined the continent led AFR100 (the African Forest Landscape Restoration Initiative) which aims to restore 100 million hectares of land in Africa by 2030. Since 2011, Rwanda has rehabilitated about 900,000 ha, about 45 percent of the total land to be restored by 2030, meaning it is on target to meet this goal (Sabiiti, 2021). Other drivers of forest degradation such as forest fires are also being addressed as discussed in Box 4-1.

Challenges with forest data

Due to different interpretations and definition of 'forests' there is significant disagreement in area reported by the Food and Agriculture Organization (FAO) and the Government of Rwanda which need to be reconciled (Box 4-2).

Table 4-3: ***Forest area by forest management status (REMA, 2019b)***

Forest management status	Forest aame/ province	Forest area (Ha)	Vegetation characteristics
National parks	Nyungwe NP	111,561	Montane tropical rainforest
	Volcanoes NP	16,000	Montane tropical rainforest
	Akagera NP	113,160	Shrub land/Savannah
	Gishwati-Mukura NP	4,520	Montane tropical rainforest
Forest reserves (107)	e.g., Busoga, Buhanga, Sanza, Iwawa, Rubirizi, Makera, etc.	37,886	Montane tropical rainforest/shrubland /Savannah woodlands
Unprotected shrub land/ savannah & woodlands	Public and Private lands	116,210	Mostly arid species, e.g., *Acacia, combretum* spp.
Public and private plantation forests	West Province	74,905	Mainly *Eucalyptus* spp., *Pinus* spp., *Grevillea robusta*, *Acacia melanoxylon* and *Callitris*
	South Province	109,765	
	East Province	35,986	
	North Province	54,813	
	Kigali city	11,340	

Box 4-1: Forest restoration

Fires are a primary threat to Rwanda's forest especially in Nyungwe Forest. Most fires are caused by local beekeepers who use smoke to calm bees. During dry season, these fires can devastate large parts of the forest. Dense ferns (*Pteridium aquilinum*) are some of the first plants to appear and quickly occupy the burned areas. This prevents other species seedling from growing leaving the burned area useless for decades. To that end, the Wildlife Conservation Service (WCS) and its partners are assisting natural forest regeneration and restoration by removing all ferns within burned areas with the help of the local communities. Since 2004 more than 70 hectares of treated plots have been cleared of ferns to encourage forest regeneration (WCS, 2021).

Box 4-2: Discrepancy in the reported area under forests due to different definitions

The Food and Agriculture Organization of the United Nations (FAO), in its 2020 Global Forest Resource Assessment, defines *forest as Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use* (FAO, 2018).

The Republic of Rwanda, because it has many small woodlots with areas less than 0.5 ha and other trees outside forests, defines forest as *a group of trees 7m tall or higher with a canopy cover that may be less than 10 percent or with trees able to reach these thresholds in situ on land 25m² in area or more* (MoFM, 2010) (MoE, 2019b).

Comparison of FAO's and Rwanda's estimates of forest land area by source (1000 ha), 2011-2019 (FAOSTAT) (RoR, 2020b)

Source	2011	2012	2013	2014	2015	2016	2017	2018	2019
FAO	266	267	268	269	270	272	273	274	275
RoR	618	637	662	674	687	696	n.a.	n.a.	725

Lion (Panthera leo) from Phinda Game Reserve at Akagera National Park: Lions returned to Rwanda from South Africa in 2015
Photo credit: Matthew Poole

4.3 Status and trends of biodiversity

Ecosystem diversity

Rwanda is in the highlands of the Albertine Rift, an important ecological structure in the eastern and central African region, a generally mountainous region heavily dissected by a complex network of rivers, lakes, and wetlands; thus, the name "*the land of a thousand hills*". The highest peak is Karisimbi (4,507m), one of 8 major volcanoes in the Virunga Mountain range. Rwanda's landscapes and natural forests are very rich in biodiversity including numerous endemic species. The diverse ecosystems range from humid montane and planted forests to savannahs, water resources and wetlands. The country has the largest mountain rainforests in Africa, which are home to closed-canopy forests, bamboo thickets and open flower-filled marshes.

Species diversity

Rwanda is home to 402 mammal species (about 40 percent of Africa's mammalian species); 1,061 bird species, 293 reptile and amphibian species and 5,793 higher plant species (REMA, 2019b). Mountain gorillas (*Gorilla beringei beringei*) generate important tourism revenue and are found in only two other countries – Uganda and the DRC. The Chimpanzee (*Pan troglodyte*), another critically endangered species, has about 500 individuals. There are many other primates including endemic species that have made Rwanda a primatologist's paradise (RoR, 2020b).

Endangered Species and IUCN Red Link index

The Red List Index (RLI) shows trends in overall extinction risk for species and is used by governments to track their progress towards targets for reducing biodiversity loss. The RLI index for Rwanda remained stable to 0.88 between 1993-2020 (UNEP, 2020).

Genetic diversity

Genetic material is any material of plant, animal, microbial, bacteria or other origin used for research or product development. To know and understand the diversity present in the country, an inventory of plant, animal and aquatic genetic resources must be carried out. The latest stock taking exercise was taken in 2016 by the FAO (FAO, 2016). In Rwanda, there is a rich history of traditional knowledge related to medicinal plants, agriculture, animal husbandry, food storage, natural resource management, ecological systems, and wildlife. Most of this knowledge is oral and passed from generation to generation usually within families.

There is a growing worldwide market for 'nature based' products including cosmetics, medicines, and pesticides. Microbes, plants, and animal parts may provide the genetic resources that could be commercialized for this purpose. Scientific research along with traditional community knowledge underpin the information required to support this process. REMA has a conducted national inventory of traditional knowledge which includes biodiversity knowledge

Herd of African elephants (Loxodonta sp), Akagera National Park, Rwanda
Photo credit: RDB

and has developed an excellent guideline and a toolkit for accessing and sharing of traditional knowledge associated with genetic resources for providers, users, and regulatory institutions (REMA, 2019a). In addition, Rwanda is part of the East African Bioeconomy initiative which is working to innovatively utilize the genetic resources for commercial ventures.

The National Gene Bank of Rwanda is carrying out *ex situ* conservation for orthodox seeds including maize, wheat, rice, and beans. *Ex situ* conservation in the form of field gene banks is also ongoing for vegetatively propagated plants, non-orthodox seed producing plants and plants that require a long-life cycle to generate breeding or planting materials. In future, Rwanda National Gene bank will collect and conserve beneficial microbial genetic resources (mushroom mycelium, rhizobia), conserve small stock animal genetic resources (goats, pigs, chicken, sheep), and conserve forestry genetic resources starting with endangered species. The gene bank will continue to enrich its existing plant genetic resources accessions through collection and conservation of different plant genetic resources (RAB, 2021).

Recent work in this field has led to the discovery of new species. For instance, communication from Professor Beth Kaplin, University of Rwanda, 2021 indicated discovery of a new insect species – the Caddis fly (Family: Pisuliidae, Order: Trichoptera and Class: Insecta) in Nyungwe National Park by Leonce Ngirinshuti in 2018.

Protected areas, national parks and biosphere reserves

Rwanda has nine Protected Areas covering a land area of 232,000 ha, about 9.11 percent of the country (UNEP-WCMC 2021) (Figure 4-9). The land use balance sheet 2050, in the proposed National Land Use and Development Master Plan 2020-2050, has set 37.7 percent of the country's surface to be set aside for conservation purposes. This is expected to meet the global set targets of 27 percent as stipulated by the SDGs (RoR, 2020a).

Three of the protected areas are transboundary. These are the Greater Virunga landscape bordering Rwanda, Uganda, DRC (1,500,000 ha), Kagera Trans Frontier Conservation Area shared by Rwanda, Tanzania, and Uganda (25,000 ha), and Nyungwe-Kibira between Rwanda and Burundi (117,100 ha).

UNESCO Biosphere Reserves in Rwanda

There are two UNESCO Biosphere reserves in Rwanda. The Volcans Biosphere Reserve, in the northwest on the border between Rwanda, DRC and Uganda, was designated in 1983. It is composed of five volcanoes namely Kalisimbi, Muhabura, Bisoke, Sabyinyo and Gahinga. The Volcans Biosphere Reserve is part of the Albertine Rift, an especially important ecological structure in the region of eastern and central Africa. It has a surface area of 160,000 ha covered by rainforest and bamboo. It is home to 30 percent of the global population of mountain gorillas (*Gorilla beringei beringei*). It has 115 mammal species, 187 bird species, 27 reptile and amphibian species, and 33 arthropod species. It has 13 orchid species protected by CITES, and 3 endangered reptile species. It has also 245 plant species, 17 of which are threatened as per IUCN Red List.

The Gishwati-Mukura Landscape Biosphere Reserve was designed as biosphere reserve in 2020. The Gishwati Forest was first established as a forest Reserve in 1933. In 2016, Rwanda gazetted this area as the fourth national park called Gishwati-Mukura. It consists of Gishwati Forest Reserve (1,570 ha) and the Mukura Forest Reserve (1,988 ha). The Gishwati-Mukura Landscape is in the Albertine Rift in the western part of Rwanda. This young national park is a global biodiversity hotspot, and home to a variety of endemic and endangered species including two primate species: the Eastern Chimpanzee (*Pan troglodytes schweinfurthi*) and the Golden monkey (*Cercopithecus (mitis) kandti*). Other species such as the Side-striped Jackal (*Canis adustus*), a variety of bats, and small mammals also claim this forest as their home. The vegetation on the reserve includes three species of bryophytes (*Porella abyssinica, Leptoscyphus ecxpansus* and *Cololejeunea parva*) that occur exclusively in the Gishwati Forest.

There are 337,782 people in the local community in the Gishwati-Mukura Landscape Biosphere Reserve area. The main economic activities include agriculture through sustainable land management activities, silvopastoralism, agroforestry and tourism. About 10 percent of all revenue generated from tourism in the National Park in the Biosphere Reserve's core area is allocated to community development projects. (UNESCO, 2020). Box 4-3 highlights the transformation in this national park.

The Convention on Biological Diversity (CBD)

Rwanda has been a contracting party of the Convention on Biological Diversity (CBD) since 1996 and has collected and reported standardized data and information within the national reporting obligations. Rwanda developed its first National Biodiversity Strategy and Action Plan (NBSAP) in 2003. The first National Biodiversity Strategy and Action Plan was revised in 2016 and aligned to the CBD Strategic Plan for Biodiversity (2011-2020) and it's Aichi Biodiversity Targets (ABTs). The sixth National Report in 2020 was prepared in a participatory manner involving consultations with stakeholders. It reported on measures undertaken from 2011 when the CBD Global Strategic Plan for Biodiversity was adopted (RoR, 2020b). Key highlights are presented in Box 4-4. The Biodiversity Policy 2011 and Biodiversity Law

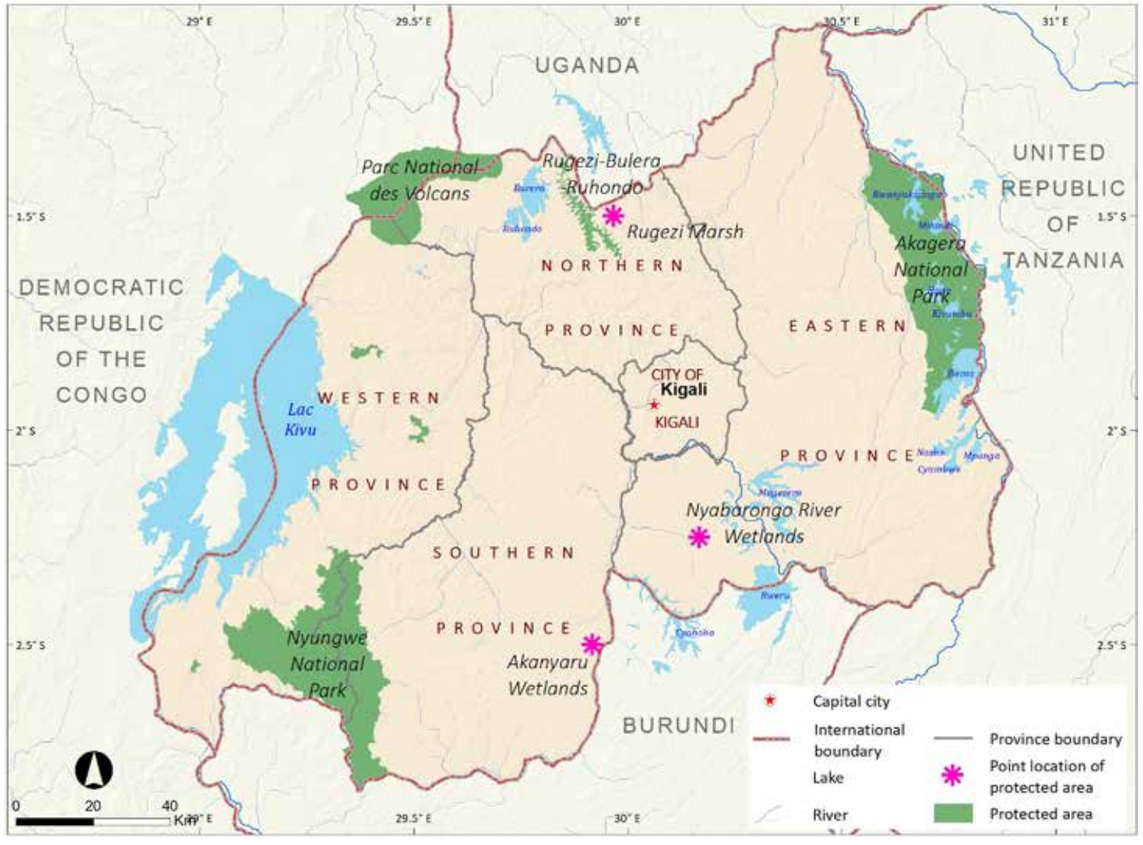


Figure 4-9: Protected areas of Rwanda (not to the scale) (created from shapefiles from UNEP-WCMC and IUCN 2021)

Box 4-3. Transforming a degraded forest to a biosphere reserve (REMA, 2021)

Finding a tree in the rangelands around the Gishwati-Mukura National Park a few decades ago was not that easy. In 2015, the Government launched the Landscape Approach to Forests Restoration and Conservation (LAFREC) Project. It is being implemented by REMA and supported by development partners including the World Bank through the Global Environment Facility. The project aimed to demonstrate the viability of a landscape management approach in enhancing environmental services and climate resilience in one priority landscape of Gishwati and Mukura. It resulted in visible improvement in the restoration of the highly degraded Gishwati-Mukura landscape, enhancing both productive and environmental values. The introduction of silvopastoralism was one of the approaches used to improve livelihoods around Gishwati-Mukura National Park. Silvopasture is a tree-based livestock production system, where trees, shrubs and other vegetation planted on pasturelands provide fodder as well as other multiple benefits. The change in landscape in Gishwati reserve between 2006 and 2019 is shown in the satellite images below.

2013 are also part of the legal framework. Rwanda has been a party to the Cartagena Protocol on Biosafety since 2004, the Nagoya Protocol on Access and Benefit-Sharing since 2014 and is a non-party to the Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress.

The Cartagena Protocol on Biosafety (CPB) implementation

This was adopted in Montreal, Canada in May 2000 and signed by Rwanda in 2002. The Protocol, among others, spells out guidelines for the transboundary movement of genetically modified organisms resulting from modern biotechnology that may have effects on the conservation and sustainable use of biological resources, and the adoption of the appropriate procedure for Advance Informed Agreement (AIA). To fulfill Rwanda's commitments under the CPB the government has formulated a draft Biosafety law. A national strategy for implementation of biosafety framework was prepared in 2020 as referral guidance to further ensure the safe transfer, movement, handling and use of biotechnology in Rwanda (REMA, 2021).

Nagoya Protocol and ABS implementation

Access and benefit-sharing (ABS) which refers to the utilization and access of genetic resources and promotion of equitable benefits between users and providers, is a key element of the Convention on Biological Diversity (CBD). Rwanda has been a Party to the Nagoya Protocol of the Convention on Biodiversity since October 2014 and has made efforts to develop an enabling legal and institutional framework for the implementation of the Protocol. Some of the legal instruments relating to the management of the country's biodiversity include a draft Ministerial Order governing access to genetic resources and the fair and equitable sharing of benefits arising from their use; the Law n°48/2018 of 13/08/2018 on environment, which determines the modalities of protection, conservation, and promotion of the environment; Law No. 70/2013 of 02/09/2013, which governs biodiversity; and Law No. 31/2009 of 26/10/2009, which enforces protection of intellectual property rights. In 2019, REMA and UNDP with University of Rwanda developed "*Guideline and Toolkit for Access and Benefit Sharing of Traditional Knowledge Associated with Genetic Resources in Rwanda*".

Progress towards the Aichi targets

The Aichi Biodiversity Targets for protecting and conserving natural systems was agreed upon in 2010. It had 20 targets and by 2020 when it expired most of its targets were not met, globally. In Rwanda (Table 4-4) out of the 19 national targets identified in the country's revised NBSAP (2016-2020), only 1 was on track to exceed the target; 12 were on track and 6 showed progresses, but at an insufficient rate (RoR, 2020b).

Box 4-4: Highlights of Rwanda's Sixth National Biodiversity Report (RoR, 2020b)

- The population of large mammals (elephants, giraffes, buffaloes) has declined significantly due to poaching pressure and loss of habitat.
- The black rhino which had been extinct in Rwanda, has been reintroduced. A reintroduction programme since 2016 has resulted in the 21 animals being brought in since 2016 (16 in 2016 and 5 in 2018). One of the rhinos is reported to have calved while one of the translocated rhinos died. Lions are also being restocked into the Akagera National Park after a 10-year absence.
- The Mountain Gorilla population has continued to increase and is stable. According to the most recent surveys of its population, it is estimated that there are now at least 1,004 individuals, demonstrated that about 60 percent of the population is likely mature based on a combination of data from known habituated Gorilla groups and population simulations from an agent-based mode (Hickey et al. 2018).
- There has been an increase in the number of primate troops and ungulate populations in Akagera National Park from 1998 to date.
- The protection of grey crown cranes is a success story as they were rescued from captivity in households and hotels and brought back to their natural environment. A sanctuary was created for them in Umusambi village, a restored wetland. So far 242 cranes have been removed from captivity, of which 166 have been reintroduced to the Akagera National Park (RWCA, 2021).
- Programmes are in place to promote in-situ and ex-situ conservation of plants and animal varieties. Guidelines on Access and Benefit-sharing (ABS) have been formulated.

Table 4-4: Relation between Rwanda's national targets and Aichi biodiversity targets (CBD, 2020) (RoR, 2020b)

Reference	Target	Related Strategic Goals/Aichi Targets	Status (CHM, 2020)
Target 1	By 2020, at the latest, Rwandan people are aware of the values of biodiversity and ecosystems services as well as apprehend the steps for use and conserve them sustainably.	1	On track to achieve target
Target 2	By 2020, the values of biodiversity and ecosystems' services have been integrated into planning processes, poverty reduction strategy and into national economy.	2	On track to achieve target
Target 3	By 2020, at the latest, positive incentives for biodiversity conservation and sustainability towards local communities' development are boosted and applied. Harmful incentives are eliminated.	3	On track to achieve target
Target 4	By 2020, public and private sectors and civil society have promoted and implemented plans that consider ecosystem carrying capacity.	4	On track to achieve target
Target 5	By 2020, natural ecosystems, especially identified "Alliance for Zero Extinction (AZE)" sites are safeguarded, their degradation and fragmentation reduced.	5	On track to achieve target
Target 6	By 2020, fishing and aquaculture, agriculture and forestry are managed sustainably, legally and taking into consideration ecosystem specificities to ensure biodiversity conservation.	6, 7	On track to achieve target
Target 7	By 2020, environmental pollutants including those from excess nutrients are controlled and their harm has been brought to levels that are not detrimental to ecosystem function and biodiversity.	8	Progress towards target but at an insufficient rate
Target 8	By 2020, invasive alien species, their pathways, spatial distribution are identified. Harmful species are controlled or eradicated and related mitigation measures are put in place.	9	Progress towards target but at an insufficient rate
Target 9	By 2020, at least 10,3 percent of land area is protected to maintain biological diversity.	11	On track to achieve target
Target 10	By 2020, the extinction of threatened species is prevented, and their conservation status improved, particularly for those that are most endangered of extinction.	12	On track to achieve target
Target 11	By 2020, the genetic diversity of local animal breeds and landraces as well as their wild relatives are conserved, thus in order minimizing genetic erosion.	13	On track to achieve target
Target 12	By 2020, the potential risks resulting from biotechnology use and placement on the market of its products have been minimized and/or eliminated.		Progress towards target but at an insufficient rate
Target 13	By 2020, all ecosystems that provide essential services to human well-being and contribute to health as well as livelihoods are restored and safeguarded, considering the needs of local communities especially the vulnerable groups.	14	On track to achieve target
Target 14	By 2020, 30 percent of the country is covered by forests hence increasing carbon stocks and contributing to climate change mitigation and adaptation.	15	On track to achieve target
Target 15	By 2017, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is integrated into national legislation and administrative practices and enforced.	16	On track to achieve target
Target 16	By 2016, Rwanda has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan (NBSAP).	17	On track to achieve target
Target 17	By 2020, values of traditional knowledge, cultural heritage and practices of local communities relevant for sustainable use and conservation of biodiversity are enhanced, fully integrated into national policy and legal framework and reflected in the implementation of the NBSAP.	18	Progress towards target but at an insufficient rate
Target 18	By 2020, knowledge in biodiversity status, values, causes and consequences of biodiversity loss, is enhanced, shared across the country and reflected in the implementation of the NBSAP.	19	Progress towards target but at an insufficient rate
Target 19	By 2020, at the latest, the mobilization of financial resources for an effective implementation of NBSAP from all potential sources, and in accordance with agreed process in the strategy for resource mobilization, is reinforced and reach an appreciable level.	20	Progress towards target but at an insufficient rate

4.4 Drivers, pressures, and impact

The most important threats to forests and biodiversity in Rwanda includes:

- High population density, poverty, and few income generating alternatives to reduce pressure on ecosystems
- Low levels of alternative skills among the local people limit their source of livelihoods to subsistence agriculture and exploitation of natural resources.
- Inadequate capacity for biodiversity and ecosystem management planning and implementation at national and local levels
- Climate change especially due to variations in the precipitation patterns, and invasive species such as *Eichhornia crassipes*; the most harmful invasive alien species in Rwanda (10 flowering plant species, 5 fish species and 5 insect species) have significant impacts on biodiversity and ecosystems functions.

A system diagram showing the drivers, pressures and impacts is captured in Figure 4-10.

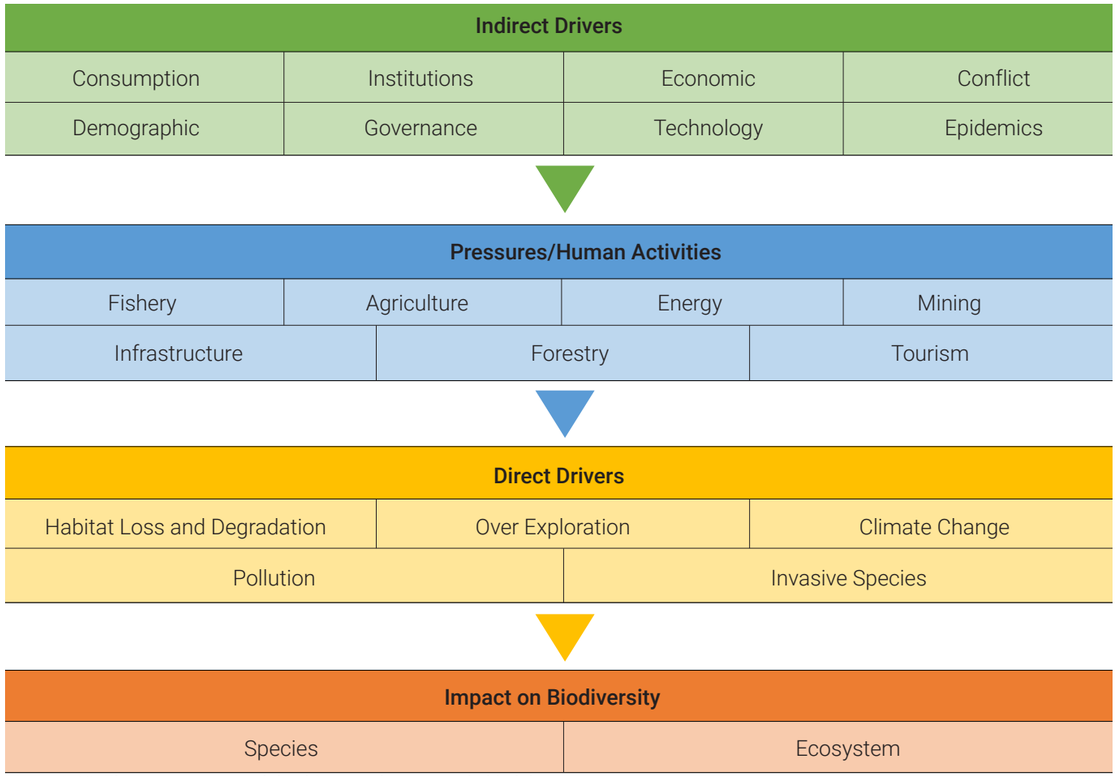


Figure 4-10: Threats to nature and the drivers and pressures behind them

4.5 Responses

Policy and legal framework

A National Forest Policy was implemented in 2004, revised in 2010 and then most recently in 2018. The revised National Forest Policy is in line with national and international development framework, and it addresses all aspects of cross-cutting issues that appear in conventions, treaties, and the regional and international programmes which the Government of Rwanda has committed to. It defines the government's medium to long-term intentions for the development and management of the national forest resources in the following seven policy statements:

1. The capacity of forest institutions and actors will be enhanced to match the requirements for Sustainable Forest Management (SFM).
2. Ensure SFM through the establishment and implementation of integrated forest management plans at all levels.
3. Private sector will be encouraged to increase their investment in forestry sector.
4. Appropriate regulatory instruments will be developed and implemented to ensure sustainable and efficient biomass supply.
5. Biodiversity and ecosystems services and values will be enhanced in accordance with the national and international agenda.
6. Active participation of stakeholders in SFM to ensure ownership and proper benefit sharing.
7. The adoption of Agroforestry and Trees Outside Forest techniques will be enhanced to contribute to overall forest resources and agriculture productivity (MINILAF, 2018c).

Rwanda has also developed several sectoral plans (RWFA, 2018) that guide the implementation of the forestry sector such as:

- Forestry Sector Strategic Plan (FSSP) (MINILAF, 2018a)
- National Tree Seed Strategy (NTSS) (MINILAF, 2018b)
- Forest Investment Plan (FIP) (MoF, 2017)
- National Forest Research Strategy
- National Agroforestry Strategy (2018)
- National Tree Reproductive Materials Strategy (2018)

Institutional framework

The mandate for management and development of forests outside national parks belongs to the Rwanda Forestry Authority (RFA) established by the Law No 72/2019 of 29/01/2020. RFA has the mandate to ensure growth of forest resources, their management and protection for sustainable development purpose. Table 4-5 highlights the main government entities that are responsible for forest and biodiversity conservation.

Rwanda Biodiversity Information System (RBIS)

The RBIS of the Center of Excellence in Biodiversity and Natural Resource Management (CoEB) which was developed in partnership with the Ministry of the Environment and REMA is the first national biodiversity information system for Rwanda that reports on ecosystem health using biodiversity data. As of September 2021, the system had more than 30,000 entries: 31,542 Avian records; 831 records for adult Odonates, 622 amphibian records; 556 invertebrate records and 2,367 records of fish (RBIS, 2021). This data is open and accessible to researchers, NGOs, government institutions and stakeholders and helps to understand patterns of biodiversity distribution, ecosystem functioning and early detection of environmental change in Rwanda.

Table 4-5: Key government institutions related to forest and biodiversity conservation (USAID, 2019)

Institution	Mission
Ministry of Environment (MoE)	Formulation of relevant policies and laws regulating the protection of the environment
Rwanda Environment Management Authority (REMA)	To promote and ensure the protection of the environment and sustainable management of natural resources
Rwanda Development Board (RDB)	To conserve the rich biodiversity of the Protected Areas and to develop a sustainable tourism
Rwanda Forestry Authority (RFA)	To ensure growth of forest resources, their management and protection for sustainable development purpose.
Rwanda Land Management and Use Authority (RLMUA)	To promote and enforce proper management and use of land in Rwanda
Center of Excellence in Biodiversity and Natural Resource Management (CoEB)	To enhance the knowledge of biodiversity and natural resource management for sustainable development

Lessons learned

While the country has made a commendable progress in increasing the forest cover to 30 percent of its total land area, there is need to look at the quality and not just the quantity of the forest resources in terms of their usability. This will ensure that forests provide for the needs of the country and its people. Rwanda is still facing a severe imbalance between wood supply and demand due to a very low productivity. Privately planted trees, though comprising a greater proportion of the forests in the country (68 percent) seldom deliver their full potential due to poor species-user-site matching, limited management, and premature cutting. Public plantations have a very narrow range of species, low stocking, and stagnated growth due to damage from fire and illegal cutting with limited active management and protection (RWFA, 2018). The Strategic Plan for Environment and Natural Resources Management Sector (2018-2024) highlights and recommends the need to improve silvicultural practices especially among the small-scale plantation farmers. This would lead to increased productivity of better-quality wood. There is also a need to diversify the type of species grown which is currently dominated by Eucalyptus. There is also a need to strengthen the monitoring and evaluation function in the various institutions implementing biodiversity programs. The second Bonn Challenge Barometer report notes that although Forest Landscape Restoration (FLR) projects were implemented in eight key biodiversity areas, "*the exact information for the type or amount of restoration taking place in these areas of conservation importance is not yet available*" (Dave, et al., 2019).

4.6. Conclusion and recommendations

Rwanda is endowed with various ecosystems ranging from montane rainforests in the west to the lowland forests, woodlands, and grasslands towards the east but also rich network of aquatic ecosystems. Agroecosystems take a big part of the country and can greatly contribute to biodiversity and ecosystem services if well managed. Ecosystems under park management status are well maintained but others are more degraded thus losing their ecological functions which are critical for Rwandan's well-being and economy. REMA and partners have had initiatives to mainstream biodiversity in agriculture, which contributes to habitat connectivity, an important consideration in the post-2020 Biodiversity Framework.

Rwanda's development agenda recognizes the important and central role that biodiversity and natural resources play in terms of supporting the economy and livelihoods as well as in the provision of critical ecosystem services such as water, soil erosion, flood control as well as climate change mitigation and adaptation. In this regard, conservation of the environment and natural resources has been well integrated in country's development blueprints including Vision 2020, EDPRS II, Vision 2050, and the National Strategy for Transformation (NST1 2018-2024). As the country works to build back better from the COVID-19 pandemic, it should be reinforced that deforestation and forest fragmentation often results in greater contact between humans, livestock, and wildlife, which in turn increases the risks of zoonotic diseases.

It is thus recommended as follows:

1. A major target set by the government of 30 percent area under forest cover to be achieved by year 2020, has been already achieved, however, in order to reduce pressure on forests Rwanda needs to promote alternative sources of energy for cooking and modern fuel cooking technologies to reduce the consumption of biomass energy for domestic purposes which is still estimated to be around 86 percent.

2. The Post-2020 Global Biodiversity Framework (GBF) currently under negotiations will contribute to the implementation of the 2030 Agenda for Sustainable Development. At the same time, progress towards the Sustainable Development Goals will help to provide the conditions necessary to implement the framework. Rwanda could provide leadership to the Africa group in respect to following priority agenda:

- Loss in revenue for nature action may be bridged in Africa via the Post-2020 GBF by:

- Setting a time-bound, achievable financing target.

- Setting up dedicated funds for channeling international biodiversity finance (like the GCF for Climate action) with an annual contribution target; and

- Mainstreaming relevant biodiversity targets into international development aid and cooperation.

- A new global agreement for cooperative global and national action to catch and punish serious wildlife criminals.

References

CBD. (2020, September 13). Rwanda National Targets. Retrieved February 2, 2021, from National Targets: https://www.cbd.int/countries/targets/?country=rw

CHM. (2020, October 15). Rwanda. (Convention on Biological Diversity (CDB)) Retrieved February 6, 2021, from Clearing House Mechanism: https://chm.cbd.int/database?hostGovernments_ss=rw

Dave, R., Satint-Laurent, C., Murray, L., Antunes Daldegan, G., Brouwer, R., de Mattos Scaramuzza, C., . . . Pearson, T. (2019). Second Bonn Challenge progress report: application of the Barometer in 2018. IUCN. doi:https://doi.org/10.2305/IUCN.CH.2019.06.en

FAO. (2016). The State of Rwanda's Biodiversity for Food and Agriculture. Rome: Food and Agriculture Organization of the United Nations. Retrieved May 28, 2021, from http://www.fao.org/3/CA3463EN/ca3463en.pdf

FAO. (2018). Global Forest Resources Assessment 2020 - Terms & Definitions. Rome: Food and Agriculture Organization of the United Nations (FAO). Retrieved February 23, 2021, from http://www.fao.org/3/I8661EN/i8661en.pdf

FAO. (2020). Global Forest Resources Assessment 2020 - Report - Rwanda. Rome: Food and Agriculture Organization (FAO) of the United Nations. Retrieved February 5, 2021, from http://www.fao.org/3/ca9878fr/ca9878fr.pdf

IPBES. (2020). IPBES Workshop on Biodiversity and Pandemics. Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). Retrieved February 17, 2020, from Intergovernmental Platform on Biodiversity and Ecosystem Services: https://ipbes.net/sites/default/files/2020-10/20201028%20IPBES%20Pandemics%20Workshop%20Report%20Plain%20Text%20Final_0.pdf

IUCN. (2021). Summary Statistics. (International Union for Conservation of Nature and Natural Resources (IUCN)) Retrieved May 27, 2021, from The IUCN Red List of Threatened Species. Version 2021-1: https://www.iucnredlist.org/statistics

IUCN; ESARO. (2020). The state of protected and conserved areas in Eastern and Southern Africa. State of Protected and Conserved Areas Report Series No. 1, Nairobi. doi: https://doi.org/10.2305/IUCN.CH.2020.15.en

MINILAF. (2018a). Forest Sector Strategic Plan 2018 – 2022. Kigali: Rwanda Ministry of Lands and Forests (MINILAF). Retrieved February 5, 2021, from http://rwfa.rw/fileadmin/user_upload/Forest_Sector_Strategic_Plan_2018_-_2022__Final.pdf

MINILAF. (2018b). National Tree Reproductive Materials Strategy 2018-2024. Kigali: Rwanda Ministry of Lands and Forests (MINILAF). Retrieved February 5, 2021, from http://extwprlegs1.fao.org/docs/pdf/rwa180223.pdf

MINILAF. (2018c). Rwanda National Forestry Policy 2018. Kigali: Rwanda Ministry of Lands and Forests (MINILAF). Retrieved February 5, 2021, from http://rwfa.rw/fileadmin/user_upload/Rwanda_National_Forestry_Policy_2018.pdf

MoE. (2018). Forestry Research Strategy and Guidelines for Rwanda (2018-2024). Kigali: Rwanda Ministry of Environment (MoE). Retrieved February 5, 2021, from https://www.iucn.org/sites/dev/files/content/documents/forestry_research_strategy_and_guidelines_for_rwanda_2018-2024.pdf

MoE, (2019a). Forestry Research Strategy and Guidelines for Rwanda (2018-2024). Ministry of Environment (MoE). https://www.iucn.org/sites/dev/files/content/documents/forestry_research_strategy_and_guidelines_for_rwanda_2018-2024.pdf

MoE. (2019b). Rwanda Forest Cover Mapping. Kigali: Republic of Rwanda (RoR), Ministry of Environment (MoE). Retrieved March 26, 2021, from https://www.environment.gov.rw/fileadmin/user_upload/Moe/Publications/Reports/Forest_cover_report_2019.pdf

MoE. (2020). Forestry Resources Management for Economic Growth. Retrieved June 1, 2021, from Mandate: https://www.environment.gov.rw/mandate/forestry-resources-management-for-economic-growth

MoF. (2017). FIP Investment Plan for Rwanda. Kigali: Rwanda Ministry of Finance (MoF). Retrieved February 5, 2021, from https://www.climateinvestmentfunds.org/sites/default/files/meeting-documents/fip_presentation_rwanda_dec_13_final.pdf

MoFM. (2010). National Forest Policy. Kigali: Republic of Rwanda (RoR), Ministry of Forestry and Mines (MoFM). Retrieved March 28, 2021, from https://www.muhanga.gov.rw/fileadmin/user_upload/National_Forestry_Policy_2011.pdf

Ngirinshuti, L. (2020) Description of a new species in the family Pisuliidae (Trichoptera, Insecta) in Nyungwe National Park, Rwanda. https://coebiodiversity.ur.ac.rw/?q=content/description-new-species-family-pisuliidae-trichoptera-insecta-nyungwe-national-park-rwanda

NISR. (2021). Statistical Yearbook 2020. National Institute of Statistics of Rwanda. https://www.statistics.gov.rw/publication/statistical-yearbook-2020

Pilling, D. (2020, November 30). Gorillas with a twist: on a COVID era safari in Rwanda. Financial Times. Retrieved February 5, 2021, from https://www.ft.com/content/f30c5436-e680-49d7-b58c-7c89d10d9fd4

RAB. (2021). National Gene Bank. Retrieved May 29, 2021, from Rwanda Agriculture and Animal Resources Development Board: http://rab.gov.rw/index.php?id=204

RBIS. (2021). Biodiversity Information System. (Rwanda Biodiversity Information System (RBIS)) Retrieved September 9, 2021, from Biodiversity Information System: https://rbis.ur.ac.rw

REMA. (2019a). Guideline and Toolkit for Access and Benefit Sharing of Traditional Knowledge Associated with Genetic Resources in Rwanda: Information for Providers, Users, and Regulatory Institute. Kigali: Rwanda Environment Management Authority (REMA). Retrieved May 28, 2021, from https://www.rw.undp.org/content/dam/rwanda/docs/Publications/Final%20Guideline%20&%20Toolkit%20for%20Access%20and%20Benefit%20Sharing%20of%20aTK%20in%20Rwanda%20FINAL.pdf

REMA. (2019b). Rwanda Compendium of Environment Statistics 2018. Kigali: Rwanda Envirnment Authority (REMA). Retrieved May 27, 2021, from https://unstats.un.org/unsd/environment/Compendia/Compendium%20of%20Environment%20Statistics%20of%20Rwanda%202018.pdf

REMA. (2021). Restoring Gishwati-Mukura Landscape: Improving livelihoods while Promoting Tourism. (REMA:Rwanda Environment Management Authority) Retrieved December 2021, from https://rema.gov.rw/index.php?id=77&tx_news_pi1%5Bnews%5D=42&tx_news_pi1%5Bday%5D=8&tx_news_pi1%5Bmonth%5D=1&tx_news_pi1%5Byear%5D=2019&cHash=2828d-78d6144ebf7a6689cfec462e54f

RoR. (2020a). National Land Use & Development Master Plan NLUDMP 2020-2050. Kigali: Republic of Rwanda (RoR). Retrieved February 8, 2021, from https://rlma.rw/fileadmin/user_upload/National_Land-Use_Development_Master_Plan.pdf

RoR. (2020b). Rwanda 6th National Report to the Convention on Biological Diversity. Kigali: Republic of Rwanda (RoR). Retrieved February 6, 2021, from https://www.cbd.int/doc/nr/nr-06/rw-nr-06-en.pdf

RWCA. (2021). 242 Grey Crowned Cranes rescued from captivity. https://www.rwandawildlife.org/saving-endangered-grey-crowned-cranes/

RWFA. (2017). Forest Investment Program for Rwanda. Kigali: Rwanda Water and Forestry Authority. Retrieved May 22, 2021, from https://www.climateinvestmentfunds.org/sites/cif_enc/files/fip_final_rwanda.pdf

RWFA. (2018). Overview. Kigali: Rwanda Water and Forestry Authority (RWFA). Retrieved February 3, 2021, from http://www.rwfa.rw/index.php?id=35

Sabiiti, D. (2021, May 28). Rwanda Shares Forest Restoration Story To Rest Of Africa. KT Press. Retrieved June 1, 2021, from https://www.ktpress.rw/2021/05/rwanda-shares-forest-restoration-story-to-rest-of-africa/

SIDA. (2019). Rwanda Environment and Climate Change Analysis– 2019-06-05. Swedish International Development Cooperation Agency (SIDA). Retrieved February 3, 2021, from https://sidaenvironmenthelpdesk.se/digitalAssets/1748/1748556_environment-and-climate-change-analysis-rwanda-2019-06-05.pdf

UNEP. (2020). Sustainable Development Goals scorecard. Nairobi: United Nations Environment Programme (UNEP). Retrieved May 22, 2021, from https://wesr.unep.org/sdg/scorecard/

UNEP-WCMC and IUCN (2021), Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-based Conservation Measures (WD-OECM) [Online], December 2021, Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net

UNESCO. (2020, November). Gishwati-Mukura Landscape Biosphere Reserve, Rwanda. Retrieved May 25, 2021, from Biosphere Reserves in Africa: https://en.unesco.org/biosphere/africa/gishwati-mukura-landscape

UNESCO. (2020, June 23). Safeguarding the Endangered Mountain Gorilla during COVID-19 Crisis. UNESCO News & Events. Retrieved February 5, 2021, from https://whc.unesco.org/en/news/2125

UNGA. (2020). Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. New York: United Nations General Assembly (UNGA). Retrieved November 1, 2020, from https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%20 2020%20review_Eng.pdf

UNStats. (2021, February 5). Rwanda. (United Nations Statistics) Retrieved October 29, 2020, from SDG Country Profile: https://country-profiles.unstatshub.org/rwa

USAID. (2019). Rwanda Tropical Forests and Biodiversity Analysis. Washington, DC: United States Agency for International Development (USAID). Retrieved May 22, 2021, from http://pdf.usaid.gov/pdf_docs/PA00X8HV.pdf

WCS. (2021). Forest Restoration. Wildlife Conservation Service (WCS). Retrieved April 2, 2021, from https://rwanda.wcs.org/initiatives/forest-restoration.aspx

The hills roll on in Nyungwe National Park
Photo credit: travelmag.com/Flickr

Chapter 5:

Soil Erosion and Land Degradation Neutrality

Terraces and tree nurseries, Green Project Gicumbi, 2020
Photo credit: FONERWA

5.1 Introduction

Soil provides ecosystem services critical for life. It acts as a water filter, a medium for plant growth and provides habitat for billions of organisms contributing to biodiversity. Humans use soil as a holding facility for solid waste, a filter for wastewater and foundation for cities and towns. Soil is the basis of agroecosystems which then provide food, fibre, and fuel. A sustainable soil resource is the foundation of environmental health, with soil offering a multitude of ecosystem services including climate mitigation and adaptation, biodiversity, agriculture (food security) and nutrient cycling.

Over the years the concept of soil degradation and its assessment has been developed as part of more holistic assessments of human-induced degradation carried out by FAO, UNEP, and other UN agencies. In the wake of the UN Sustainable Development Goals (SDGs), soil erosion has been considered an integral part of the broader land degradation process identified in the Land Degradation Neutrality (LDN) framework. The United Nations Convention to Combat Desertification (UNCCD) defines Land Degradation Neutrality (LDN) as "a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems" (UNCCD, 2021a).

LDN targets have synergies with the SDGs Sustainable Development Goal (SDG) target 15.3 which states: "By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world." The objectives of LDN are:

- Maintain or improve the sustainable delivery of ecosystem services.
- Maintain or improve productivity to enhance food security.
- Increase resilience of the land and populations dependent on the land.
- Seek synergies with other social, economic, and environmental objectives; and
- Reinforce responsible and inclusive governance of land.

Actions to achieve LDN include land management approaches that avoid or reduce degradation, coupled with efforts to reverse degradation through restoration or rehabilitation of land that has lost productivity. The response hierarchy of Avoid > Reduce > Reverse land degradation articulates the priorities in planning LDN interventions. The implementation of LDN is managed at the landscape scale, considering all land units of each land type and their interactions and ecological trajectories, so that LDN interventions can be optimized among those land units, to maintain or exceed no net loss, per land type (UNCCD, 2021a).

Rwanda is party to the United Nations Convention to Combat Desertification (UNCCD) to address land degradation causes which can occur on any land types. Rwanda has developed and adopted several policies, legal instruments that can support and contribute to the Land Degradation Neutrality (LDN). The Government is also substantially investing its domestic resources in agriculture and activities related to sustainable land management (SLM) (Bizimana, 2018).

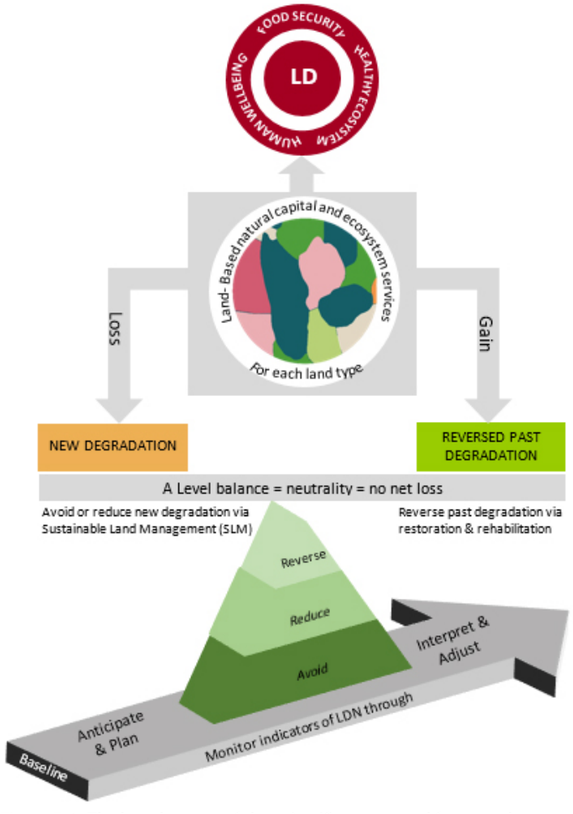


Figure 5-1: The key elements of the scientific conceptual framework for LDN and their interrelationships (Orr, et al., 2017)

5.2 The status of soil erosion in Rwanda

Rwanda has experienced accelerated soil erosion because of unsustainable human activities and changes in land use. The main factors affecting the amount of soil eroded include land use and vegetation cover, topography, soil, and climate. Around 90 percent of Rwandan territory lies on slopes with the consequent risk of soil loss, erosion and decreasing fertility. From a recent survey based on 25,144 plots countrywide, it was shown that 88 percent of the plots were subject to low degree of soil erosion (splash erosion or wind erosion), followed by moderate (diffuse overland flow erosion) and severe soil loss (rill erosion, gully erosion, or mass movement of soils and landslides). This is highlighted in Figure 5-2. Huge portions of the soils in the country are exhausted due to incessant farming, soil degradation and soil erosion to the extent that even the low use of fertilizers cannot compensate for the loss of nutrients caused by soil loss or overexploitation (SIDA, 2019).

A survey carried out by the Catchment Restoration and Erosion Control Division of the Rwanda Water Resources Board (RWB) found that about 46 percent of the country's areas was exposed to some form of soil erosion risk (Figure 5-2) (RWB Personal communication 2021). The area exposed to soil erosion by district is given in Table 5-1. The two highest risk-affected districts in terms of percent area to total area of the district are Ngororero and Muhanga (Figure 5-3).

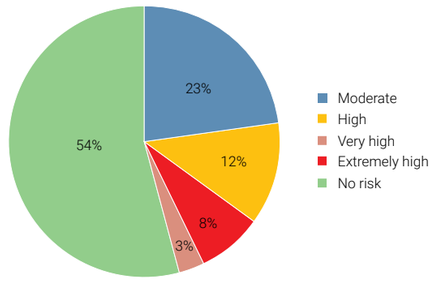


Figure 5-2: Distribution of percent of Rwanda's land area exposed to soil erosion according to risk levels (Source: RWB, 2021)

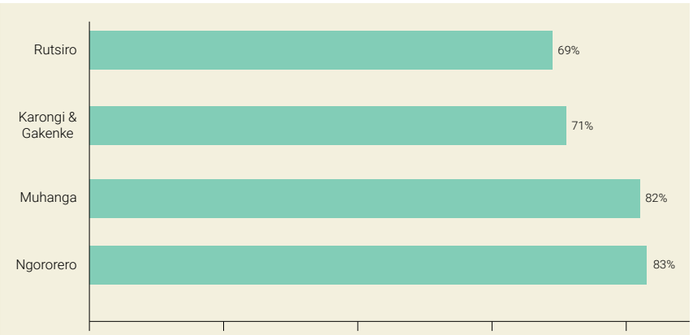


Figure 5-3: Most risk affected districts in terms of percent area to total area of the district (Source: RWB, 2021)

Erosion ravines in the vicinity of Kigeme refugee camp, Nyamagabe
Photo credit: Rugege D./EPI

Table 5-1: Areas exposed to soil erosion per district (Source, RWB, 2021)

District name	District administrative area (ha)	Soil Erosion Risk					
		Moderate (ha)	High (ha)	Very high (ha)	Extremely high (ha)	Grand Total (ha)	Percent
Ngororero	67,899	14,985	17,278	15,912	8,260	56,435	83
Muhanga	64,772	12,911	17,743	15,515	7,255	53,424	82
Karongi	79,298	21,941	17,897	11,175	5,454	56,467	71
Gakenke	70,325	15,001	16,012	13,078	5,612	49,703	71
Rutsiro	65,995	10,466	11,130	15,912	8,067	45,575	69
Rulindo	56,699	15,334	12,104	8,528	2,294	38,260	67
Kamonyi	65,553	24,971	9,920	7,003	2,195	44,089	67
Ruhango	62,678	26,911	9,743	3,796	1,225	41,675	66
Huye	58,153	21,354	9,053	4,796	2,165	37,368	64
Nyaruguru	101,027	24,315	16,670	14,195	6,971	62,151	62
Nyamagabe	109,036	23,375	19,398	17,862	6,192	66,827	61
Nyanza	67,215	25,066	9,791	4,336	891	40,084	60
Nyarugenge	13,395	3,125	2,995	1,309	311	7,740	58
Burera	58,856	10,592	11,414	8,406	3,210	33,622	57
Gisagara	67,920	24,230	11,048	3,137	353	38,768	57
Nyabihu	52,958	10,779	9,195	6,824	2,334	29,132	55
Gicumbi	82,721	24,327	9,978	3,717	600	38,622	47
Kayonza	135,105	38,626	15,552	7,285	828	62,291	46
Kirehe	115,507	33,555	14,185	4,634	341	52,715	46
Gasabo	42,777	10,928	5,133	2,268	911	19,240	45
Kicukiro	16,671	3,452	1,875	1,125	235	6,687	40
Nyamasheke	94,802	15,707	8,466	5,820	3,645	33,638	35
Musanze	50,717	8,915	4,468	3,423	1,161	17,967	35
Rubavu	34,090	5,342	2,467	2,402	1,683	11,894	35
Bugesera	122,187	32,277	4,687	616	179	37,759	31
Ngoma	81,258	17,657	4,766	799	85	23,307	29
Rwamagana	65,490	9,650	1,642	291	21	11,604	18
Rusizi	91,731	9,790	4,168	1,715	200	15,873	17
Gatsibo	127,786	15,819	1,588	252	53	17,712	14
Nyagatare	174,795	11,053	2,663	323	133	14,172	8
Total	**2,297,416**	**522,452**	**283,029**	**186,454**	**72,864**	**1,064,799**	**46**

Soil erosion control

Erosion control practices are required in unprotected areas or where the existing erosion control techniques are judged inadequate regarding the type of risks found and existing land use. For instance, contour bank terraces are recommended in high-risk agricultural lands and contour banks in the forested area without ditches. Bench terraces are recommended in areas at high to extremely high risk. Grassed waterways are recommended for existing terraces which were made without waterways or with but no grasses which can cause severe gullies and destruction of bench terraces created. No-till agriculture is recommended for perennial crops on the extremely high-risk area while storm-water management facilities (SWMF) or water harvesting infrastructure is recommended in built-up areas. Bamboos are recommended to close gullies or for riverside buffers. Forests are recommended in extremely high-risk areas as shown in Figure 5-4 and Figure 5-5 (MoE, 2020).

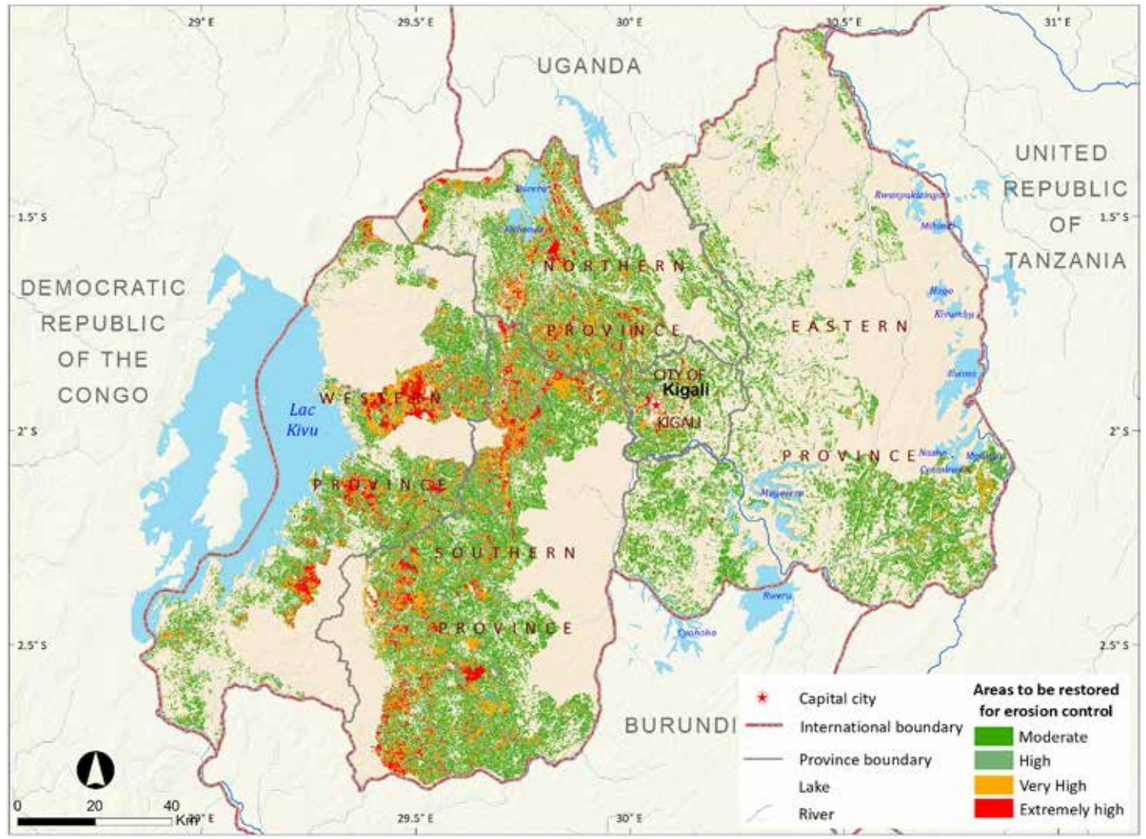


Figure 5-4: Areas to be restored for erosion control (Source: RWB, 2021)

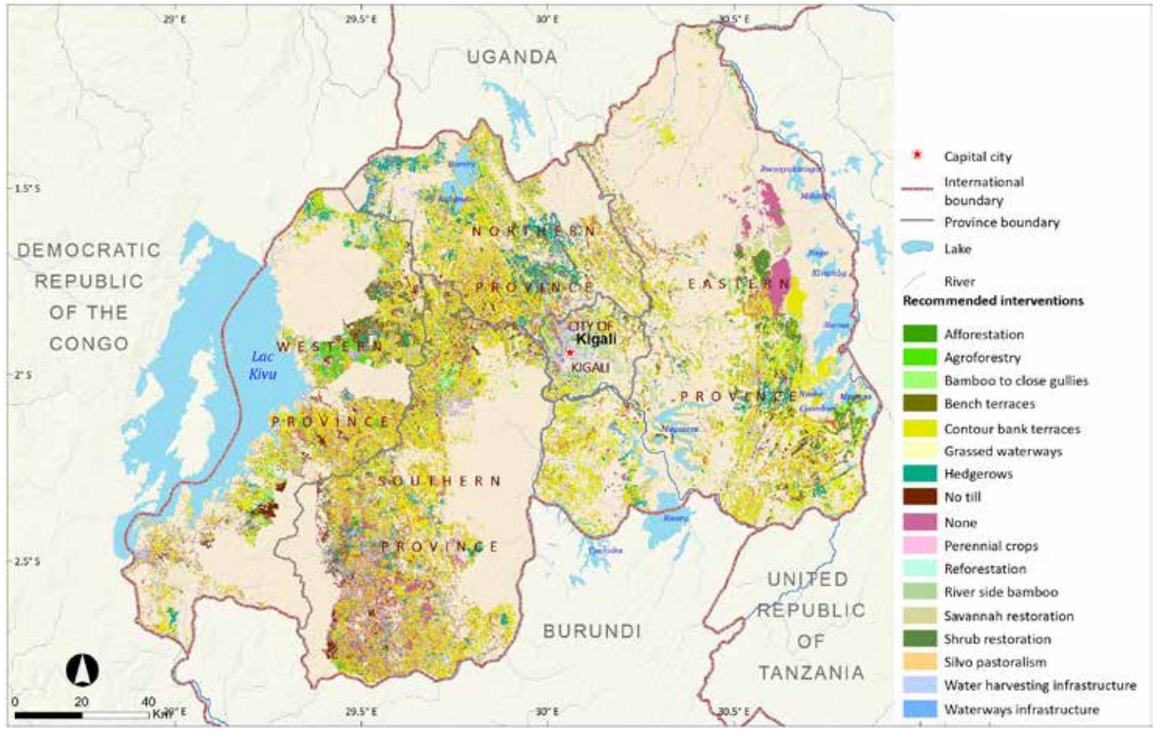


Figure 5-5: Recommended interventions for erosion control in Rwanda (Source: RWBA, 2021)

5.3 Land degradation neutrality (LDN)

The Government of Rwanda launched the Land Degradation Neutrality Target Setting Programme (LDN TSP) in 2017 engaging the leadership and stakeholders to identify and leverage opportunities.

LDN Indicators

The extent of land degradation for reporting on SDG Indicator 15.3.1 (Proportion of land that is degraded over total land area) is calculated as a binary - degraded/not degraded - quantification using its three sub-indicators which are:

- Trends in land cover (LC).
- Trends in land productivity (LPD), and
- Trends in carbon stocks (above and below ground), currently represented by soil organic carbon (SOC) stocks.

They represent a minimum set that could be enhanced and complemented by national or sub-national level indicators for a more accurate picture of land degradation. They are computed primarily, and to the largest extent possible, using comparable and standardized national data sources but since there are no continuous, standardized and validated national datasets, global data sources were used to complement and to validate national LDN baseline (UNCCD, 2021b).

An analysis of data for the country, presented in Table 5-2 shows the average net annual changes of LC between 2000 and 2015, LPD and SOC. Significant increases occurred on artificial surfaces which increased by 104.24 sq.km followed by forest cover which gained about 111.84 sq. km while cropland and grassland lost about 28.36 and 175.75 sq. km, respectively (Figure 5-6). On another hand, land productivity decreased in Eastern, Southern and Western provinces and in the City of Kigali. This decline is mainly associated with the conversion of forest to other types of land cover (Bizimana, 2018). The overall 86.67 percent of the land has not reached alarming levels of depleted productivity while 12 percent (declining, moderate, and stressed land productivity) is the land that requires immediate attention to halt the negative trend in land productivity (Figure 5-7). On soil organic carbon, the highest baseline SOC is observed in tree-covered areas with 130 t/ha (Bizimana, 2018) (Figure 5-8).

Table 5-2: Presentation of LDN baseline based on global default data using LDN indicator framework (Bizimana, 2018)

Land Use/ Cover Category	Area (2000) (ha)	Area (2015) (ha)	Net Area Change (2000-2015) (ha)	Net Land Productivity Dynamics (2000-2013) (sq. km)						Soil Organic Carbon (2000) (tonnes/ ha)
				Declining	Moderate Decline	Stressed	Stable	Increasing	No Data	
Tree-covered areas	3,667.51	3,779.35	111.84	52	39	191	1,723	1,448	95	130.5
Grasslands	1,846.47	1,670.72	-175.75	64	44	198	770	549	41	93.9
Croplands	17,383.70	17,355.35	-28.36	585	231	1,211	6,068	9,081	86	102.0
Wetlands	834.57	831.65	-2.91	19	22	74	355	243	94	111.8
Artificial surfaces	30.71	134.95	104.24	12	1	4	10	4	0	100.0
Other land	0.00	0.06	0.06	0	0	0	0	0	0	0.0
Water bodies	1,552.23	1,543.11	-9.12							
SOC Average (ton/ha)										89.7
Total land area (%)				3.14	1.45	7.19	38.29	48.58	1.36	100.00
Total sq.km	25,315	25,315	0	732	337	1,678	8,926	11,325	316	

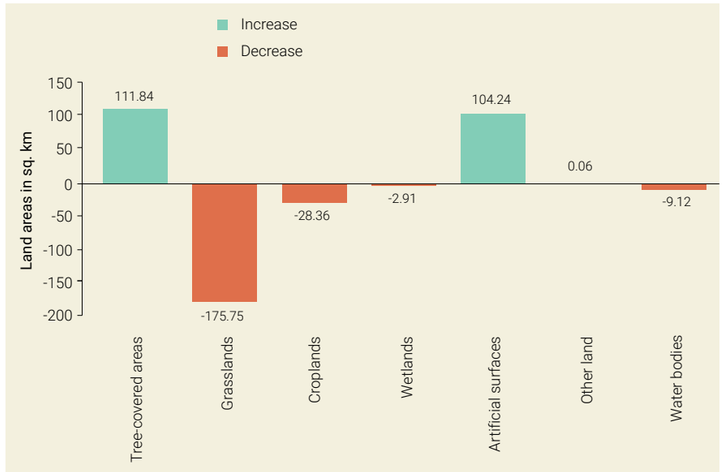


Figure 5-6: Change in land use/cover from year 2000 to 2015 (Bizimana, 2018)

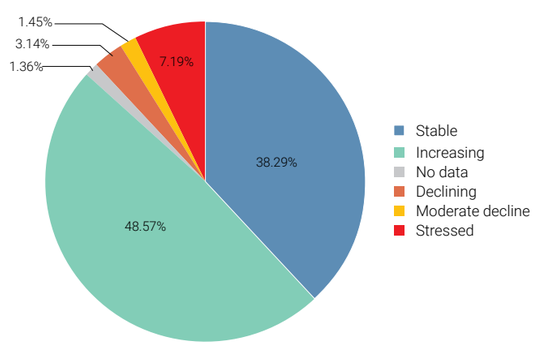


Figure 5-7: Land productivity dynamics (2000-2013) (Bizimana, 2018)

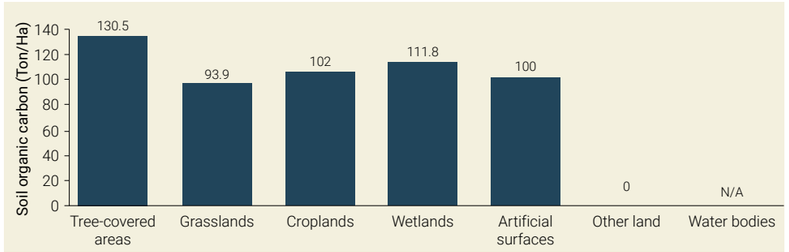


Figure 5-8: Amount of soil organic carbon in different land types (Bizimana, 2018)

Hotspots of Land Degradation

Geographically defined areas exposed to serious land degradation trends are referred to as hotspots. These areas are characterized by various and diverse drivers that lead to negative trends of land degradation. The map in Figure 5-9 represents the degradation areas in Rwanda (Bizimana, 2018).

The proposed measures to be adopted for each hotspot and ecological zone are summarized in Table 5-3.

The Government has set ambitious national voluntary LDN targets at the national scale with an ambition to reach LDN for the entire country to align to the 2030 Agenda for Sustainable Development (SDG target 15.3) considering all LDN indicators.

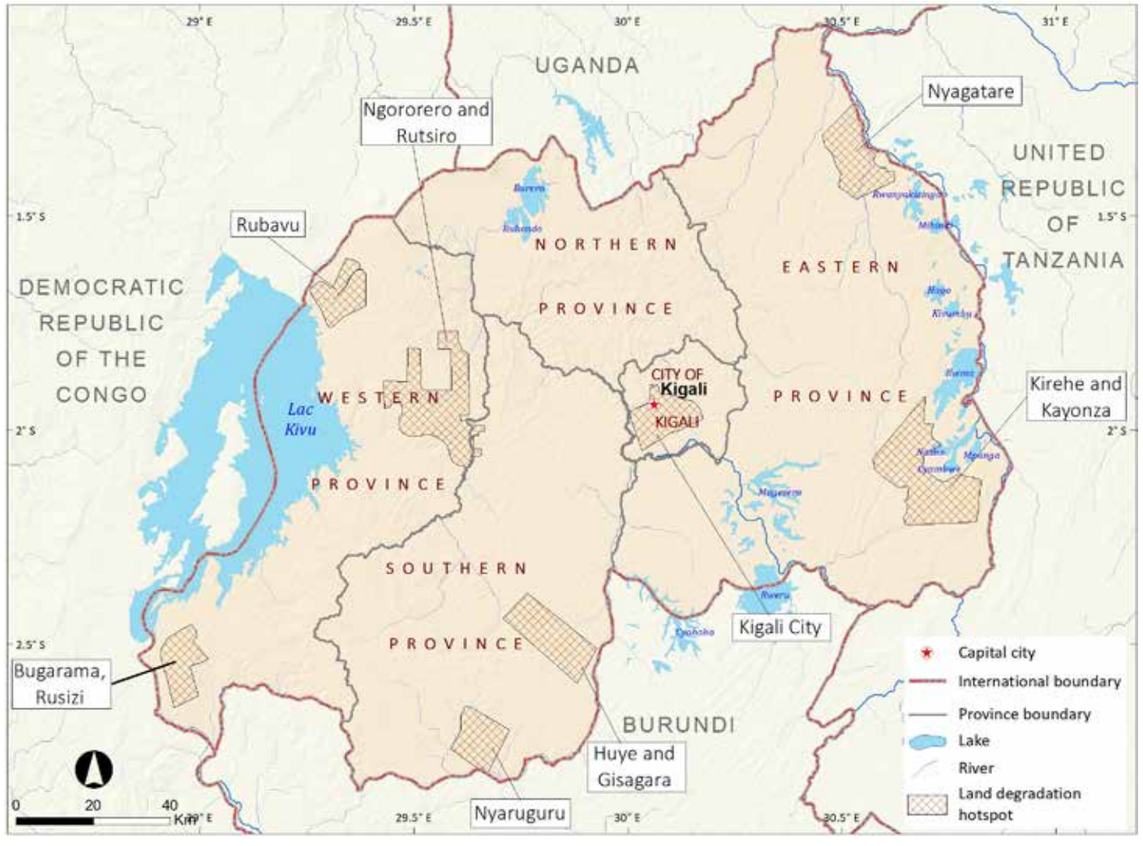


Figure 5-9: Rwanda's land degradation hotspots (Bizimana, 2018)

Table 5-3: Hotspots of land degradation and proposed measures (Bizimana, 2018)

Hotspots	Proposed Measures
Bugarama plain (Rusizi) in Imbo and Impara ecological zone: 14,447 ha	Land restoration through afforestation and erosion control measures.
Kigali City in Central plateau: 16,909 ha	Urban forestry and use of alternative sources of energy for cooking
Ngororero and Rutsiro in Congo-Nile watershed divide: 40,798 ha	Develop soil erosion control measures such as radical and progressive terraces, reforestation and agroforestry
Nyaruguru in Central plateau: 14,082 ha	Increasing trees by afforestation and agroforestry, fruits trees, tree species diversification, Improve organic matter by use of manure and liming, improved agronomic practices
Huye and Gisagara in Mayaga and peripheral Bugesera: 23,646 ha	Reorganization of settlement, rainwater harvesting, agroforestry, inputs (fertilizers), capacity building for land tenure, Agroforestry, improved agronomic practices, use of manure
Nyagatare in Eastern Savannah: 22998 ha	Development and management of improved pasture and promotion of irrigation
Rubavu in lake Kivu border: 12,721 ha	Develop soil erosion control measures including afforestation and agroforestry

Table 5-4: LDN target setting (Bizimana, 2018)

Scale	LDN Targets
At the national scale	• LDN is achieved by 2030 as compared to baseline 2015 (no net loss) • National Forest Cover increased from 29.6 percent (2015) to 30 percent (2024) and maintained at 30 percent by 2030 based on the National Strategy for Transformation and Prosperity (NST1) • Area under agroforestry increased from 6 percent in 2015 to 12 percent in 2030 (in line with the Environment and Natural Resources Sector Strategic Plan (ENR SSP/ NST1 2017-2024) • Level of land productivity and SOC at country level maintained and improved by 2030 compared to 2015 baseline • The percentage of land designated for biodiversity conservation will be increased from 10.13 percent in 2017 to 10.3 percent in 2020 according to ENR SSP. • Biomass energy reduced from 83.3 percent (2014) to 42 percent (2024) • Increase of land protected against soil erosion from 1,034,509 ha in 2018 to 1,495,624 Ha in 2024 according to Strategic Plan for the Transformation of Agriculture.
LDN at the sub-national scale	• LDN is achieved in the Eastern Province: Districts of Nyagatare, Kayonza, Rwamagana, Kirehe and Ngoma by 2030 as compared to 2015 (no net loss) and an additional 7 percent of the province has improved (net gain) • LDN is achieved in the Western Province: Districts of Rubavu, Ngororero, Nyabihu, Rutsiro, and Rusizi by 2030 as compared to 2015 (no net loss) and an additional of 12 percent of the province has improved (net gain) • LDN is achieved in the Southern Province: Districts of Nyaruguru, Huye, Gisagara and Ngoma by 2030 as compared to 2015 (no net loss) and an additional of 6 percent of the province has improved (net gain) • LDN is achieved in the Northern Province by 2030 as compared to 2015 (no net loss) • LDN is achieved in the City of Kigali: Districts of Gasabo, Kicukiro and Nyarugenge by 2030 as compared to 2015 (no net loss) an additional of 23 percent of the province has improved (net gain)
Specific targets to avoid, minimize and reverse land degradation	• Ensure the compliance to the national land use master plans • Reduce the conversion of forests and wetlands into other land cover classes by 2030 (no net loss) • Reduce the conversion of cropland and grassland into artificial surfaces by 2030 (no net loss) • Degraded forests rehabilitated from 4,379 ha in 2017 to 12,379 ha by 2024 • Improve the land productivity on 282 sq.km (28,200 ha) of forest area, 306 sq.km (30,600 ha) of grassland, and 2027 sq.km (202,700 ha) of cropland currently showing declining productivity, moderate decline, and stressed productivity through SLM practices

5.4 Drivers of land degradation

The main direct and indirect drivers contributing to land degradation in Rwanda, which are putting pressure on land resources impacting biomass production including agriculture and forestry, storing, filtering, and transforming nutrients, water sedimentation, biodiversity, carbon pool and physical human activities, are depicted in Table 5-5.

Table 5-5: Main direct and indirect drivers of land degradation (Bizimana, 2018)

Direct Drivers of Land Degradation	Indirect Drivers of Land Degradation
• Improper management of the soil • Low tree cover especially in the Eastern Province • High evapotranspiration in Eastern Province • Improper management of annual, perennial, and tree crops • Deforestation and removal of natural vegetation cover • Over-exploitation of vegetation for domestic use • Overgrazing • Industrial activities, waste deposition and mining and quarrying • Urbanisation and infrastructure development • Disturbance of the water cycle • Natural causes (for instance, Rwandan soils with steep slopes are vulnerable to erosion, landslides, flooding)	• Population pressure • Poverty/wealth • Low level of application of mineral fertilizers. • Low levels of education, limited access to knowledge and support services • Governance, institutional settings, and policies (including taxes, subsidies, incentives) • Compliance with land use and management policies and plans.

5.5 Responses

Institutional and legal framework

Institutions that directly deal with land degradation include the Ministry of Environment (MoE), the Ministry of Agriculture and Animal Resources, the Ministry of Finance and Economic Planning , Ministry of Local Government, Ministry of Infrastructure, Ministry of Disaster Management and Refugee Affairs, Rwanda Environment Management Authority, Rwanda Water Resources Board (RWB), Rwanda Land Management and Use Authority (RLMUA), the National Fund for Environment (FONERWA), Rwanda Meteorology Agency, National Institute of Statistics, Rwanda Development Board, Rwanda Agriculture Board, Rwanda Energy Group, Rwanda Transport Development Agency, Rwanda Housing Authority, research centres and Universities, Rwanda Mines, Petroleum and Gas Board and Decentralized entities (City of Kigali, Districts, Sectors, Cells and villages).

The legal framework that provides enabling conditions for addressing negative trends are well enshrined in the following laws such as the Constitution of the Republic of Rwanda of 2003 revised in 2015, the law N° 48/2018 of 13/08/2018 on Environment, the Law N° 43/2013 of 16/06/2013 Governing land in Rwanda, Law Nº 47/2013 determining the Management and Utilisation of Forests in Rwanda, Law N° 13/2014 Of 20/05/2014 on Mining and Quarry Operations, Ministerial Order N° 005/16.01 of 15/07/2010 determining the List of prohibited plains to constructions, Ministerial Order N° 007/16.01 of 15/07/2010 determining the Length of Land on Shores of Lakes and Rivers transferred to Public Property, Ministerial Order Nº 002/16.01 of 24/05/2013 Determining the Procedure for Declaration, Authorisation and Concession for the Utilisation of Water, the Ministerial Order N° 003/2008 of 15/08/2008 relating to the requirements and procedure for environmental impact assessment and the Ministerial Order No 001/ 2019 of 15/04/2019 establishing the list of projects that must undergo environmental impact assessment, instructions, requirements and procedures to conduct environmental impact assessment.

The LDN targets reflect Rwanda's ambition for achieving LDN considering domestic circumstances and capabilities to apply the LDN response hierarchy (avoid, reduce, and reverse).

Lessons learned from the LDN target setting process

Lessons learned suggest that the only way to establish important drivers of change is to address the following:

- Ensuring efficient implementation and monitoring of land use and urban development plans to achieve SLM and sustainable development.
- Ensure SFM through establishment and implementation of integrated forest management plans at national, district and local level.
- Enhance the use of agroforestry techniques and tree species to contribute to increasing overall forest resource output and agriculture land productivity.
- Maintain and enhance Biodiversity and ecosystems resources and values in accordance with national and international programs and targets to which Rwanda is committed.
- Promote sustainable land husbandry and crop production intensification for increased agricultural productivity and resilience to climate change.
- Encourage private sector actors to wise use of natural resources in Rwanda towards achieving LDN by 2030.

Rwanda has several projects for integrated soil conservation practices including soil erosion control through the establishment of both progressive and bench terraces, establishment of new and monitoring of the existing soil erosion infrastructures and implementation on large hillside irrigation schemes (RAB, 2021). These include the Land Husbandry, Water Harvesting and Hillside Irrigation Project (LWH), Sebeya Landscape Restoration Pilot Program (SLRPP), Muhazi Catchment Rehabilitation Project, Secoko Catchment Rehabilitation Project, Rehabilitation of Giciye-Shyira-Karago-Mugogo-Satinskyi-Ndiza Catchments Project, and the Green Gicumbi Project. The "Land Husbandry, Water Harvesting and Hillside Irrigation Project (LWH) (2010-2018)" is briefly described in Box 5-1.

Box 5-1: Land husbandry, Water harvesting and Hillside irrigation Project (LWH) (2010-2018)

The Land Husbandry, Water harvesting and Hillside irrigation Project (LWH) was initiated in 2009 by the Government through basket funding from various multi-donor organisations and was implemented during the next eight years. The Project was implemented in 15 sites across 13 districts (Nyanza, Gatsibo, Rwamagana, Kayonza, Ngoma, Rulindo, Gicumbi, Rutsiro, Nyabihu, Ngororero, Gakenke, Nyamagabe and Burera) countrywide. The LWH project was a flagship initiative aligned with Rwanda's Ministry of Agriculture and Animal Resources (MINAGRI) and was integral to MINAGRI's strategy under PSTA-III and PSTA-IV and the goal of transforming the rural economy.

The Project aimed at increasing productivity and commercialization of agriculture on the hillside of Rwanda. The primary focus was to reduce at all costs soil erosion while introducing hillside irrigation in the country. During the implementation, LWH project applied a modified watershed approach to introduce comprehensive sustainable land husbandry technologies through hillside transformation by soil erosion control and increasing soil fertility to boost land productivity on some selected sites, as well as develop water retention dams for hillside irrigation.

At the end of the project LWH benefitted more than 280,000 farmers (half of whom were women). The project successfully achieved its two main objectives of increasing both productivity and the commercialization rate. Productivity on irrigated lands (as measured by dollar amount of farm products sold per hectare of farmland) rose from a baseline figure of US$492 in 2009 to US$2,575 by mid-2016. The share of farm products commercialized (as opposed to consumed locally) more than doubled from 35 to 76 percent. To achieve this outcome, the project disseminated improved technologies to farmers that addressed issues such as erosion control, productivity enhancement, and soil fertility. Further, the project irrigated 1,356 hectares of land, protected about 88 percent of hilly land areas against soil erosion, and reduced the volume of sediment yield or soil washed down from hilly slopes during heavy rain in project areas by 89 percent.

LWH also increased access to various formal financial products, such as committed savings accounts, and by mid-2016, the proportion of beneficiaries using formal financial services had increased from a baseline of 20 to 80 percent. The project strengthened farmers' organizations to effectively support farmers in their transition to move to higher value chain activities, helping to form and strengthen 2,624 self-help groups comprised of 15-25 farmer members each.

Finally, the project improved the composition of peoples' diets and thus their nutritional status by carrying out nutrition awareness training and constructing 47,611 kitchen gardens. As a result, by mid-2016, approximately 83 percent of households were consuming an acceptable diet, including food from various food groups.

Lessons Learned

Among the project's lessons learned, flexibility in landscape approaches was important. The project proved that site-specific conditions were critical for determining what type of land husbandry package to apply. The initial model of implementing all three components of land husbandry, water harvesting dams and hillside irrigation did not meet all sites' needs. Flexibility had to be introduced to ensure cost effectiveness and technical soundness. Next, the involvement of local leaders, such as village and Grievance Redress Committee leaders was key to resolving conflicts over plots between neighbours, landowners and the owners of assets on that land and within families over asset ownership or social issues, such as the proper management or use of compensation funds received by some displaced people.

(GAFSP, 2018); (SPIU World Bank, 2021)

Forest landscape restoration: The Bonn Challenge

In addition, Rwanda has number of related forest landscape restoration (FLR) initiatives contributing towards the land degradation neutrality. Activities include afforestation, agroforestry, improved management of public and private forest plantations, terracing, riverbank protection, organic farming buffer zone protection, hillside irrigation, lake shore protection and natural forest protection.

In 2011, Rwanda made an ambitious pledge to the Bonn Challenge to restore 2 million hectares of forest and agricultural land, establishing itself as a global leader in the restoration movement (IUCN, 2019). Rwanda's pledge represents a significant commitment to both its people and environment by recognizing the value of the goods and services provided by landscapes and providing a platform for Rwanda to achieve many of the goals outlined in EDPRS 2 and Vision 2020. The country, in 2019, reached its goal of increasing forest cover to 30 percent of total land area one year ahead of plan despite continuing population and land pressures and is now aiming to fulfil its Bonn Challenge commitment of bringing 2 million ha under restoration by 2030.

A rapid assessment conducted for the 44 FLR projects identified from 2011 to 2018 provides an indicative amount of funds flowing to FLR. This assessment revealed that a total of US$ 530,762,526 was invested in FLR from 2011 to 2018. Public investments represent US$ 274,479,097 (51.71 percent) and projects co-funded by international donors and the government represent a total of US$ 188,555,240 (35.61 percent). International donor support represents US$ 67,490,843 (12.63 percent), whereas the contributions of the private sector and non-profit organisations are still extremely low at US$ 216,680 (0.041 percent) and US$ 20,665 (0.004 percent), respectively as shown in Figure 5-10 (Dave, et al., 2019).

Lessons learned from the Bonn Challenge

Since 2010 Rwanda has succeeded in bringing 708,628 ha under restoration through a total of 44 projects or programs resulting in total cumulative removals of 27,860,228 tCO2 from 2011 to 2018. The findings of the pilot application of the Barometer in Rwanda revealed that:

- It has made much progress in developing policy frameworks that can boost restoration efforts taking into consideration all sectors involved in shaping Rwandan landscapes. However, the coordination and implementation of these policies is sometimes not fully achieved.
- Restoration is happening across the country with the combined effort of various stakeholders. However, proper monitoring capacity needs to be developed to better track restoration progress; and
- Additional efforts to clarify FLR-linked jobs in sectors other than forestry are also required for a more complete picture of the economic impacts of FLR interventions (Dave, et al., 2019).

Tea plantations in the buffer areas of Gishwati
Photo credit: Denis Rugege

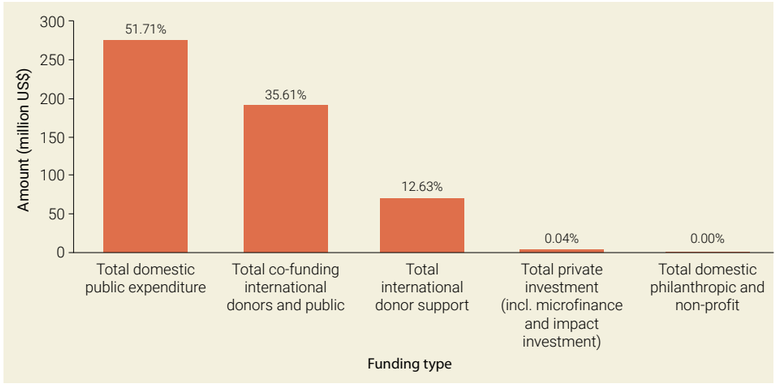


Figure 5-10: Funding streams by type in support of FLR implementation (Dave, et al., 2019)

Box 5-2: Green Amayaga -Forest Landscape Restoration in the Amayaga Region

Landscape restoration of Amayaga in Rwanda's Southern Province, 2018
Photo credit: REMA

Rwanda has launched an ambitious landscape restoration project in cooperation with GEF and UNDP to restore the natural forests of Amayaga in the Southern Province to the benefit of 1.3 million Rwandans. The Green Amayaga Project is a six-year initiative that will promote biodiversity, foster ecosystem services, increase agricultural productivity and reduce the vulnerability of people and ecosystems to the adverse effects of climate change. Overall, the project will advance the restoration of the degraded forests in the area, the landscape of which covers more than 550 hectares, or 0.14 percent of Rwanda's total national natural forests, 10 percent of the planted forest as well as many patches of remnant forest. The Amayaga region hosts the 354-hectare natural forest of Kibirizi-Muyira as well as the Busoga Forest reserves. 1.4 million trees will be planted through the project in the 2020/2021 Forest Planting Season alone. The Green Amayaga project will increase the erosion control and protection of marshlands and buffer zones to foster agriculture productivity. In total, 263,000 hectares of agricultural land will be restored and rehabilitated. Small and large watersheds will also be rehabilitated and restored to provide water for human consumption as well as livestock and agriculture activities.

(REMA, 2020)

5.6 Scenarios for policy assessment

To substantiate a business case for both public and private investment, the Economics of Land Degradation Initiative (ELD) recently used following scenarios for policy assessments for Rwanda (Lal, et al., 2020):

Scenario 1: Only agroforestry expands with fixed forestry land (AGROFOR). This scenario assumes an increase in agroforestry area to a total of 1,110,476 hectares by 2030.

Scenario 2: Cropland consolidation (LANDCON). This scenario of cropland consolidation was implemented such that both food crops area and export crops yield increase. Crop productivity increases by 30 percent in newly consolidated cropland throughout 2019-2024 (IFAD, 2019).

Scenario 3: Both agroforestry and cropland consolidation (COMBI12). This is the combined scenario comprised of Scenario 1 and 2. Here, agroforestry expands to 1,110,476 hectares by 2050, and the cropland consolidates from the current 635,603 hectares to 980,000 hectares by 2024. The interplay of agroforest program along with cropland cover is allowed and can come from conversion of arable land and open grasslands.

Scenario 4: Agriculture-improvement in fertilization and irrigation (FERTIRRIG). This scenario involves increasing the fertilizer use by 134 percent (75 kg/ha) in tandem with a modest increase in irrigable area by 0.6 percent/year through 2035. The plan also estimated that the cost of integrated input use including fertilizers is about USD 450 million and that of use of improved irrigation methods is about USD 450 million over a period of 2018-2024.

Scenario 5: Comprehensive implementation of policies (COMBI). This scenario implements Scenarios 3 and 4 together and examines the interactions of agroforestry and improvements in agricultural productivity in the context of economic development within a sustainable environment.

Based on the results of these models, researchers recommended that the government take measures to begin implementing the COMBI scenario. This scenario has few negative impacts and shows strong improvements in socio-economic and environmental outcomes. However, it should be noted that the scenarios require caution as each province or region have different topographies and ecosystems, which require different adaptive measures to be applied. Secondly, each scenario, has both its environmental, social, economic benefits and costs, as a result policymaker should keenly weigh the trade-offs for the most optimal outcome.

5.7 Conclusion and recommendations

Because soil erosion itself is a symptom of poor land management, erosion control measures alone will remain insufficient to improve the management of land and water resources given the current agricultural land uses and related management. There should be a switch of emphasis to focus on the promotion of a high-quality, integrated soil management system rather than stand-alone erosion control measures in agricultural land. High quality soil management could be achieved through an integrated conservation agriculture approach that provides profitable agricultural yields, while minimising environmental damage. Rainwater harvesting in settlements and storm-water infrastructure in urban areas also have the potential to address accelerated erosion and other problems resulting from rainfall run-off (MoE, 2020). The following are recommended:

1. Rwanda is majorly a mountainous country and has slopes that range from the following: 64.5 percent is between 0 – 30 percent slopes, 22.9 percent is between 30 and 55 percent slopes, and 12.6 percent is above 55 percent: sloped areas suffer from erosion, sedimentation, stormwater runoff, which all leads to a limitation to the use of the sloped hills. Currently, there is a limitation on the construction of slopes above 30 percent. Based on the NLUDMP analytical work, the following is recommended:

   - Slopes of 30 – 50 percent can be used for settlement, ensuring that there are no risks for earthquakes, landslides, and floods.

   - As noted above, ensuring that the bare slope above 55 percent is planted with trees to become part of the forest cover. Where possible, they could be used for perennial/cash crops like upland tea, wheat, pyrethrum, coffee, and other cash crops in those slopes (RoR, 2020a).

2. While significant efforts have been made in promoting sustainable agriculture and especially agroforestry in agricultural landscapes, care should be taken in implementing the NST1 targets regarding increasing area of irrigated land under the Integrated Water Resources Management (IWRM) Framework. The necessary safeguards must therefore be put in place to ensure that agriculture (irrigated and rain fed) is undertaken sustainably (RoR, 2020b).

3. Rwanda's effort towards achieving LDN targets would move the country forward by meeting multiple SDGs. In this regard building upon ongoing successes further actions related to following recommendations are to be implemented (Bizimana, 2018):

   - Afforestation and sustainable forest management

   - Agro-forestry and soil conservation

   - Efficiency in the use of energy and promotion of renewable energy

   - Increase agricultural productivity, sustainability, and resilience of agricultural production

   - Enhanced environmental management and resilience to climate change

   - Role of private sector and community participation

   - Institutional strengthening and capacity building

   - Financial sustainability

References

Bizimana, I. (2018). Final Country Report of the LDN Target Setting Programme in Rwanda. Kigali: Ministry of Lands and Forestry. Retrieved May 6, 2021, from https://knowledge.unccd.int/sites/default/files/ldn_targets/2019-01/Rwanda%20LDN%20TSP%20Country%20Report.pdf

Dave, R., Saint-Laurent, C. M., Antunes Daldegan, G., Brouwer, R., de Mattos Scaramuzza, C., Raes, L., . . . Pearson, T. (2019). Second Bonn Challenge progress report. Application of the Barometer in 2018. Gland. Switzerland: International Union for Conservation of Nature (IUCN). doi:https://doi.org/10.2305/IUCN.CH.2019.06.en

GAFSP. (2018). Land Husbandry, Water Harvesting and Hillside Irrigation Project (LWH). Global Agriculture and Food Security Program (GAFSP). Retrieved May 18, 2021, from https://www.gafspfund.org/projects/land-husbandry-water-harvesting-and-hillside-irrigation-project-lwh

IFAD. (2019). Republic of Rwanda Country Strategic Opportunities Program 2019–2024. International Fund for Agricultural Development (IFAD). Retrieved June 4, 2021, from https://www.gtai.de/resource/blob/45938/fe1c62c39e821a638471d69ef0ee5261/pro201904175029-data.pdf

IUCN. (2019). Barometer of Restoration. International Union for Conservation of Nature (IUCN). Retrieved June 4, 2021, from https://www.iucn.org/theme/forests/projects/barometer-restoration

Lal, P., Masozera, M., Kayitare, A., Banerjee, O., Cicowiez, M., Wolde, B., . . . Oluoch, S. (2020). Achieving Green Growth through Terrestrial Natural Capital Restoration in Rwanda. Bonn: Economics of Land Degradation (ELD) Initiative. Retrieved May 6, 2021, from https://www.eld-initiative.org/fileadmin/Natural_capital/Rwanda_Green_Growth_through_Natural_Capital_Restoration_Report.pdf

MoE. (2020). Erosion Control Mapping Report. Kigali: Ministry of Environment. Retrieved May 6, 2021, from https://waterportal.rwb.rw/sites/default/files/2020-05/Erosion%20Control%20mapping%20report_2020.pdf

Orr, B., Cowie, A., Castillo Sanchez, V., Chasek, P., Crossman, N., Erlewein, A., . . . Welton, S. (2017). Scientific Conceptual Framework for Land Degradation Neutrality. A Report of the Science-Policy Interface. Bonn: United Nations Convention to Combat Desertification (UNCCD). Retrieved May 17, 2021

RAB. (2021). 2021. Kigali: Rwanda Agriculture and Animal Resources Development Board (RAB). Retrieved May 24, 2021, from http://rab.gov.rw/index.php?id=114

REMA. (2020). Green Amayaga - Forest Landscape Restoration in Rwanda's Amayaga Region. Kigali: Rwanda Environment Management Authority (REMA). Retrieved June 4, 2021, from https://rema.gov.rw/index.php?id=106

RoR. (2020a). National Land Use and Development Master Plan NLUDMP 2020-2050. Kigali: Republic of Rwanda (RoR). Retrieved June 4, 2021, from https://rlma.rw/fileadmin/user_upload/National_Land-Use_Development_Master_Plan.pdf

RoR. (2020b). Rwanda 6th National Report to the Convention on Biological Diversity. Kigali: Republic of Rwanda (RoR). Retrieved February 6, 2021, from https://www.cbd.int/doc/nr/nr-06/rw-nr-06-en.pdf

RWB (2021) Personal communication, Rwanda Water Resources Board

SIDA. (2019). Rwanda Environment and Climate Change Analysis– 2019-06-05. Swedish International Development Cooperation Agency (SIDA). Retrieved February 3, 2021, from https://sidaenvironmenthelpdesk.se/digitalAssets/1748/1748556_environment-and-climate-change-analysis-rwanda-2019-06-05.pdf

SPIU World Bank. (2021). LWH Land Husbandry Technologies Drive Rwanda's Ambition in Improving Crop Productivity. SPIU World Bank / KOICA. Retrieved May 18, 2021, from http://lwh-rssp.minagri.gov.rw/index.php?id=64

UNCCD. (2021a). Achieving Land Degradation Neutrality. United Nations Convention to Combat Desertification (UNCCD). Retrieved May 17, 2021, from https://www.unccd.int/actions/achieving-land-degradation-neutrality

UNCCD. (2021b). SDG indicator 15.3.1. United Nations Convention to Combat Desertification (UNCCD). Retrieved May 24, 2021, from https://knowledge.unccd.int/ldn/ldn-monitoring/sdg-indicator-1531

Chapter 6:

Water and Wetland Resources

Fishing canoes on Lake Kivu
Photo credit: Johnny Peacock/Flickr

6.1 Introduction

Water and wetland resources are crucial for almost all economic activities including agriculture, energy production, industry and are a vital asset for ecosystem health. However, Rwanda's water and wetland resources are threatened by population growth, the impact of climate change, and the growing demand for water. Achieving a balance between the maintenance of water and wetland resources and their full use as engines of the country's development is essential for Rwanda.

This chapter presents Rwanda's water and wetland resources, describes their current and future state, identifies government responses, promising interventions, and formulates recommendations for advancing sustainable water and wetlands management.

6.2 Status and trend

Rwanda has abundant water resources, but with large untapped water reserves. Water resources consist of the freshwater systems of lakes, rivers, wetlands, and groundwater, all replenished by rainfall through a dense drainage network that channels water to most parts of the country. This network is, however, unevenly distributed spatially, temporally and in quantity. For example, the general climate pattern reflects two rainy seasons and two dry seasons during the year, but about half of the precipitation occurs in a single season (March to May). While the country receives a relatively high average annual rainfall of 1,200 mm, the West of the country receives an average of 1,400 mm, and the East receives less than 1,000 mm (RWB, 2021a). The total annual precipitation the country receives is 27.5 billion m^3 while the total renewable water resources per year is only 6.8 billion m^3 with a groundwater recharge of 4.5 billion m^3 (African Water Facility, 2016). This translates into a per capita freshwater availability of less than 1,000 m^3/year and therefore the country is classified as water scarce (NISR, 2019).

Surface water bodies

Surface water in Rwanda occupies a total of 135,295 ha, or 5.3 percent of the country's land area, which includes 101 lakes and 861 rivers (NISR, 2021). According to the National Water Resources Master Plan, for management purposes, the country has been divided into four levels of catchments. The most widely used are the level 1 catchments, composed of nine catchments. A catchment is an area of land where precipitation collects and drains off into a common outlet, such as a river, lake, or other body of water. Catchment planning and management is based on the principles of Integrated Water Resources Management (IWRM) to which Rwanda has been committed since 2011 (GoR, 2011b).

Hydrologically, Rwanda is located at the pinnacle of two main river basins: the Nile basin and the Congo basin, which are composed of the Nyabarongo, Mwogo, Mbirurume, Muvumba, Mukungwa, Rugezi, Akanyaru, Akagera, Sebeya, Koko, Pfunda, Rusizi and Ruhwa rivers and their tributaries (RWFA, 2019b).

Rwanda shares some of these water resources with neighboring countries. Rivers Rusizi, Akanyaru, Akagera and Cyohoha south and Lake Rweru are shared with Burundi; River Akagera with Tanzania; the Muvumba River with Uganda; and Lake Kivu and Rusizi River with the Democratic Republic of Congo (MINIRENA-RNRA, 2015) (Figure 6-1).

Artificial water storage

The main artificial water storage in the country are water ponds, valley dams and dams. The water ponds are mainly used for small scale irrigation, valley dams for livestock watering and dams are used for irrigation and hydropower generation (RWB, 2021c). Table 6-1, Figure 6-2 and Figure 6-3 provide an overview of the country water storage status as of June 2021.

Nyabarongo I Hydropower Plant (28 MW), Muhanga District
Photo credit: REG

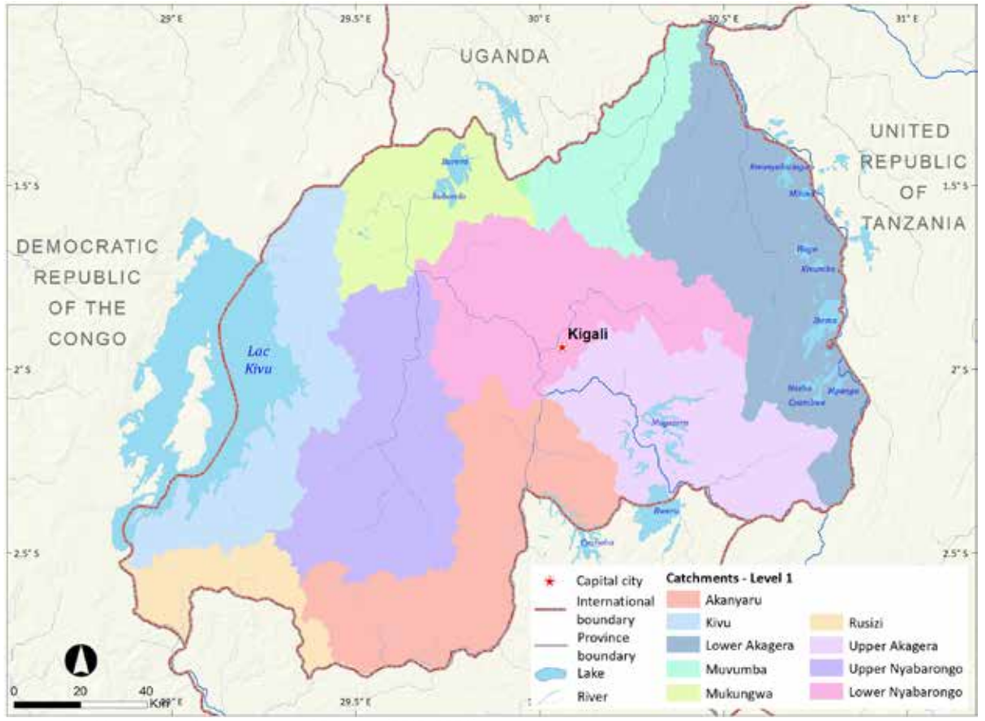


Figure 6-1: Map of level 1 catchments of Rwanda (RBIS, 2021).

Table 6-1: Number of water ponds and their storage capacity per districts (RWB, 2021c)

District	Number of ponds of 120m^3 storage	Total storage (m^3)
Bugesera	183	21,982
Gakenke	8	960
Gasabo	27	3,240
Gatsibo	69	8,280
Gicumbi	17	2,040
Gisagara	31	8,760
Huye	26	3,480
Kamonyi	12	1,440
Karongi	6	720
Kayonza	40	5,160
Kirehe	172	35,040
Muhanga	1	120
Ngoma	15	1,800
Ngororero	11	1,320
Nyamagabe	9	1,080
Nyanza	71	12,120
Nyarugenge	1	120
Ruhango	60	10,800
Rulindo	20	2,400
Rutsiro	1	120
Rwamagana	33	3,960
Total	**813**	**124,942**

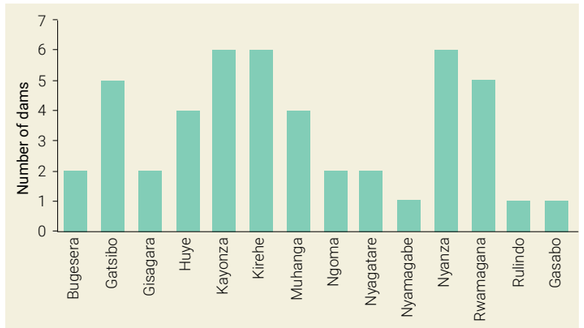


Figure 6-2: Distribution of dams per district (RWB, 2021c)

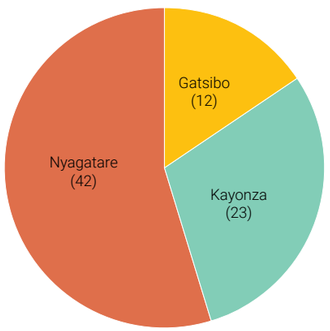


Figure 6-3: Distribution of valley dams per district (RWB, 2021c)

Groundwater

Renewable groundwater is estimated to be 401 million cubic meters and is an important source for water supply especially in rural areas (WASAC, 2018). Groundwater in Rwanda is quantified from boreholes and springs sources, but data is limited to boreholes and currently only available from the Eastern Province. Across the Eastern province, Bugesera, Rwamagana and Kirehe districts have the fewest recorded boreholes (Table 6-2). As part of the Water for Growth program, a groundwater monitoring network has been designed and its implementation is underway (RWFA, 2019a).

Table 6-2: Borehole characteristics per district (RWFA, 2019a)

District	No. of records	No. of records borehole depth	Average borehole depth (m)	Maximum depth (m)
Bugesera	8	8	55	100
Gatsibo	50	47	48	90
Kayonza	51	50	77	145
Kirehe	7	7	62	150
Ngoma	17	17	63	105
Nyagatare	87	87	73	140
Rwamagana	8	8	70	122
Grand Total	228	224	67	150

Current and projected water uses and availability in Rwanda

Despite the constraints of unequal distribution which influence the availability and use of water in the nine catchments, the country is endowed with reserves that could provide enough water for Rwanda (MINIRENA-RNRA, 2015). However, only less than ten percent of the available water resources are used (RWB, 2021a). Data on water use and availability is important for water resources management, especially in Rwanda which faces problems of water withdrawal and demand imbalance within different sectors. Water withdrawal is defined as freshwater taken from underground or surface water sources, either permanently or temporarily, and conveyed to a place of use (RWB, 2021a). The two main water users in Rwanda are the agriculture and domestic sectors. Industry, mining, fishponds, coffee washing stations, and infrastructure are classified as minor water users. In general, the demand for water resources and competition for water uses between various economic sectors are increasing. In 2012 the water use and availability ratio was less than five percent and it increased to nine percent in 2019 (Figure 6-4).

Water withdrawal in 2019 was 608,2 million m^3/year (RWB, 2021a). During this period, the estimated water uses and availability ratio for the Muvumba catchment was 33.7 percent followed by Akagera Upper catchment with a ratio of 16.3 percent (RWB, 2021a). These ratios are attributed to the presence of large-scale irrigation in these catchments. Irrigation was the leading consumptive water use, followed by domestic water use. Figure 6-5 shows the water uses in different sectors in 2019.

While actual water use certainly exceed these recorded data, current water use in Rwanda is still extremely low. However, this is expected to change dramatically by 2040. Figure 6-6 shows the projected water uses by sectors in the Level 1 catchments. By 2040, East and Kigali will face severe water shortages if not managed adequately, especially from Akagera upper and Muvumba catchments.

From these forecast water demands; it is clear the agricultural sector and more specifically the irrigation sector will continue to be the largest consumptive water user in Rwanda. The demand from the industry and domestic sectors is expected to be minor. However, the industrial sector will need close monitoring, because even when their actual demand is limited at the scale of a catchment's water resources, as point source pollution, their exploitation and operations will continue to affect the quality of water resources in Rwanda.

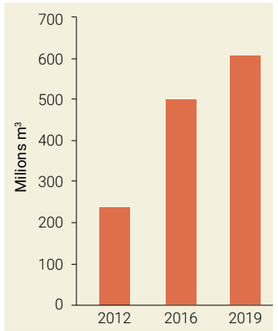
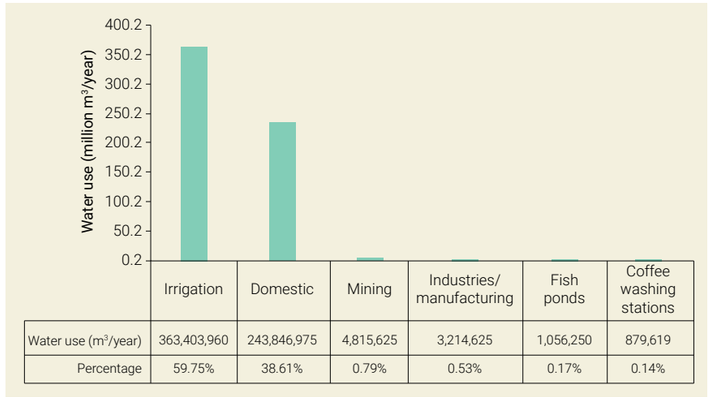


Figure 6-4: Total water withdrawal 2012-2019 (MINIRENA-RNRA, 2015), (RWB, 2021a).



	Irrigation	Domestic	Mining	Industries/ manufacturing	Fish ponds	Coffee washing stations
Water use (m^3/year)	363,403,960	243,846,975	4,815,625	3,214,625	1,056,250	879,619
Percentage	59.75%	38.61%	0.79%	0.53%	0.17%	0.14%

Figure 6-5: Consumptive water uses by sectors during 2019 (RWB, 2021a).

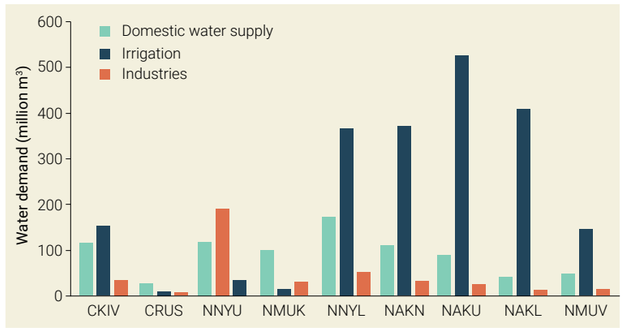


Figure 6-6: Projected water uses by sectors in level 1 catchment, 2040 (MINIRENA-RNRA, 2015).

Note: Lake Kivu catchment (CKIV), Rusizi catchment (CRUS), Upper Nyabarongo catchment (NNYU), Mukungwa catchment (NMUK), Lower Nyabarongo catchment (NNYL), Akanyaru catchment (NAKN), Akagera Upper catchment (NAKU), Lower Akagera (NAKL), Muvumba catchment (NMUV).

Rainwater harvesting tank
Photo credit: SuSanA Secretariat/Flickr

6.3 Wetlands

Wetlands (*"Ibishanga n'ibibaya" or "ubutaka buhehereye"* in Kinyarwanda) play a vital role in maintaining water resources and are part of the green infrastructure of healthy catchments. They reduce the risk of flooding, sequester carbon, protect water quality, and more importantly maintain water supplies by replenishing rivers and streams during the dry season, among others. Wetlands also offer habitat for a vast array of biological diversity that cannot survive elsewhere.

In Rwanda, the total number of wetlands are 935, covering a total area of 176,337 ha (REMA, 2020). They are classified according to characteristics such as soil type, vegetation, hydrology, and climatic zone. Figure 6-8 shows the spatial distribution of wetlands across the country while Figure 6-9 gives name of the wetlands in the city of Kigali.

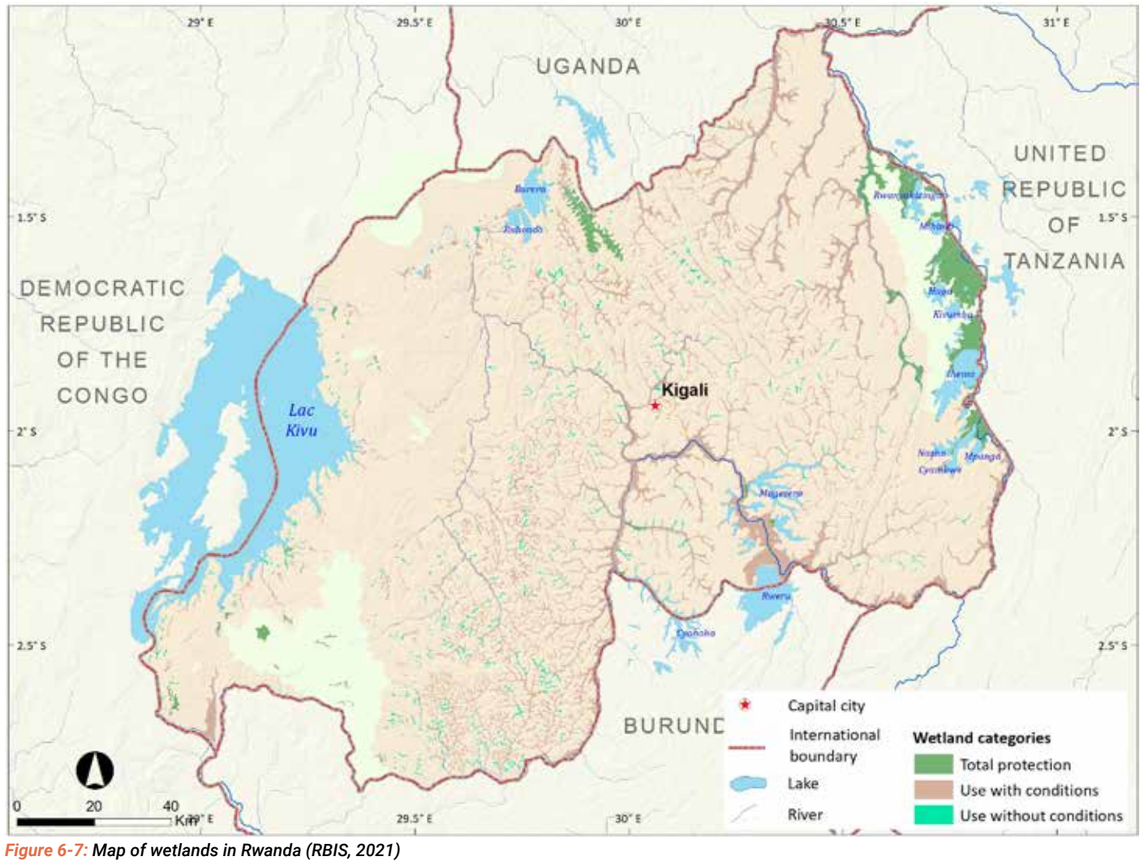


Figure 6-7: Map of wetlands in Rwanda (RBIS, 2021)

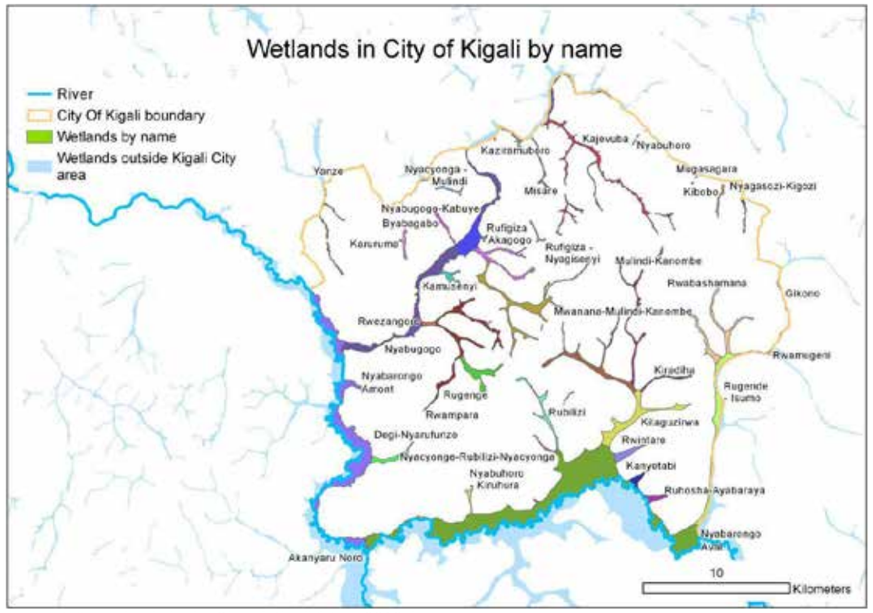


Figure 6-8: Wetlands in the City of Kigali (MoE, 2019a)

Rehabilitation of Lake Cyohoha
Photo credit: Rwanda Green Fund/Flickr

Wetland biodiversity

Wetlands are home to biodiversity of great conservation importance. According to the study on the biodiversity of Rwanda's wetlands conducted in 2019 by the Albertine Rift Conservation Society (ARCOS), Rugezi and Nyungwe wetlands have been identified as key areas for biodiversity in Rwanda, with the presence of endemic and endangered bird species such as the Grauer's marsh warbler: *Bradypterus graueri* and the Grey-crowned crane: *Balearica regulorum* (ARCOS, 2019).

Wetland protection status

Rwanda recognizes the importance of wetlands and the need to manage them proactively. For example, current legislation classifies wetlands into total protected wetlands, or non-protected wetlands (Figure 6-9) (REMA, 2020). The latter category is further divided into those with status of use under specific conditions, and those with a status of use without conditions. These conditions are documented in the Prime Minister's Order gazetted in 2017, which lists all swamp lands, their characteristics, boundaries and determining modalities of their use, development, and management (REMA, 2020).

The Ramsar sites

Rwanda is a signatory to the Ramsar Convention on Wetlands which defines wetlands as: "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (Ramsar Convention, 2016). Marine water is not applicable to Rwanda. The Convention requires that Ramsar sites be conserved but also recognizes the interdependence of people and wetlands and the ecosystem services they provide. Three percent of Rwanda's wetlands that encompasses Rugezi wetland have Ramsar status, while 53 percent are proposed for Ramsar status. Some of these are located in the city of Kigali, Akanyaru, Akagera and Rweru-Mugesera wetland complexes (REMA, 2020).

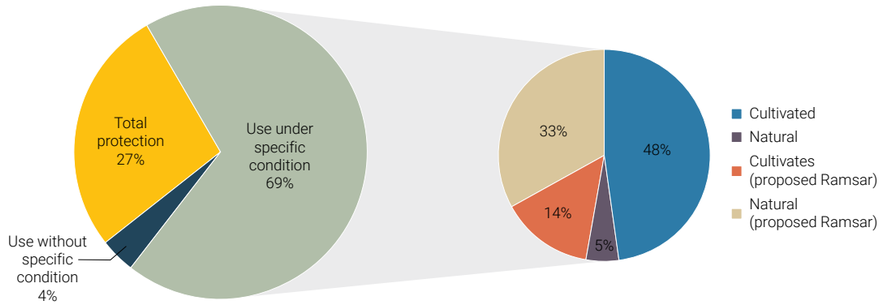


*Figure 6-9: **Rwanda Wetland Protection Status (REMA, 2020).***

Note: Wetlands in Rwanda are managed according to their protection status: wetlands under total or full protection (all activities are prohibited except for research or science), use under specific condition (wetlands that require an Environment Impact Assessment prior to a change in land use), and the use without specific condition or unprotected wetlands (most of these wetlands are under cultivation or plantation, with no remaining natural vegetation) (REMA, 2020).

6.4 Pressures and impact

Rwanda's water and wetlands resources are under great pressure due to population growth, urbanization, pollution, and degradation from numerous economic activities compounded by the effects of climate change (MoE, 2019a), (MINIRENA-RNRA, 2015). All these pressures degrade the quantity and quality of water and wetland resources.

Wetland degradation

As part of the implementation of Vision 2020 and the EDPRS, the government has made rural development and agricultural transformation central to its sustainable development programmes. As a result, many of Rwanda's wetlands were converted to other land uses. For instance, in 1988, wetland coverage was 276,488 ha and decreased to 176,337 ha in 2016 representing 36 percent of the wetland ecosystem lost in just 28 years (WCS, 2019). In real terms, the Rwanda Wetlands Cover Change Report 2008-2018 by the Albertine Rift Conservation Society (ARCOS), describes a decrease in the natural vegetation and an increase in cropland and water bodies in the Muvumba wetland complex. The City of Kigali, Southern and Western wetland complexes also exhibited a loss of cropland and a large increase in settlement and fallow (Figure 6-10). According to the study, wetlands loss has also been seen in Nyarugenge District, in Mukungwa wetlands adjacent to Gakenke and Burera Districts, and in the Western wetlands alongside Rubavu District, as well as in the Southern wetland complexes near Huye and Nyamagabe Districts in the Southern wetland complexes (ARCOS, 2021).

The level of intensity and frequency of threats to wetlands continues to increase. The main threats continue to come from the agricultural sector, as well as the mining, industrial, and infrastructure sectors (ARCOS, 2019). By 2019, 4 out of 8 national wetland complexes were classified as exposed to a level of threat intensity and frequency between 80 and 100 percent (ARCOS, 2019). The percentage of the level of intensity and frequency of threats was assigned following the state, pressure and response model and indicators measured (Table 6-3).

Pressures around Rweru-Mugesera and Akagera wetland complexes

Rweru-Mugesera wetland complex is in the Southeast part of the Bugesera and constitutes a part of the Nile Basin. It is fed by the Akagera river and is connected to Rweru lake, which are transboundary waters between Rwanda and Burundi. The wetland hosts a high species richness including fish and water birds but experiences a high level

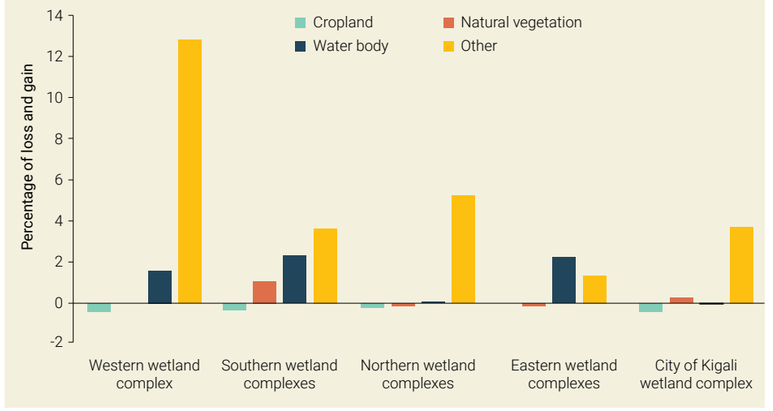


*Figure 6-10: **Percentage of gain and loss of wetland cover types over the last 10 years (2008-2018) (ARCOS, 2021). Note: Most of the wetland loss was conversion to cropland.***

*Table 6-3: **Intensity and frequency of threats in Rwandan wetlands (ARCOS, 2019)***

Wetland complexes	Intensity and frequency of threats				
	Very low (0-20%)	Low (20-40%)	Medium (40-60%)	High (60-80%)	Very high (80-100%)
Southern wetland complexes			X		
Eastern Kirehe wetland complexes			X		
City of Kigali					X
Akanyaru					X
Rweru-Mugesera					X
Muvumba					X
Rusizi			X		
Rugezi	X				

of threat and degradation from overfishing, the spread of invasive species (Water hyacinth), siltation from Akagera river, and overexploitation due to agriculture activities even in the buffer zone area (ARCOS, 2021) (Figure 6-11).

Akagera Wetland Complex is in the southeast within Kirehe District. Several factors have led to the increase in water extent associated with the wetland. These include recurring water from the outflow of Rweru lake at the upstream end, the ongoing construction of Rusumo hydropower plant, and flooding from heavy rains that have hit the region in the last 3 to 5 years (ARCOS, 2021). Some of the pressures on this wetland complex include sand mining, overharvesting of wetland plants, drought, floods, and agriculture (Figure 6-12) (ARCOS, 2021).

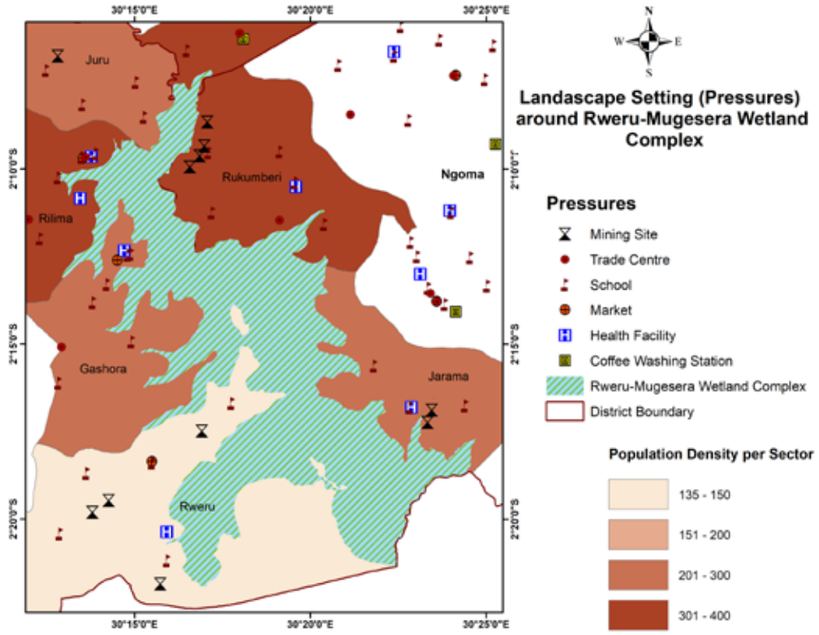


Figure 6-11: Pressures around Rweru-Mugesera wetland complex (ARCOS, 2021).

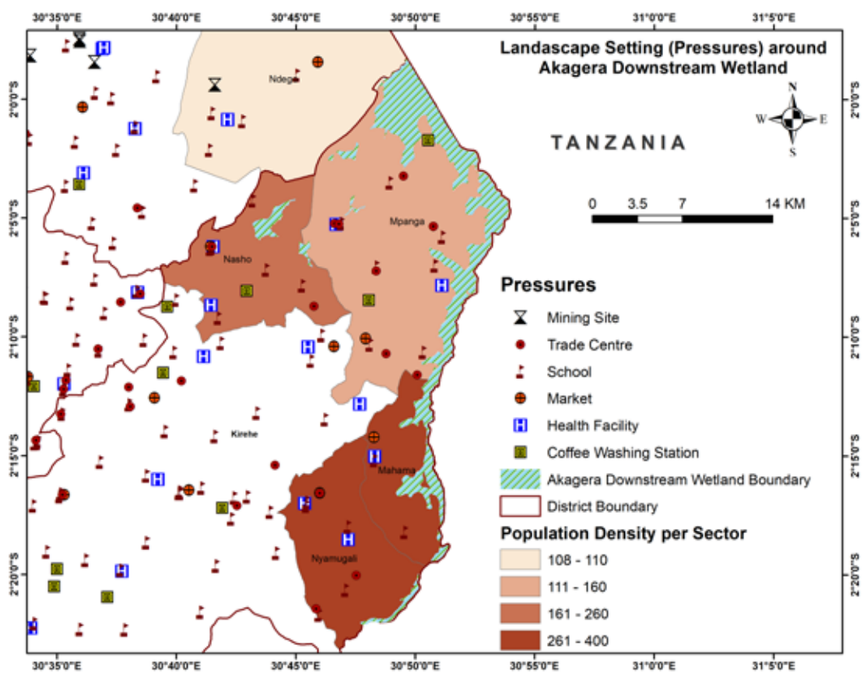


Figure 6-12: Pressures around Akagera upstream wetland (ARCOS, 2021).

6.5 Responses

Despite these challenges Rwanda has also recorded several achievements. Various management responses and policies have been adopted to ensure sustainable and integrated management of water resources and protection of wetlands. These include the National Water Resources Management Plan of 2011, the Green Growth Strategy, which includes a program dedicated to integrated water resources management (IWRM), the 2015 national water resources master plan (REMA, 2018), the Wetland Master Plan for the City of Kigali and Law N°49/2018 of 13/08/2018 determining the use and management of water resources in Rwanda. A summary of the instruments governing wetland management in Rwanda is presented in Table 6-4.

Rwanda Water Authority

The Rwanda Water Resources Board (RWB) was established by law N° 71/2019 of 29/01/2020 following the institutional transformation of the Rwanda Water and Forestry Authority (RWFA). Its mission is to ensure the availability of sufficient and well managed water resources for sustainable development. In addition, an initiative to facilitate public access to information related to water use in Rwanda, a web platform, the Rwanda Water Resource Portal, was developed where water resources related information such as water quality, surface water, and ground water, water laws and policies is easily accessible.

These instruments and established institutions have contributed to the strengthening of the efficient, productive, equitable and sustainable management of the country's water resources and continue to ensure the protection of wetlands. Rwanda's progress in water and wetland resource management includes the rehabilitation of wetlands such as Rugezi, Rweru-Mugesera, Murago and Nyandungu (including the rehabilitation of the Nyandungu Wetland Eco-Tourism Park) and adoption of rainwater harvesting and stormwater management. Some of the policy actions include completion of water ponds and gabions on the mainstream, completion of water drainage channels, terrestrial habitat rehabilitation, and aquatic habitat creation and restoration (REMA, 2021). Box 6-1 highlights the rehabilitation of the Gikondo (Rugenge) wetland which is important as an example of integrated management of water and wetland resources and interventions towards Rwanda's 2030 commitment towards mitigating and adapting to climate change. The Nationally Determined Contributions (NDCs) aims to "develop national water security through water conservation practices, wetlands restoration, water storage and efficient water use" (MoE, 2020).

Table 6-4: Summary of policies, laws, and orders for the management wetlands in Rwanda (REMA, 2020)

Policies	Law	Orders
• Land Policy 2019 • National Environment and Climate Change Policy 2019 • National Policy for Water Resources Management 2011 • Biodiversity Policy 2011	• Law Governing Land in Rwanda N° 43/2013 • Environmental Law No 48/2018 of 13/08/2018 • Water Law N° 49/2018 of 13/08/2018 • Law Governing Biodiversity in Rwanda N° 70/2013	• Prime Minister's Order N° 006/03 of 30/01/2017 drawing up a list of swamp lands, their characteristics and boundaries and determining modalities of their use, development, and management. • Ministerial order N° 005/16.01 of 15/07/2010 determining the list of prohibited plains to constructions. • Rwanda National Land Use Planning Guidelines (RLMUA, 2017)

Nyandungu Urban Wetland Ecotourism Park in 2021
Photo credit: REMA

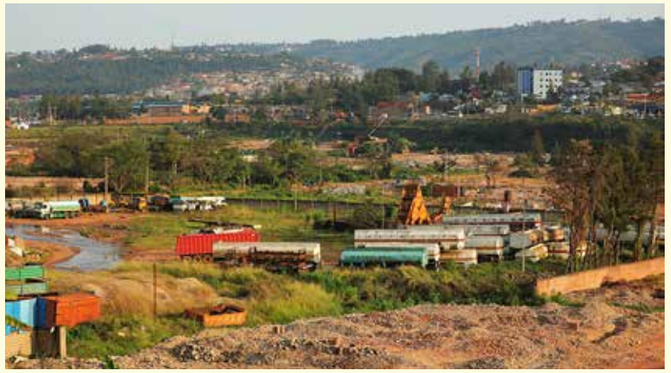
Box 6-1: Rehabilitating the Gikondo (Rugenge) wetland

The Gikondo (Rugenge) wetland has gained attention as a case study for wetlands management in Rwanda, particularly in the city of Kigali. The wetland has an area of 140.2 hectares, drains into Rwampara, Rwezangoro and Nyabugogo wetlands, and includes the area known as Gikondo which had been used as an industrial park since the 1960s (MoE, 2019a).

The Gikondo industrial park clean-up plan has been in existence since 2011, when a memorandum of understanding was signed between the Ministry of Trade and Industry and Rwanda Free Zones Company Ltd. Some of the terms of the agreement included the construction of facilities in the new industrial park, where Gikondo industries would be relocated (Mugisha & Byishimo, 2020).

Government Law No 48/2018 of 13/08/2018 on environment determining the modalities of protection, conservation, and promotion of environment in Rwanda, as well as the Land law which states that wetlands constitute public land and prohibits construction in wetlands, served as grounds for the relocation of the industrial park of Gikondo. Infrastructure such as factories, warehouses, and paved roads had destroyed the wetland, decreasing biodiversity and important ecosystem services in the wetland and surroundings (MoE, 2019a). Some of the impacts included the reduction of the infiltration area and increase of runoff erosion in the lower parts of the wetland which resulted in pollution of ground and surface water and contamination of the soil from industrial wastes, among others. Apart from polluting the wetland, the industrial waste is reported to have meandered through the Nyabugogo-Akagera wetland belt, eventually ending up in Lake Victoria (Mugisha & Byishimo, 2020). It is also reported that the increase of built-up areas and bare land to the wetland area reduced from 32.03 percent (1987) to 25.70 percent (2010) (Mutaganda & Bizimana, 2020).

Current work for rehabilitation, the process to re-establish a wetland ecosystem in an area where a diverse wetland previously existed, is underway in Rugenge wetland (MoE, 2019a). Remediation, including the removal of all infrastructure, has been undertaken and data from 2010 to 2019, shows that the area of wetland has increased. Finally, there are plans to develop a green and environmentally friendly Gikondo Recreational Park in the former Gikondo industrial park.



Before (top) and after (bottom) images of Gikondo wetland showing the major change in wetland vegetation after industries relocation.
Photo credit: top image - Dan Nsengiyumva;
bottom image - N. Amizero/EPI

Wetland master plan for the City of Kigali

The Wetlands Master Plan for the City of Kigali provides guidance on wetland use, rehabilitation, management, and monitoring as shown in Figure 6-13. The Kigali Urban Wetlands Master Plan has the following objectives:

- Adopt a balanced approach, promoting conservation and rehabilitation but also with a wise use, green growth perspective.
- Integrate seamlessly with the ongoing Kigali Master Plan, generating synergies between the wetlands and the developed urban area.
- Provide streamlined regulations and indications for all wetlands, identifying areas of particular importance for their potential conservation or sustainable use.
- Identify strategic projects to be implemented within the wetlands and in synergy with City of Kigali Implementation Plan.

In addition to Rugenge, other priority wetlands for rehabilitation are Rwampara, Rwezangoro, Nyabugogo and Mwanana-Mulindi-Kanombe and there are several proposed projects for wetlands protection (Figure 6-14) (MoE, 2019b). The Rugenge (Gikondo) wetland rehabilitation process will present lessons for other wetland rehabilitation practices in the city of Kigali, and in the country in general.

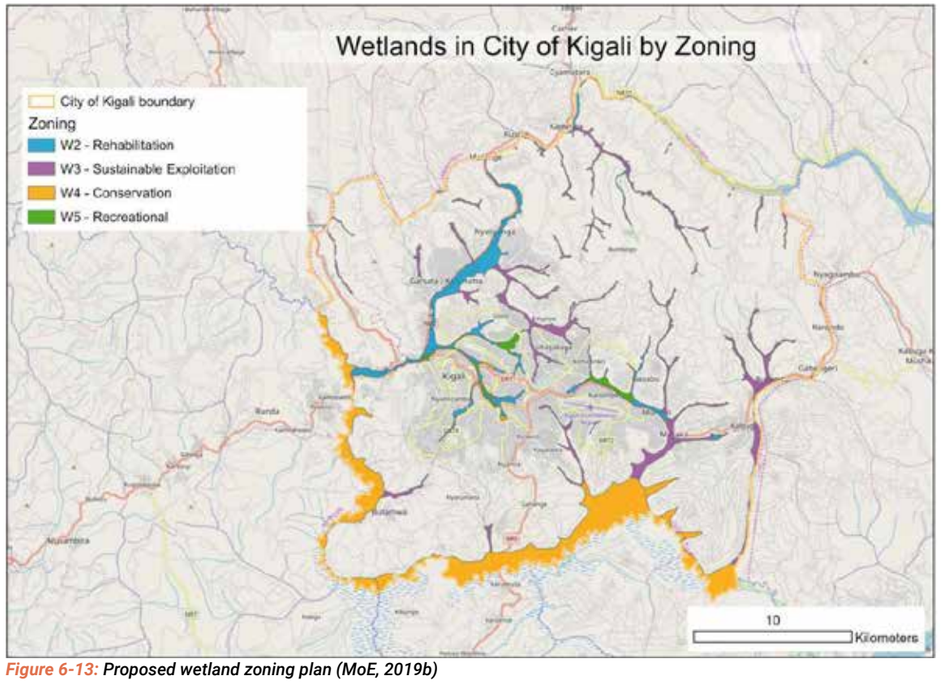


Figure 6-13: ***Proposed wetland zoning plan (MoE, 2019b)***

Nyandungu Urban Wetand Ecotourism Park
Photo credit: Rugege D./EPI

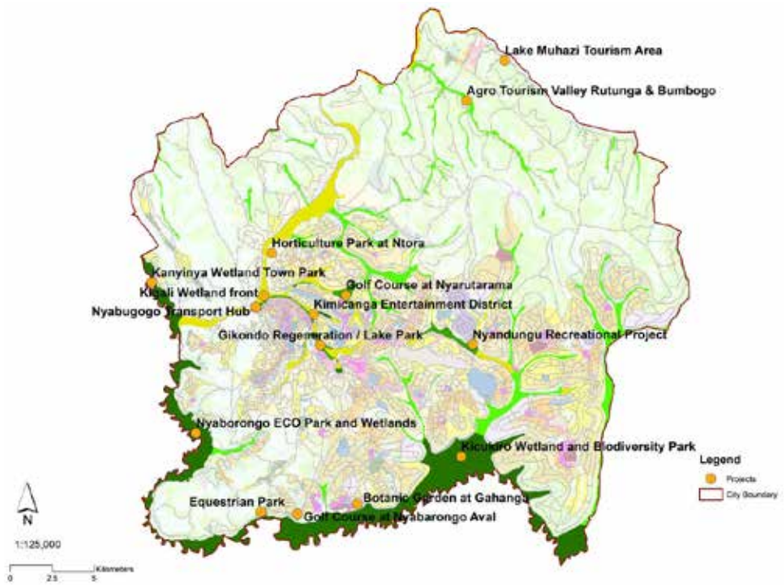


Figure 6-14: Map showing proposed projects as per Kigali 2050 Master Plan (MoE, 2019b)

Rainwater harvesting in Rwanda

In response to the growing pressure on the existing water resources the government aims to increase the water storage capacity as part of an integrated solution for the management and use of water resources. To this end, the government is promoting the adoption of rainwater harvesting (RWH) as a key output under the water resources management policy (GoR, 2016). RWH techniques involve the capture, storage and use of rainwater and runoff. These techniques also have environmental benefits such as erosion and flood control. The common rainwater harvesting technologies in Rwanda are rooftop technologies and groundwater recharge techniques. Rooftop technologies include aboveground tanks made of reinforced concrete, bricks, masonry wall as well as plastic sheets (GoR, 2016). Groundwater recharge technologies include multipurpose dams, retention dams, gully plugs, ditches, and water ponds (GoR, 2016). Irrigation techniques, agroforestry practices and other methods of hillside and land husbandry across the country play an important role in in-situ rainwater harvesting and contribute to groundwater recharge and soil moisture retention.

Status of rainwater harvesting in Rwanda

In 2016/17, an estimated 15 percent of households had measures in place to manage rainwater (Figure 6-15). This was, however, a decrease from 2013/14 when around 17 percent of households were using some form of rainwater management. The most used rainwater management system at household level was ditches (9.4 percent) and only 2.2 percent of households used rainwater tanks (NISR, 2018).

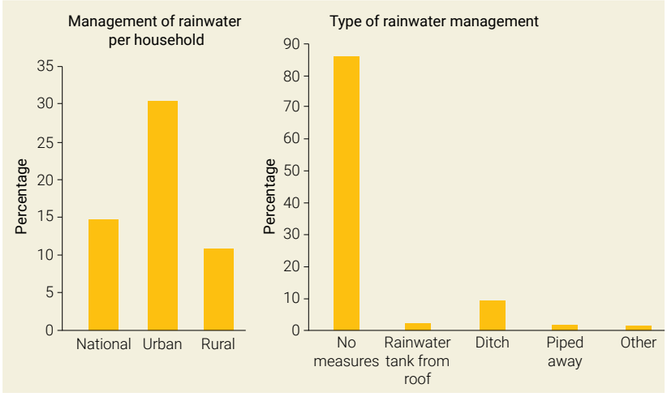


Figure 6-15: Rainwater management in Rwanda, 2016/17 (NISR, 2018)

Challenges, opportunities, and potential of rainwater harvesting

Rainwater harvesting is a viable alternative source of water in Rwanda but as the data shows there is still a low level of adoption of rainwater management. The government through its Water policy has, since 2011, targeted to have at least 50 percent of households with rainwater facilities (GoR, 2011a). However, this has not yet been achieved. The challenges that hinder the adoption of RWH must be addressed if these practices are to be scaled up across the country. An analysis of the Strengths, Weakness, Opportunities and Threats (SWOT) for RWH in Rwanda from the RWH strategy and the study "Potential of Rainwater Harvesting in Rwanda 2019", is given in Table 6-5.

Table 6-5: Strengths, Weakness, Opportunities and Threats (SWOT) analysis for RWH in Rwanda (GoR, 2016), (RWFA, 2019c)

	Strengths	Weaknesses
Internal Factors	-Well set-out policy, legal and institutional framework -A pilot phase has been implemented -Available best practices at national level -Availability of the National Environment and Climate Change Fund (FONERWA)	-Low awareness of the local population -Poor institutional coordination -Low community involvement -Limited research on importance and use of RWH -Limited data -Limited finances/funds -Limited number of skilled people in RWH
	Opportunities	**Threats**
External Factors	-Relatively abundant rainfall -Local and international research -institutions -International donors may finance -Experiences from other countries	-Vulnerability to climate change -Severe environmental degradation -Dependency on external financing -Mountainous topography -High investment cost

One of the water storage ponds created in the Yanze Watershed
Photo credit: Rwanda Green Fund/Flickr

6.6 Sustainable Development Goals and water and wetland resources

Water use efficiency over time

SDG 6 is to "*Ensure availability and sustainable management of water and sanitation for all*". 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 the use of water resources. Data from recent Natural Capital Accounts for Water indicate that water use efficiency in Rwanda has increased over the 4-year period since 2012, efficiency has increased by around 4,500 to 5,100 Rwf/m^3 in 2019, an improvement of almost 13 percent (Figure 6-16) (NISR, 2019).

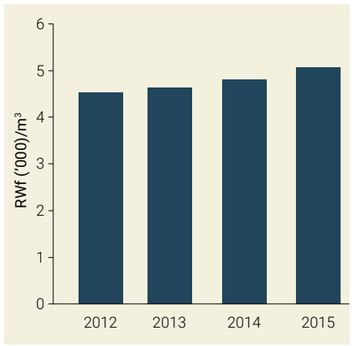


Figure 6-16: Total water use efficiency (NISR, 2019)

Level of water stress

Indicator 6.4.2 addresses the level of water stress over a year. This is the ratio of the total freshwater withdrawn by all major sectors to the total renewable freshwater resources available after considering environmental requirements water flow (UN Water, 2021). In 2019, water stress in Rwanda was 8.9 percent. Water stress refers to the ability, or lack thereof, to meet human and ecological demand for water. Table 6-6 shows trends in the total availability of renewable water resources and water stress.

Table 6-6: Trends in the total renewable water resource availability and water stress (NISR, 2019) (RWB, 2021a)

Year	Water availability per capita (m^3/capita/year)	Water stress (%)
2012	1,112	7.2
2013	941	8.3
2014	1,084	7.4
2015	999	8.1
2017	1,110	-
2019	-	8.9

The 500 kW Gaseke Hydro Power Project while under construction along the Gaseke River, downstream of Birambo Village in Busengo Sector, Gakenke District
Photo credit: Rwanda Green Fund/Flickr

Degree of Integrated Water Resources Management

Indicator 6.5.1 is related to the degree of integrated water resources management (IWRM) implementation in a country. Rwanda has adopted the IWRM as a comprehensive approach to national water resources policy and other frameworks such as the Green Growth and Climate Resilience Strategy (Figure 6-17) (RWB, 2021b).

This IWRM framework and the Strategic Environmental Assessment (SEA) process have also been integrated in the development of catchment plans in the country. By 2021, four out of nine catchment management plans had been developed. These were for Sebeya, Upper Nyabarongo, Nyabugogo, and Muvumba catchments. The rest are to be finalized within the next 2 years (Vital Munyandinda, 2019). Furthermore, in alignment with the IWRM, the rehabilitation of priority degraded areas in five catchments under implementing projects from Water for Growth, The Rwanda Green Fund (FONERWA), Water for Growth, Adaptation Fund, Land Husbandry, Water Harvesting and Hillside Irrigation (LWH), among others, have been completed. A list of the restored areas is given in Figure 6-18.

Transboundary water management

Indicator 6.5.2 concerns the management of transboundary water. It is disaggregated into values for transboundary river and lake basins and transboundary aquifers. Rwanda, as a riparian country within the Nile and Congo basins, has consolidated its regional integration agenda, through the East African Community (EAC), Nile Basin Initiative (NBI), Lake Victoria Basin Commission (LVBC), Lake Kivu and Rusizi River Basin Authority (ABAKIR). The principles of transboundary water resources management have been taken on board in the main regional instruments to which Rwanda subscribes, including the protocol for the sustainable management of Lake Victoria and its basin and the Nile basin cooperation framework (GoR, 2011a). Rwanda has achieved a value of 100 percent or full inclusion management of all its transboundary river and lake basins, however, none of its transboundary aquifers are included (UN Water, 2021).

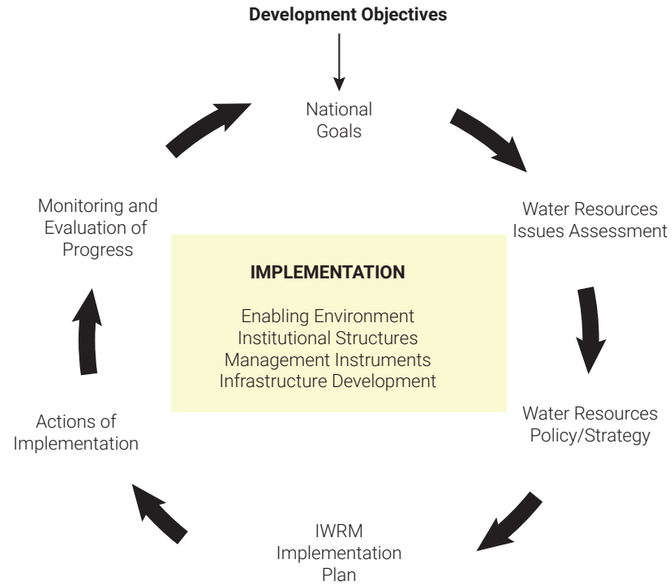


Figure 6-17: The IWRM framework (RWB, 2021b)

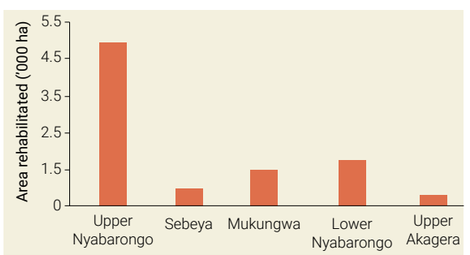


Figure 6-18: Rehabilitated area per catchment (Munyandinda, 2019)

6.7 Conclusion and recommendations

The government aims to achieve a balance between maintaining water and wetlands ecosystems and their full use as engines of development. The analysis of Rwanda's national water resources master plan indicated that for the forecast water demand for 2040, the level 1 catchment of lower Nyabarongo, Akanyaru, upper and lower Akagera and Muvumba, where some of the most threatened wetlands are found, will require strengthened strategic planning. The report recommends several measures in these catchments, including protection of land and water resources, demand reduction, creation of water storage capacities of surface area, development of water supply in rural and urban areas and the transfer of additional resources from other catchments (MINIRENA-RNRA, 2015).

Additional recommended interventions for water resources and wetland management in Rwanda include:

Accelerate the process of rehabilitation of Rugenge (Gikondo) wetland. This process is an impressive and important example of environmental law enforcement for wetland protection, the acceleration and success of the process will encourage future wetland rehabilitation plans.

Develop management plans for the Rweru Mugesera and Akagera wetlands at local, national, and international levels. This is especially crucial given their importance in the broader ecology of the area.

Improve data management on the quantity of groundwater. Groundwater is vital for Rwanda's water resources, however there is still a lack of information on their condition and transboundary management. It is recommended that Rwanda improve efforts to monitor the quantity of groundwater and possibly include this resource in its integrated management of water resources.

Accelerate the adoption of rainwater harvesting in Rwanda. Although rainwater harvesting plays an important role in achieving water security, there is still low adoption of rainwater harvesting techniques in Rwanda, it is important that efforts for the adoption of rainwater harvesting be accelerated through, for example, pilot projects.

A wetland in the Akagera National Park, Rwanda
Photo credit: John Cooke/Flickr

References

African Water Facility. (2016). Rwanda National Integrated Water Supply: Project Appraisal Report. African Water Facility & African Development Bank. https://projectsportal.afdb.org/dataportal/VProject/show/P-RW-EA0-013

ARCOS. (2019). Rwanda Wetlands Ecological Integrity Rapid Assessment Report. Albertine Rift Conservation Society (ARCOS). http://arbims.arcosnetwork.org/ipt/resource?r=wet_ecol_int_assess_odonata&request_locale=en

ARCOS. (2021). Rwanda Wetlands Cover Change Mapping Report 2008-2018. Albertine Rift Conservation Society (ARCOS). http://arcosnetwork.org/uploads/2021/07/Rwanda_Wetlands_Cover_Change_Report_2008-2018.pdf

MINIRENA-RNRA. (2015). Rwanda National Water Resources Master Plan. Rwanda Natural Resources Authority. Kigali. https://www.rwb.rw/fileadmin/user_upload/RWRB/Publications/Policies/Rwanda_National_Water_Resources_Master_Plan.pdf

MoE. (2019a). Technical Support for Development of Wetland Master Plan for Kigali City: Final Report: Volume 3 – Conservation Investment. Ministry of Environment (MoE): SMEC International Pty Limited. https://wetlandskigali.maps.arcgis.com/home/index.html

MoE. (2019b). Technical Support for Development of Wetland Master Plan for Kigali City, Final Report: Volume 2 – Wetland Master Plan. Ministry of Environment (MoE): SMEC International Pty Limited. https://www.arcgis.com/home/item.html?id=0008227cca8a44fe8df0ecb14c917272

MoE. (2020). Nationally Determined Contributions (NDC). Ministry of Environment (MoE), Government of Rwanda. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

GoR. (2011a). National Policy for Water Resources Management. Government of Rwanda (GoR): Ministry of Natural Resources. http://extwprlegs1.fao.org/docs/pdf/rwa182099.pdf

GoR. (2011b). Water Resources Management Sub-Sector Strategic Plan (2011 – 2015) Kigali: Ministry of Natural Resources. http://extwprlegs1.fao.org/docs/pdf/rwa179827.pdf

GoR. (2016). National Rainwater Harvesting Strategy. Government of Rwanda (GoR): Ministry of Natural Resources. Kigali https://waterportal.rwb.rw/sites/default/files/inline-files/20161116%20Final%20draft%20%20Rainwater%20Harvesting%20Strategy_0.pdf

Mugisha, C., & Byishimo, B. (2020). Gikondo industrial zone to be vacated by March. Retrieved June 2, 2020, from The New Times: https://www.newtimes.co.rw/news/gikondo-industrial-zone-be-vacated-march

Munyandinda, V. (2019). Catchments and spatial planning. Integrated Water Resources Management Conference.

Mutaganda, T., & Bizimana, J. P. (2020). Application of Geospatial Techniques for Monitoring Gikondo Park. International Journal of Environmental & Agriculture Research (IJOEAR), 30-35. https://ijoear.com/assets/articles_menuscripts/file/IJOEAR-JUL-2020-4.pdf

NISR. (2018). 2016/2017 EICV5_Environment and Natural Resources. Kigali: National Institute of Statistics of Rwanda (NISR).

NISR. (2019). Natural Capital Accounts for Water. National Institute of Statistics of Rwanda (NISR). Kigali. https://www.wavespartnership.org/sites/waves/files/kc/RW%20NCA%20Water%20Account%20_Published%203-12-2019.pdf

NISR. (2021). Seasonal Agricultural Survey: Season A 2021 Report. National Institute of Statistics of Rwanda(NISR). Kigali City: National Institute of Statistics of Rwanda. Retrieved from http://www.statistics.gov.rw/

Ramsar Convention. (2016). An Introduction to the Convention on Wetlands (previously The Ramsar Convention manual). Gland, Switzerland: Ramsar Convention Secretariat. https://www.ramsar.org/sites/default/files/documents/library/handbook1_5ed_introductiontoconvention_e.pdf

REMA. (2018). Third National Communication: Report to the United Nations Framework Convention on Climate Change. Kigali, Rwanda: Rwanda Environment Management Authority (REMA) http://climateportal.rema.gov.rw/node/136

REMA. (2020). Environment and Natural Resources Management (ENRM): National Wetlands Management Framework for Rwanda. Rwanda Environment Management Authority. Kigali City,

REMA. (2021). Policy actions implementation progress 2020-2021. Rwanda Environment Management Authority (REMA)

RWB. (2021a). Understanding Rwanda's water users and uses. Retrieved June 2, 2021, from Rwanda Water Resources Board (RWB): https://www.rwb.rw/updates/news-detail/understanding-rwandas-water-users-and-uses

RWB. (2021b, June 7). Integrated Water Resources Management. Rwanda Water Resources Board (RWB) Retrieved from Rwanda Water Portal: https://waterportal.rwb.rw/toolbox/504

RWB. (2021c). Annual Water Storage Status Report for 2020-2021. Rwanda Water Resources Board (RWB).

RWB. (2021d). Rwanda Water Resources Board (RWB). Retrieved July 28, 2021, from https://www.rwb.rw/

RWFA. (2019a). Rwanda IWRM Programme: Ground Water Recharge and Storage Enhancement in Eastern Province. Kigali, Rwanda: Rwanda Water and Forestry Authority (RWFA). https://waterportal.rwb.rw/report/ground-water-recharge-and-storage-enhancement-eastern-province-rwanda

RWFA. (2019b). IWRM Programme Rwanda: Water quality monitoring in Rwanda final report. Rwanda Water and Forestry Authority. Kigali https://waterportal.rwb.rw/sites/default/files/2019-05/Water%20Quality%20Monitoring%20phase%20I%20%26%20II%20final%20report%20%2825th%20April%202019%29-2.pdf

RWFA. (2019c). Potential of Rainwater Harvesting in Rwanda. Rwanda Water and Forestry Authority (RWFA). Center for Science and Environment. https://waterportal.rwb.rw/sites/default/files/2019-04/Potential%20of%20Rainwater%20Harvesting%20in%20Rwanda%20report-Final.pdf

Schulte, P. (2014). Defining Water Scarcity, Water Stress, and Water Risk. Retrieved July 28, 2021, from https://pacinst.org/water-definitions/#:~:text=Water%20scarcity%20is%20a%20physical,across%20regions%20and%20over%20time.&text=%E2%80%9CWater%20stress%E2%80%9D%20refers%20to%20the,more%20inclusive%20and%20broader%20concept.

UN Water. (2021). Rwanda. Retrieved June 2, 2021, from UN Water: https://www.sdg6data.org/country-or-area/Rwanda#anchor_6.5.2

WASAC. (2018). Sustainable water and sanitation program in Rwanda. Ministry of Infrastructure. Kigali, Rwanda: Water and Sanitation Corporation (WASAC).

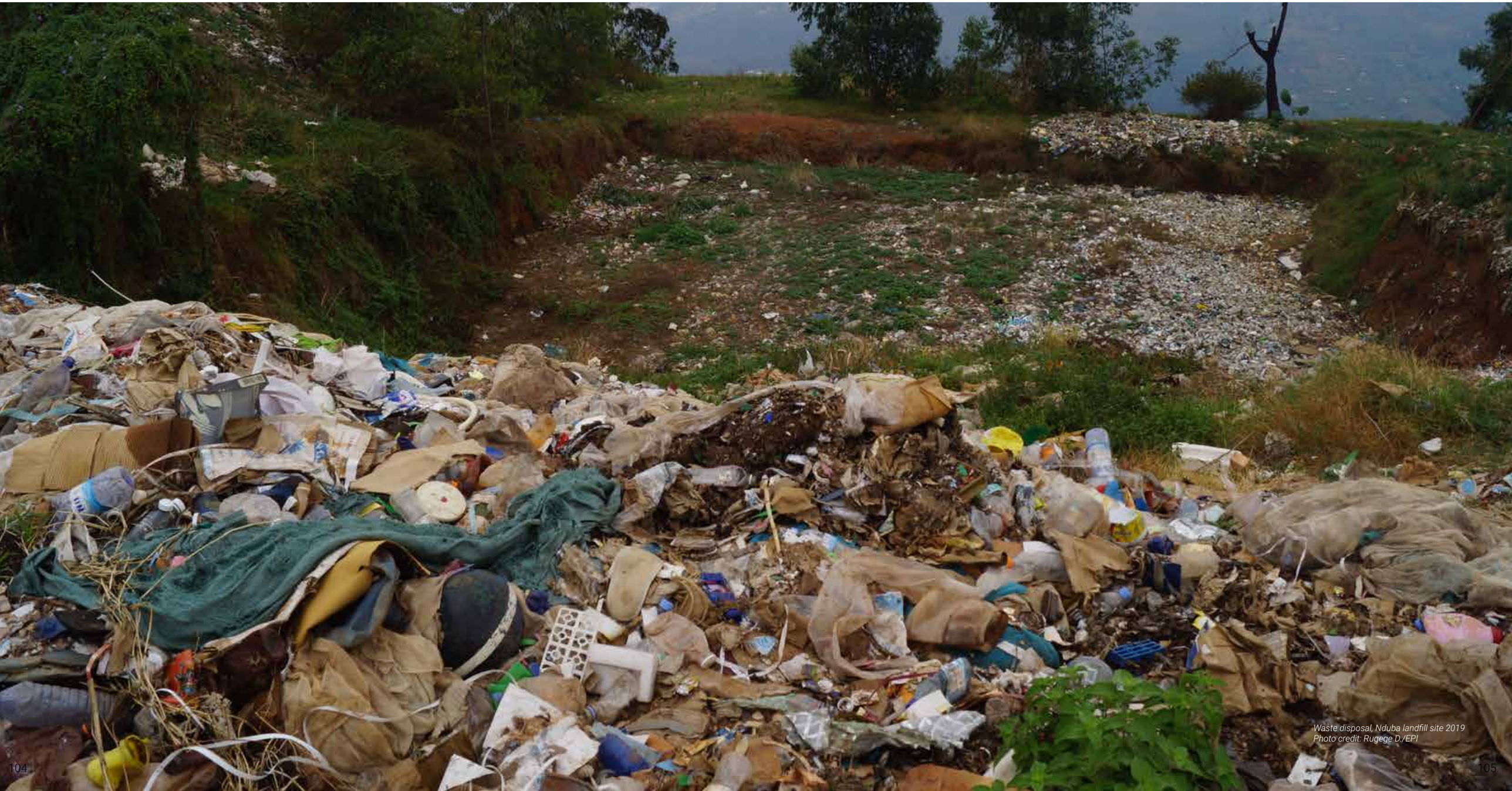
Water for Growth Rwanda. (2019). IWRM Programme Rwanda TR90 – Catchment Plan & SEA development manual. https://waterportal.rwb.rw/sites/default/files/2019-07/Catchment%20Plan%20Manual_v6_complete.pdf

WCS. (2019). Vital Signs' Data Analysis for Ecosystem Management and Climate Resilient Agricultural System. The Wildlife Conservation Society (WCS). https://www.researchgate.net/publication/342888628_Vital_Signs'_Data_Analysis_for_Ecosystem_Management_and_Climate_Resilient_Agricultural_System_towards_Environmental_Sustainability_in_Rwanda

A rice paddy in Rwanda
Photo credit: Adam Cohn/Flickr

Chapter 7:

Waste Management



Waste disposal, Nduba landfill site 2019
Photo credit: Rugege D./EPI

7.1 Introduction

Waste generation and unsafe disposal is a major environmental problem. Poor waste management leads to pollution of the air, ground and surface waters and has adverse impact on human health. With Rwanda's high rates of urbanization and economic growth, the amount of waste produced is increasing and proper waste management is needed as an integral part of the country's priority to pursue green growth and sustainable development. This chapter presents the state and challenges of waste management in Rwanda, highlights the government's responses, explores opportunities in the waste sector and provides recommendations for sustainable waste management in the country.

7.2 Status and trends

Waste can be classified and for this discussion we will consider four categories: solid, liquid, and hazardous waste - medical and electronic waste.

Solid waste

The main sources of solid waste are the residential, commercial, construction, and institutional sectors. All which can constitute municipal solid waste (MSW).

MSW generation

The amount of waste produced per capita varies considerably and is estimated between 0.56 and 0.7 kg per capita per day for urban areas such as the cities of Kigali, Muhanga and Huye. Considering the rate of increase of solid waste in these urban areas, the management of MSW is proving a challenge. In the city of Kigali, MSW generation increased from 180 tonnes per day in 2012 to over 600 tonnes per day in 2019, which amounts to a total waste of 193,434 tonnes per year (Vice, Rugege, & Benitez, 2019). The waste generation proxy for the waste collected and disposed in Kigali is represented in Table 7-1.

MSW composition

Waste composition is the categorization of types of materials in waste and has direct implications for how they are collected and disposed of. Food and green waste constitute the largest MSW waste in Rwanda. Recyclable materials such as plastic, paper, metal, and glass are another key source. This composition varies considerably across the country, due to differences in waste accounting, consumer attitudes, income level and urbanization (Figure 7-1). Organic waste in urban Rwanda represents between 64-74 percent of the total waste generated, which is higher than its proportion of the total solid waste for sub-Sahara Africa region (57 percent) (UNEP, 2018).

Table 7-1: ***Waste quantity and character of disposal in Kigali (Vice, Rugege, & Benitez, 2019)***

Type of waste	Waste quantity analysis	Collected and disposed (tonnes/day)	Collected and disposed (tonnes/year)
Organics	Green waste (organic material mostly yard-derived waste)	91	28,448
	Food waste	369	115,651
Recyclables	Plastic	20	6,211
	Paper & Cardboard	33	10,445
	Metal	2	774
	Glass	7	2,128
Other	Textiles	17	5,416
	Special care waste	1	387
	Other waste	74	23,201
C&D	Construction and demolition (C&D) waste	2	774
Total		**618**	**193,434**

Note: The above figures are however considered extremely conservative since the actual levels of waste generated are more than double these amounts (Vice, Rugege, & Benitez, 2019).

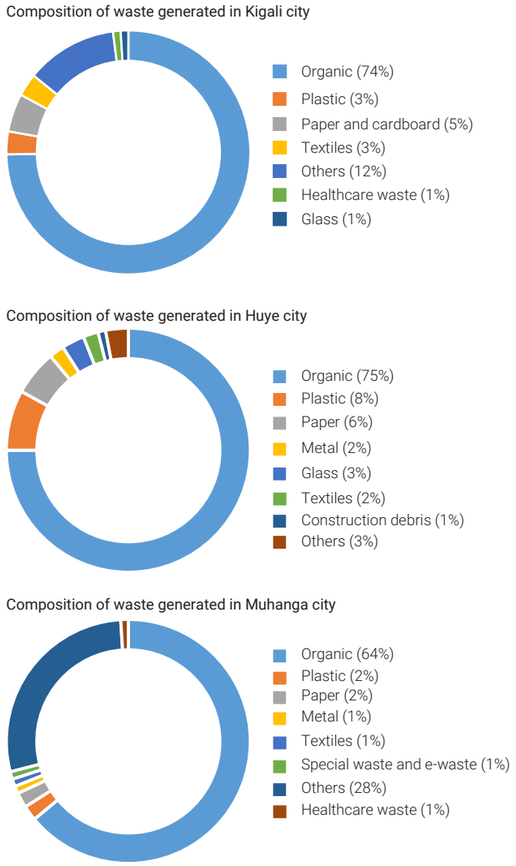


Figure 7-1: ***Composition of MSW waste generated in Kigali and secondary cities, Huye and Muhanga (GGGI, 2019); (Vice, Rugege, & Benitez, 2019)***

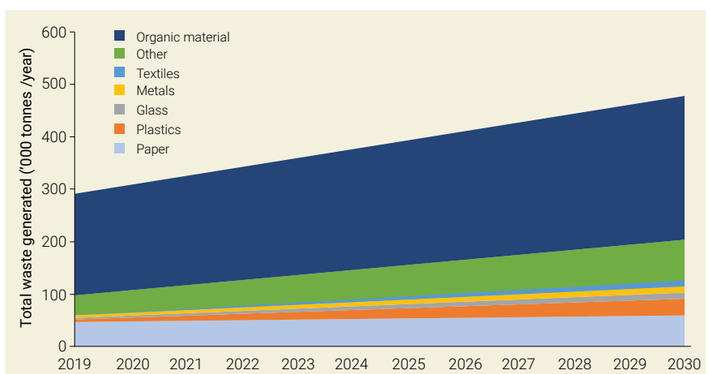


Figure 7-2: ***Projected waste generation by waste component (Rajashekar, Bowers, & Gatoni, 2019)***

Future solid waste flow

Waste generation is expected to increase with urbanization and population growth (GoR, 2020). Urban areas are expected to have the greatest waste generation compared to rural areas. Urban waste in Kigali will increase by 63 percent over the next ten years, from around 600-800 tonnes generated per day in 2019 to 1,300 tonnes per day by 2030 (Figure 7-2) (Rajashekar, Bowers, & Gatoni, 2019).

Solid waste collection

Most of the Rwandan population does not have access to proper waste management services and collection rates vary widely across the country. In high income countries, waste collection is close to 100 percent, while it is around 39 percent in low-income countries and 49 percent in Rwanda (UNEP, 2018); (NISR, 2018).

The collection of waste in Rwanda is largely outsourced and is carried out by private companies and cooperatives that collect waste and fees directly from households. Most solid waste collectors and transporters are found in urban areas. Indeed, by March 2020, 42 percent of all registered licenses for solid waste and transportation collectors were in Kigali city (Figure 7-3).

Solid waste disposal

For waste collected in Kigali city or urban areas such as Huye district, final solid waste disposal takes place either in an uncontrolled central landfill site or dumpsite (RALGA, 2016). Uncollected waste in rural or urban areas beyond Kigali city is often managed independently by households and may be dumped in the open, burned, or composted

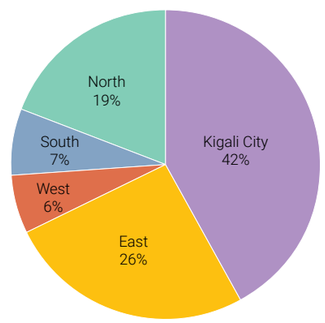
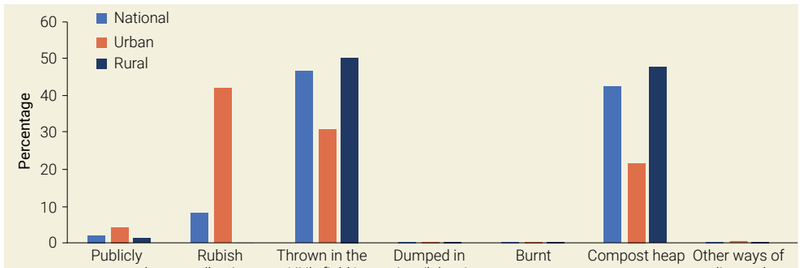


Figure 7-3: ***Distribution of solid waste collection and transportation operators (RURA, 2020)***

(Figure 7-4). Globally, nearly 40 percent of waste is disposed in landfills, about 19 percent is recovered through recycling and composting, and 11 percent is treated by modern incineration (UNEP, 2018). In Rwanda only 10.3 percent of solid waste is disposed of via private dustbins or publicly managed dumps (NISR, 2018).

According to a study by Rajashekar, Bowers, & Gatoni (2019), less than ten percent of this collected waste is recycled and an even lower percentage of organic waste is formally composted. Paper and plastic waste are recycled or reused. For instance, wastepaper is transported to the treatment plant located in Bugesera and transformed into hygienic toilet paper, while the plastics are transported to Mageragere or other landfills for recycling (GoR, 2016). There are currently five firms involved in sustainable waste disposal methods, up from just two in 2016 as shown in Table 7-2 (RURA, 2020).



Note: HH = House Hold

Figure 7-4: Waste management facilities in Rwanda, 2016/17 (NISR, 2018) ;

Liquid waste

Liquid waste is generated by public and private institutions and households. The main wastewater treatment and disposal systems in Kigali city and secondary towns are dominated by septic tanks, soak channels and direct discharges into natural wetlands (GoR, 2020). Hotels, hospitals, real estate, major governmental buildings, and some industries have their own wastewater treatment works (WWTWs) (GoR, 2018). There are about 161 wastewater treatment systems in Rwanda, with most of the systems concentrated in the city of Kigali (Figure 7-5) (REMA, 2020). These are small, often on-site treatment systems and several of them present environmental or public health concerns to the respective region (REMA, 2020).

As of 2021, there is no centralized wastewater treatment systems, but efforts to develop a centralized wastewater treatment for Kigali and secondary cities are being undertaken by Water and Sanitation Corporation Ltd (WASAC). One of which - the centralized sewage system of Kigali – is scheduled to be ready in 2024. The system to collect sewage from the central part of Kigali will consist of an 89 km sewer network and a 3.1 km trunk main sewer to transport the collected water to the wastewater treatment plant (WASAC, 2019). A list of projects planned for the construction of wastewater treatment plants and their capacity is presented in Figure 7-6.

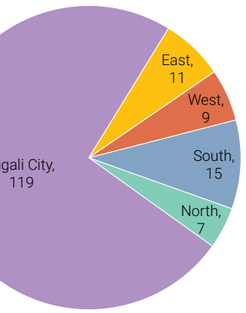


Figure 7-5: Distribution of waste water treatment works in Rwanda by province (REMA, 2020)

Table 7-2: List of solid waste recycling and compost operators (RURA, 2020)

Name of license	Type of Operation
Ecoplastic	Recycling
Agruni Ltd	Recycling
Green Care Rwanda	Compost & Recycling
Agroplastic	Recycling
Soft Packaging Ltd	Recycling

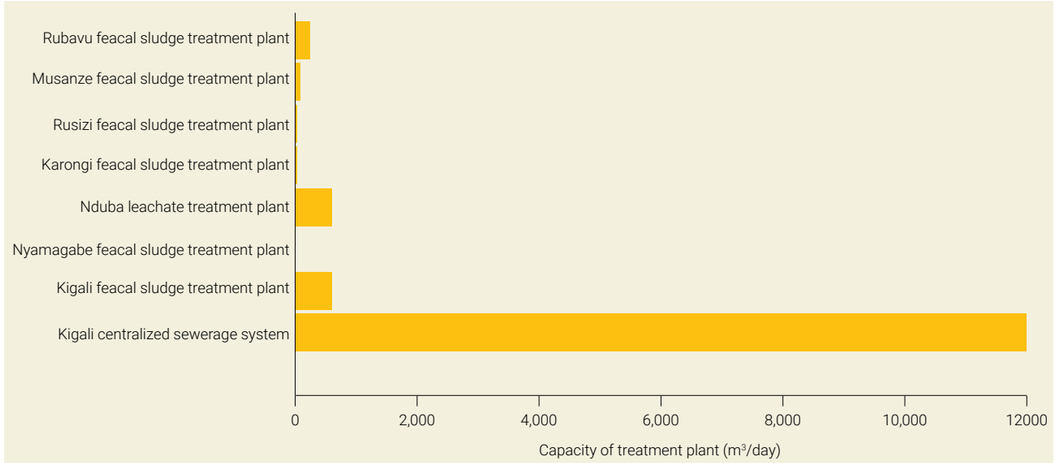


Figure 7-6: Planned projects for wastewater treatment plants in Kigali and secondary cities. Data from WASAC, 2021.

Medical waste

Healthcare waste includes all waste generated during medical activities. It includes waste produced by medical institutions, medical research facilities, laboratories, and outpatient clinics (REMA, 2014). According to the Ministry of Health (MoH) this waste is segregated, collected, and incinerated. The incineration ashes are placed in a cement-covered septic tank and disposed at appropriate landfill or public dumpsites. MoH has so far identified 34 incinerators in the country. Based on a health facilities assessment conducted across the country, 5,168 kg of medical waste is generated by in- and out-patients per day. This translates into 60,775,164 kg of medical waste per year (MoH, 2017). Of this, 74 percent is non-infectious waste, 24 percent is liquid waste and 1.3 percent is infectious or hazardous waste such as infectious material, sharps, pharmaceutical, radioactive, cytotoxic, chemical substances (MoH, 2017).

An inspection by REMA on the state of incinerators in the country and their services related to the incineration of hazardous waste, revealed that most incinerators are poorly managed. For example, Kanombe Incinerator (Kanombe District Hospital) was flagged for poor management of fly ash (contaminated ash); Butaro incinerator (Butaro District hospital) and Nyabihu incinerator identified with poor management and disposal of ashes in landfills; Nyanza incinerator (Nyanza District Hospital) and Nyamata incinerator (Nyamata District Hospital) highlighted for poor operation and management of ash. The commercial incinerators - Gatsata incinerator, Mageragere incinerator and Gakirage/Musha incineration services - hand the ashes over to a private company for disposal in a landfill or in the Nduba landfill.

Electronic waste (E-waste)

Collected electronic waste (laptops) for dismantling at EnviroServe, Kigali
Photo credit: EnviroServe

E-waste covers almost all types of electrical and electronic equipment (EEE) that enter the waste stream. Rwanda had an annual generation of 9,741 tonnes in 2017, of which 7,677 tonnes (82.9 percent) came from individuals, 597 tonnes (6.34 percent) from private institutions and 1,143 tonnes (12.14 percent) from public institutions (Mugabo, Khetriwal, & Magalini, 2017). The quantity of EEE by type put on the Rwandan market and the corresponding estimates of the amount generated in 2017 are presented in the Figure 7-7. Figure 7-8 shows the amount of EEE generated and the corresponding collection amounts in 2018 and 2019. During this period, the e-waste collection rate in the country was 15.4 percent in 2018 increasing to 19.3 percent in 2019.

Despite the current low collection rate of E-waste, demand for EEE is increasing significantly in Rwanda due to economic growth and modernization. Imports of EEE into Rwanda are expected to increase at the rate of 5.95 percent annually and may reach around 70,000 tonnes of waste by 2050 (Figure 7-9) (Mugabo, Khetriwal, & Magalini, 2017).

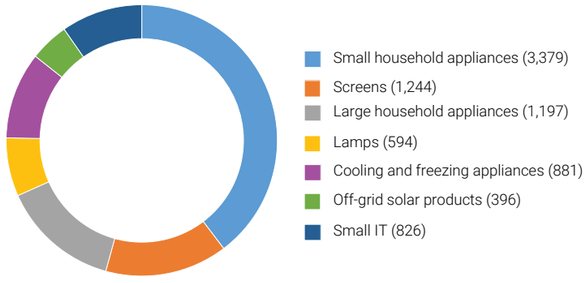


***Figure 7-7:** Tonnes of e-waste generated in Rwanda, 2017 (Mugabo, Khetriwal, & Magalini, 2017).*

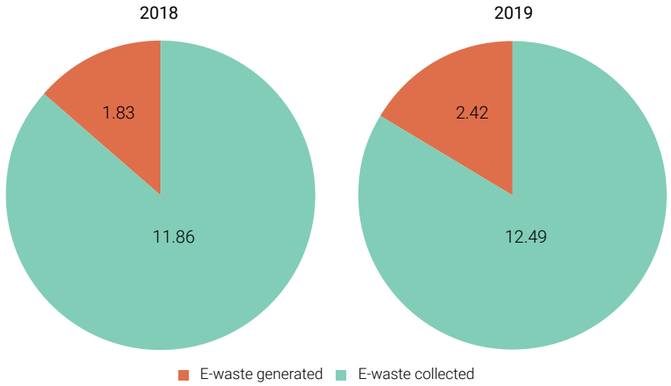


***Figure 7-8:** E-waste generation and collection (unit: 1,000 tonnes) in 2018 and 2019 in Rwanda. Data from EnviroServe Rwanda Ltd, 2021*

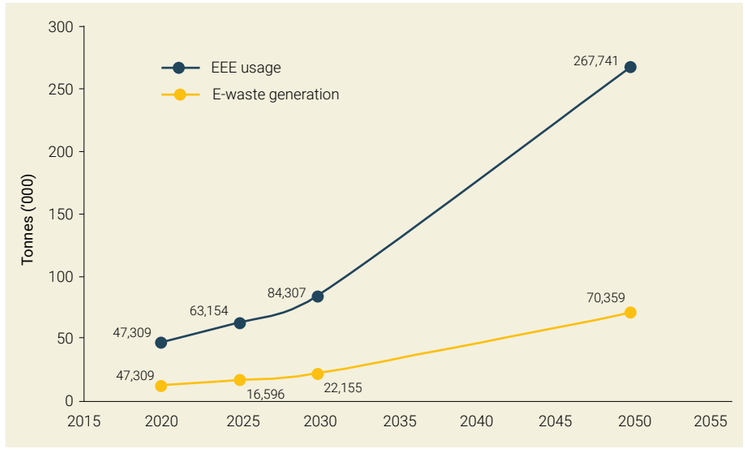


***Figure 7-9:** Estimated electrical and electronic equipment (EEE) usage and E-waste generation (Twagirayezu, Uwimana, Irumva, Nkundabose, & Nizeyimana, 2021)*

A technician on duty at the Rwanda E-Waste Recycling Facility
Photo credit: Rwanda Green Fund

7.3 Pressure and impact

Population growth, urbanization and the economic development are among pressures that produce increasing amounts of waste and overburden the existing waste management systems in the country. These pressures, added to other factors such as inadequate and faulty operation of existing landfills, lack of effective public participation and mismanagement of the waste sector budget provisions constrain sustainable waste management (GoR, 2021).

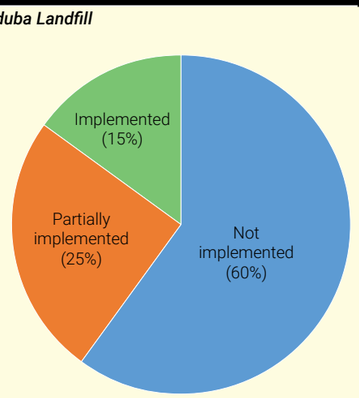
Waste management is an expensive service and requires significant financial investments, as well as good planning, management, and coordination between all levels of government and involved stakeholders. The government has initiated the construction of landfills in all cities and districts to improve solid waste disposal practices, but even the operating landfills are not environmentally sound (GoR, 2020). The Nduba landfill, which is the main and only waste disposal in the city of Kigali presents prominent waste management problems (Box 7-1). In addition, there is little public awareness of efficiency of waste disposal. As a result, waste management problems arise at all stages from waste generation, collection to disposal. Waste sorting at household level is non-existent despite government initiatives and attempts to raise awareness of waste sorting (Rajashekar, Bowers, & Gatoni, 2019).

Drivers of low collection and recycling capacity

Rates of collection and recycling activities are still very low, even though a large part of the waste contains organic and recyclable waste. The transition to improved recycling and collection is hampered by economic, regulatory, legal, and social barriers. These barriers are linked to existing consumption patterns, to inequalities between urban and rural in access to household waste collection services, to the high cost and availability of inputs for recycling, lack of appropriate facilities for waste recycling, highly competitive markets, and difficulties in selling recycled products (Rajashekar, Bowers, & Gatoni, 2019). Beyond economic and social barriers, there are also weaknesses in current legislation and support for circularity of products and materials, weak institutional capacity, management, and enforcement of waste regulations. For example, an attempt to enforce sorting of household waste in the city of Kigali in 2012 failed after a few months due to the lack of clear downstream sorting guidelines at the landfill, and the lack of necessary waste management infrastructures (Rajashekar, Bowers, & Gatoni, 2019).

Box 7-1: Audit on management of solid waste at Nduba landfill, March 2021

Municipal solid waste disposal from a truck at the Nduba landfill, 2019
Photo credit: Denis Rugege/EPI



A 2015 performance audit in the city of Kigali concluded that the management of solid waste at Nduba landfill had become an environmental and health hazard to the city. A follow-up audit in 2021, assessed progress on 20 recommendations highlighted by the 2015 audit as shown. Despite government investments of 5, 690, 402,136 RWf, the management of Nduba landfill still has persisting environment problems and implementation is proceeding at an extremely low pace. Some of the reasons include:

Solid waste at Nduba landfill is disposed of on the site by compacting and covering it with soil. This is done at least once in a week instead of at the end of every working day. The effect of this is the production of leachate and gases coming out of the compacted waste on the surface resulting in a bad odour and flies at the site.

Liquid wastes are disposed in pits, and they have become like small lakes. This contaminates ground and surface water. Faecal sludge ponds that are no longer in use, are not closed presenting a health hazard.

Drainage constructed to channel the leachate into new pits and protect the leachate overflow from the neighboring community around the landfill is inadequate and does not prevent the overflow of the leachate.

The extraction of lateritic soils used to compact the waste in the area reserved for the extension of the landfill and to leave the borrow pits covered, leads to soil erosion and environmental degradation.

(GoR, 2021)

Environment and health impacts

Inadequate waste collection, improper disposal, and inappropriate location of facilities have negative impacts on environmental and public health. Current uncontrolled landfills such as Nduba, and the old Nyanza landfill pollute the air, water, and soil with many harmful effects on the health of neighboring communities. The Nduba landfill contaminates groundwater due to the deep percolation of toxins and pathogens from leachate and septage. The hazardous fumes from waste combustion pollute the air and can lead to various health impacts in people (Vice, Rugege, & Benitez, 2019). These health impacts can range from mild psychological effects to severe morbidity, disability or death and depend on many factors, including the nature of the waste, the method of disposal, the duration of exposure, the population exposed and availability of mitigation interventions (Ziraba, Haregu, & Mberu, 2016).

Increased pressure due to COVID-19

Even before the COVID-19 pandemic, Rwanda's waste sector faced various challenges. The current pandemic continues to affect waste management, particularly due to the containment of the spread of COVID-19 and the limitations of business activities and population mobility. As a result, waste generation has shifted from industrial and commercial waste streams to residential and medical waste streams (IFC, 2020). In accordance with World Health Organization (WHO) and Rwanda government guidelines to reduce the spread of COVID-19, the use and production of personal protective equipment (PPE), such as gloves, masks, and disinfectant bottles increased. In addition, containment measures aimed at slowing the spread of the virus resulted in interruptions in waste management work and delayed the establishment of waste collection centers across the country such as e-waste (Kovacevic, 2020).

Although to date, no study has assessed the impact of COVID-19 on Rwanda's waste sector, the pandemic is expected to have adversely affected existing waste management systems in Rwanda.

In response, the GoR, in collaboration with the UNDP, has developed guidelines and initiatives to ensure that PPE, especially face masks used to combat the spread of the COVID-19 pandemic, are managed safely. One of the pilot projects of REMA and stakeholders is the initiation of general collection of PPEs. Local waste collection companies collect and dispose of used masks and gloves at the central collection center in Kabuye where they are kept before incineration.

Clean streets with pedestrian walkways within Kigali City
Photo credit: Brian Harries/Flickr

7.4 Responses

Keeping Rwanda clean

Despite the current challenges in the waste sector, the country has made great strides through several well-known waste related interventions, including, but not limited to, its renowned policy on the ban of plastic bags (Box 7-2), the E-waste Bill, and the national clean-up day (Box 7-3). Rwanda has also established a legal and regulatory framework for waste management and committed to several waste related multilateral environmental agreements.

Box 7-2: Plastic ban in Rwanda

Rwanda's plastic ban came into effect in 2008 and extended to anyone visiting the country. The main aim was to reduce plastic waste and promote a cleaner country. Poorly managed and disposed plastics damaged the environment through litter, and by contributing to flooding and poor water infiltration. The policy has made the production, sale and usage of plastic bags and packaging illegal, except for certain industries such as the medical and pharmaceutical industry. In 2019, the government passed a stricter law banning all single-use plastics. This stopped the manufacture and sale of plastic bottles, straws, coffee cups among others.

The plastic ban protects the environment, the economy, and the health of the population. Kigali is often considered the cleanest city in Africa and based on this markets itself as an eco-friendlier destination than its neighbours. In fact, the country has seen a steady boost in tourism since 2008.

However, the plastic ban is not without its drawbacks. The ban on single-use plastic packaging for food creates challenges for importers, manufacturers, traders, and consumers. Manufacturers or retailers, for example, are required to put in place mechanisms to collect and segregate used plastics for recycling. At an individual level, plastic has become a part of everyday life, and people found throwing away single-use plastic items are fined and must repair the damage caused. Regionally, some of Rwanda's neighbors are either lax in enforcing the plastic ban or fail to see the need for it. Therefore, smuggling of plastics remains a problem despite border controls. There are no primary plastic bag production industries in Rwanda following the prohibition laws enacted in 2008 and 2019. Currently, five major companies are involved in recycling plastic waste into new materials like trash bags, sheeting, agricultural tubes, silage bags, sacks, and plastic tubes.

Lessons learned

The key lesson from Rwanda is that a strong political will to enforce the plastic ban is essential. Multiple campaigns and efforts are underway to push countries to act on the reduction and recycling of plastic products, but too few countries in general have specific legislation that either impose controls on producers or manufacturers to reduce waste, adopt recycling or charge enough to disincentivize the purchase of plastic products.

(Whyte, et al., 2020) (Samantaray, 2021)

Box 7-3: National clean-up day (*Umuganda*)

Umuganda is a compulsory national cleaning day organised and enforced by the Rwandan government on the last Saturday of each month. This community service is important in terms of public involvement and government commitment to a clean environment. In East Africa, this exercise was unique to Rwanda, however, the idea was eventually copied by others like Tanzania and Nigeria (Kabera, Wilson, & Nishimwe, 2018). Besides waste management practices such as digging drainage ditches or gardening or street sweeping, a significant percentage of Umuganda efforts also center on environmental protections such as reforestation (Whyte, et al., 2020

Institution and legal framework

Waste management in the country is guided by principles centered on environmental protection, sustainability, and sanitation. The backbone of waste management activities in the country is the law on the environment determining the modalities of protection, conservation, and promotion of the environment in Rwanda. This is complemented by law on water resources and management, as well as national policies on sanitation, E-waste, environment and climate change, and the environmental health policy. Policy and guidelines development institutions such as the Ministry of Environment (MoE), Ministry of Infrastructure (MININFRA), Rwanda Environment Management Authority (REMA) and the Regulatory Utilities Authority (RURA) are largely involved in drafting policies and directives to be implemented by local administrative authorities including the city of Kigali, districts, sectors, local government bodies and the Water and Sanitation Corporation (WASAC) which participate in the implementation of waste management practices through involvement such the management of landfills and wastewater treatments. However, the fragmented nature of waste management regulation and enforcement means that policy goals, regulatory oversight and implementation are not always coherent (Rajashekar, Bowers, & Gatoni, 2019).

Transboundary waste management

Rwanda is a signatory of and has ratified several multilateral environmental agreements on waste management. For example, the Basel Convention on the control of transboundary movements of hazardous wastes and their disposal was ratified by Rwanda in August 2003; the National Implementation Plan for the Basel Convention on the control of transboundary movements of hazardous wastes and their disposal 2014 – 2021 was developed by REMA; and the Bamako Convention adopted under the auspices of the Organization of Africa Unity (OAU), which bans imports of hazardous waste into Africa. At the national level, the overreaching Law n°48/2018 of 13/08/2018 on Environment contains restrictions on export for recovery, import for final disposal, import for recovery, and for transit of waste. This law is supported by Instruction n° 01/04 of the Rwanda Bureau of Standards related to the issuance of quality certificates for imported goods and by Ministerial order n° 005/04/10/MN setting rules of calculation for entrance rights presenting the list of industrial chemical products or related admitted being imported in Rwanda (REMA, 2014).

Since August 2021, REMA has warned that hazardous waste entering the Rwandan market illegally will be returned to their country of origin. In addition, companies and industries involved in the trade of and transboundary movements of hazardous wastes were also reminded to have the required authorization from the competent authority for the transport of hazardous wastes (REMA, 2021).

Sustainable Development Goals (SDGs) and waste management

Waste management is a powerful driver of sustainable development. SDG 11 (Sustainable cities and communities) and SDG 12 (Responsible consumption and production) are particularly pertinent for SWM. Related indicators such as quantity and types of MSW waste managed or disposed of; waste generation per capita; quantity of waste recycled; hazardous wastes generated per capita and the proportion treated, are essential tools for monitoring waste management and environmental progress in a country. However, for the waste sector in Rwanda, the underlying datasets that should feed into the above indicators are difficult to obtain or even unreliable. According to the recent sustainable development report, 2021, Rwanda is on track to achieve SDG targets on hazardous waste management, but major challenges remain for MSW management and recycling interventions (Sachs, Kroll, Lafortune, Fuller, & Woelm, 2021).

Waste as resource: unlocking opportunities in the waste sector

The circular economy

Currently, waste in Rwanda is managed linearly, with the collection and disposal of waste in landfills forming the common practice. Waste generated by household and commercial entities is collected and sent to landfill with little formal recycling of inorganic waste or organic waste reprocessing (Whyte, et al., 2020). In addition, the domestic market for recyclables and reprocessed waste is nascent. According to the Circular Economy - Country Report for Rwanda, the waste sector is ranked among the main sectors with the greatest potential for the circular economy. Figure 7-10 highlights some recommendations for future growth in this sector (Whyte, et al., 2020).

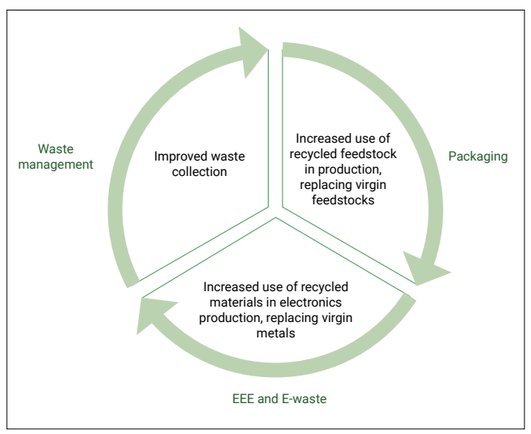


Figure 7-10: Circular economy activities in the waste sector (Whyte, et al., 2020)

Composting

Composting is a waste minimization strategy and the potential for waste reduction through this process in Rwanda is enormous (Whyte, et al., 2020). Compost has applications in agriculture, one of Rwanda's largest economic activities. In addition, the organic wastes used for compost make up more than half percent of the MSW collected and disposed of on a national level. Rwandan farmers use organic fertilizers in addition to chemical, which highlights the need of value-added strategies that turn organic waste into compost. Despite this, much of the country's organic waste still ends up in landfills when it could be used as organic fertilizers. Currently, very few firms in Rwanda have implemented projects for waste minimization through waste composting. An example of such an intervention is given in Box 7-4.

Box 7-4: Transforming waste into compost and ecological paver block in Huye District

Packaging of organic compost at Greencare, Huye District, 2021
Photo credit: Greencare

Greencare Rwanda Ltd, is a recycling company located in Huye District, which transforms biodegradable waste into organic compost, and plastics and sachets into ecological paver blocks. In collaboration with Huye district, the company started operations in 2017, and embarked on journey to transform waste into resources as a solution to several waste management issues facing the district. Waste in Huye was not professionally managed, the waste collection services were poorly organized and even the small amount collected was disposed of in an unhygienic manner and dumped mostly on the streets or in unmanaged landfill. This situation created several serious health and social threats including diseases, unbearable odors, leakage of pollutants into water sources, emissions of methane gas, and exposing waste pickers to toxic and hazardous substances. Greencare Rwanda, in collaboration with local authorities, implemented a sustainable solution for MSW management by organizing waste collectors and transforming waste generated at Huye dumpsite. Today, they produce 400 tonnes of compost per year, under the Grekompost brand, which it distributes to farmers across the country, and 2,560 m^2 of ecological paver blocks per year.

Some of the challenges include the lack of inclusion of stakeholders in the implementation of solid waste management activities, and the lack of an appropriate model or policy for the financing of innovative solid waste management projects. One of the solutions to these drawbacks is the development of policies and regulations regarding integrated solid waste management from waste generation to waste treatment in Rwanda.

(Nizeyimana Noel, CEO of Greencare Rwanda Ltd, 2021)

Integrated Waste Management (IWM)

An effective IWM system considers how to prevent, recycle, and manage solid waste in the most effective way to protect human health and the environment. It includes waste minimization and integrates elements of infrastructure, stakeholder participation and other strategic aspects, including political, health, institutional, social, economic, financial, environmental, and technical aspects of waste management systems (UNEP, 2018). Rwanda has set targets for the sustainable management of waste in the country including minimizing waste generation and safe disposal of waste. In the National Sanitation Policy Implementation Strategy 2016, the government aims to properly dispose of 80 percent of domestic waste by 2030 and is targeting a recycling rate of 40 percent for non-organic solid waste by the same time (MININFRA, 2016).

To achieve the above, Rwanda will need to consider strategies such as a national integrated and sustainable solid waste management strategy, which aligns with waste minimization in the country particularly in urban regions such as the city of Kigali. A 2019 study formulated an integrated waste process that can minimize 60 percent municipal solid waste landfilled, minimize the cost and greenhouse gas emissions from the waste sector, and maximize the value of current waste generated (Vice, Rugege, & Benitez, 2019) (Figure 7-11). This MSW flow system can be used to transform waste into a valuable resource through several processes during the pre-treatment and treatment and recovery of waste streams. For instance, the 304 tonnes per day (82 percent) of organics, 50 tonnes per day (13 percent) of recyclables, 16 tonnes per day (4 percent) of textiles, special care waste, and 1 tonne per day (50 percent) of construction and demolition waste, can be diversified instead of being disposed at Nduba landfill.

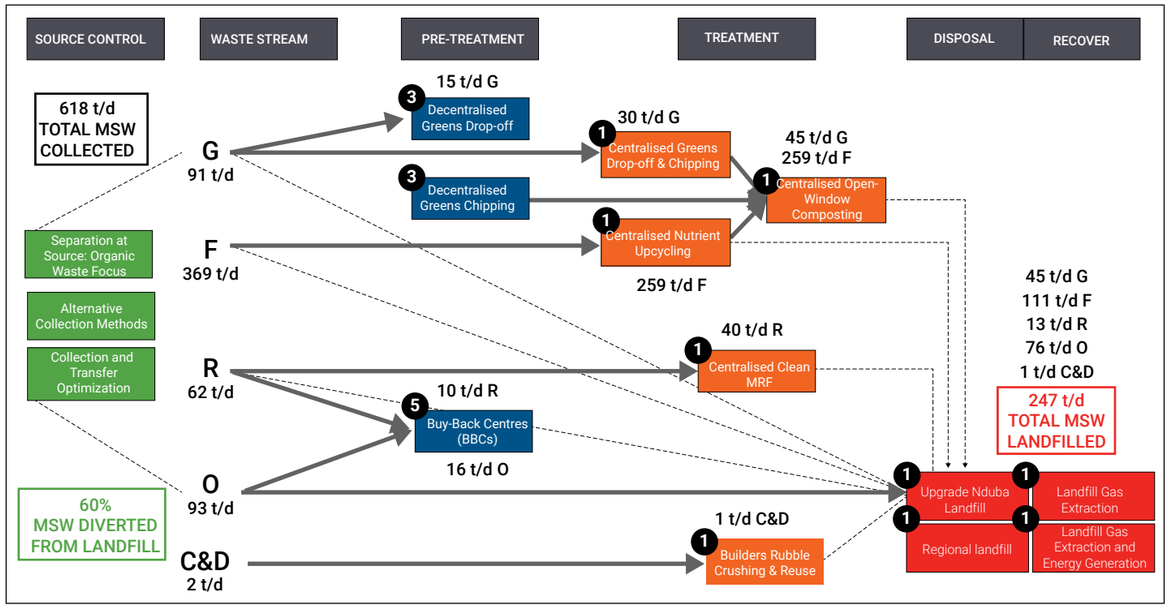


Figure 7-11: MSW Flow proposed for Kigali City (Vice, Rugege, & Benitez, 2019).
Note: The waste stream options formulation was based on different waste minimization categories 0: supply chain, 2: Reuse, 3: Recycling, 4: Recovery, 5: Disposal. Greens (G), Food Waste (F), Recyclables (R), Other Waste (O) and Construction and Demolition Waste (C&D).

7. 5 Conclusion and recommendations

Waste management is a major challenge in Rwanda. Although the pressure of population growth, high urbanization rates and economic development continue to increase the quantities of waste and overburden the existing waste management systems in the country. Factors such as inadequate and faulty operations of current landfills, weak environmental legislation related to waste management and its enforcement limit an effective waste management system, with the potential for adverse implications to human health and the environment.

The current COVID-19 pandemic has highlighted the importance of a sustainable waste management system, such collection, recycling, and waste management. Recommended actions for building an effective waste management system in Rwanda include:

- Develop a comprehensive system for obtaining up-to-date and reliable waste data, as the lack of robust data is a barrier to the development and implementation of efficient and cost-effective waste management practices.
- Develop a national integrated and sustainable waste management strategy that can guide waste management practices, integrate waste minimization, and complement other technologies for unlocking opportunities in the waste sector.
- Implement regulations and policies to ensure compliance at household and community level to achieve the National Sanitation Policy goals for waste disposal and recycling.
- Implement an efficient and appropriate collaboration between private operators and the government.

References

GGGI. (2019). Solid Waste Management in Secondary Cities of Rwanda - Muhanga & Huye: Situation assessment and potential intervention areas. Global Green Growth Institute (GGGI). https://gggi.org/site/assets/uploads/2019/08/Solid-waste-management-in-Secondary-Cities-of-Rwanda_A-situation-assessment-report_2019_Publication-.pdf

GoR. (2018). Third National Communication: Report to the United Nations Framework. Kigali, Rwanda: Government of Rwanda (GoR). https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

GoR. (2016). Performance audit report on management of solid and liquid (sewage) waste in the city of Kigali. Office of the Auditor General of State Finances, Rwanda. https://oag.gov.rw/fileadmin/user_upload/Performance_Reports/MANAGEMENT_OF_SOLID_AND_LIQUID__SEWAGE__IN_CITY_OF_KIGALI.pdf

GoR. (2021). Report of the Auditor General for the year ended 30 June 2020. Kigali, Rwanda: Government of Rwanda (GoR): Office of the l Auditor Genera of States Finances. http://documents1.worldbank.org/curated/en/123341613206823927/pdf/GLTFP-Final-financial-audit-report-for-the-year-ended-30-June-2020-pdf.pdf

GoR. (2020). Analysis and Vision Kigali Master Plan 2050. Government of Rwanda (GoR). https://bpmis.gov.rw/asset_uplds/kigali_master_plan/1_Kigali%20Master%20Plan_Analysis%20&%20VisionLowRes.pdf

IFC. (2020). COVID-19's Impact on the waste sector. International Finance Corporation (IFC). https://www.ifc.org/wps/wcm/connect/dfbceda0-847d-4c16-9772-15c6afdc8d85/202006-COVID-19-impact-on-waste-sector.pdf?MOD=AJPERES&CVID=na-eKpI

Kabera, T., Wilson, D. C., & Nishimwe, H. (2018). Benchmarking performance of solid waste management and recycling systems in East Africa: Comparing Kigali Rwanda with other cities. Waste Management & Research. https://pubmed.ncbi.nlm.nih.gov/30761955/

Kaza, S., Yao, L. C., Bhada-Tata, P., & Van Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Washington, DC: World Bank. Retrieved from https://openknowledge.worldbank.org/handle/109

Kovacevic, M. (2020). Rwanda setting example for electronic waste recycling. Retrieved June 23, 2021, from https://trade4devnews.enhancedif.org/en/impact-story/rwanda-setting-example-electronic-waste-recycling

MININFRA. (2016). National Sanitation Policy Implementation Strategy. Ministry of Infrastructure, Government of Rwanda. https://www.rura.rw/fileadmin/Documents/Water/Laws/NATIONAL_SANITATION_POLICY_IMPLEMENTATION_STRATEGY__DECEMBER_2016.pdf

MoH. (2017). Medical Waste Management Plan (MWMP): Prepared for the Stunting Prevention and Reduction Project. Kigali City: Ministry of Health (MoH), Government of Rwanda. http://www.rbc.gov.rw/fileadmin/user_upload/SPRP_MWMP_November_21_2017.pdf

Mugabo, C., Khetriwal, D. S., & Magalini, F. (2017). Sustainable Management of E-waste in the Off-grid renewable energy sector in Rwanda. https://www.gov.uk/research-for-development-outputs/sustainable-management-of-e-waste-in-the-off-grid-renewable-energy-sector-in-rwanda

NISR. (2018). 2016/2017 EICV5_Environment and Natural Resources. National Institute of Statistics of Rwanda. Kigali, Rwanda: National Institute of Statistics of Rwanda (NISR). https://www.statistics.gov.rw/publication/eicv-5-rwanda-poverty-profile-report-201617

Nizeyimana N., CEO of Greencare Rwanda Ltd. (2021).

Rajashekar, A., Bowers, A., & Gatoni, A. S. (2019). Assessing waste management services in Kigali. Jerry-Can Ltd. International Growth Center (IGC). https://www.theigc.org/wp-content/uploads/2019/11/Rajashekar-et-al-2019-paper.pdf

RALGA. (2016). Sustainable waste management system for improved local economic development in Rwandan cities: 100 Climate Solutions Project Campaign. Rwanda association of local government authorities (RALGA). https://regions20.org/wp-content/uploads/2016/10/100-SolutionClimateProject-WA_030.pdf

REMA. (2014). National Implementation Plan for the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal 2014-2021. Rwanda Environment Management Authority (REMA). http://climateportal.rema.gov.rw/sites/default/files/National%20implementation%20plan%20for%20the%20Basel%20Convention%20on%20the%20control%20of%20transboundary.pdf

REMA. (2020). Technical assistance in environment and natural resources management: water quality management. Kigali, Rwanda: Rwanda Environment Management Authority.

REMA. (2021). Hazardous waste entering the Rwandan market illegally will be returned to the country of origin – REMA warns. (Rwanda Environment Management Authority (REMA)) Retrieved August 20, 2021, from Rwanda Environment Management Authority (REMA): https://www.rema.gov.rw/index.php?id=77&tx_news_pi1%5Bnews%5D=128&tx_news_pi1%5Bday%5D=12&tx_news_pi1%5Bmonth%5D=8&tx_news_pi1%5Byear%5D=2021&cHash=9d-657544f9aadf7feda3f9635920255d

RURA. (2016). Kigali, Rwanda: Rwanda Utilities Regulatory Authority (RURA).

RURA. (2020). Water and Sanitation Statistic as of March 2020. Economic Regulation Unit. Kigali, Rwanda: Rwanda Utilities Regulatory Authority. https://rura.rw/index.php?id=104&tx_news_pi1%5Bnews%5D=922&tx_news_pi1%5Bday%5D=13&tx_news_pi1%5Bmonth%5D=7&tx_news_pi1%5Byear%5D=2020&cHash=45754c5ae-41abf63713f47bb64054d7b

Sachs, Kroll, Lafortune, Fuller, & Woelm, 2021

full reference needed

Samantaray, S. (2021). How Rwanda is leading the way in the fight against the plastic pollution crisis. Retrieved June 23, 2021, from The Vegan Review: https://theveganreview.com/rwanda-leading-way-fight-against-plastic-pollution-crisis/

Twagirayezu, G., Uwimana, A., Irumva, O., Nkundabose, J. P., & Nizeyimana, J. C. (2021). Current Status of E-waste and Future Perspective in Developing Countries: Benchmark Rwanda. Energy and Environmental Engineering, 1-12. doi: 10.13189/eee.2021.080101 https://www.hrpub.org/download/20210430/EEE1-14522440.pdf

UNEP. (2018). Africa Waste Management Outlook. Nairobi, Kenya: United Nations Environment Programme (UNEP). https://www.unep.org/ietc/resources/publication/africa-waste-management-outlook

Vice, M., Rugege, D., & Benitez, P. (2019). Rapid Assessment & Options Analysis: Waste Disposal in the City of Kigali. World Bank. https://www.wasac.rw/fileadmin/user_upload/Kigali_Centralised_Sewage_System.pdf

WASAC. (2019). Kigali, Rwanda: Water and Sanitation Corporation Ltd (WASAC). https://www.vei.nl/partners/wasac

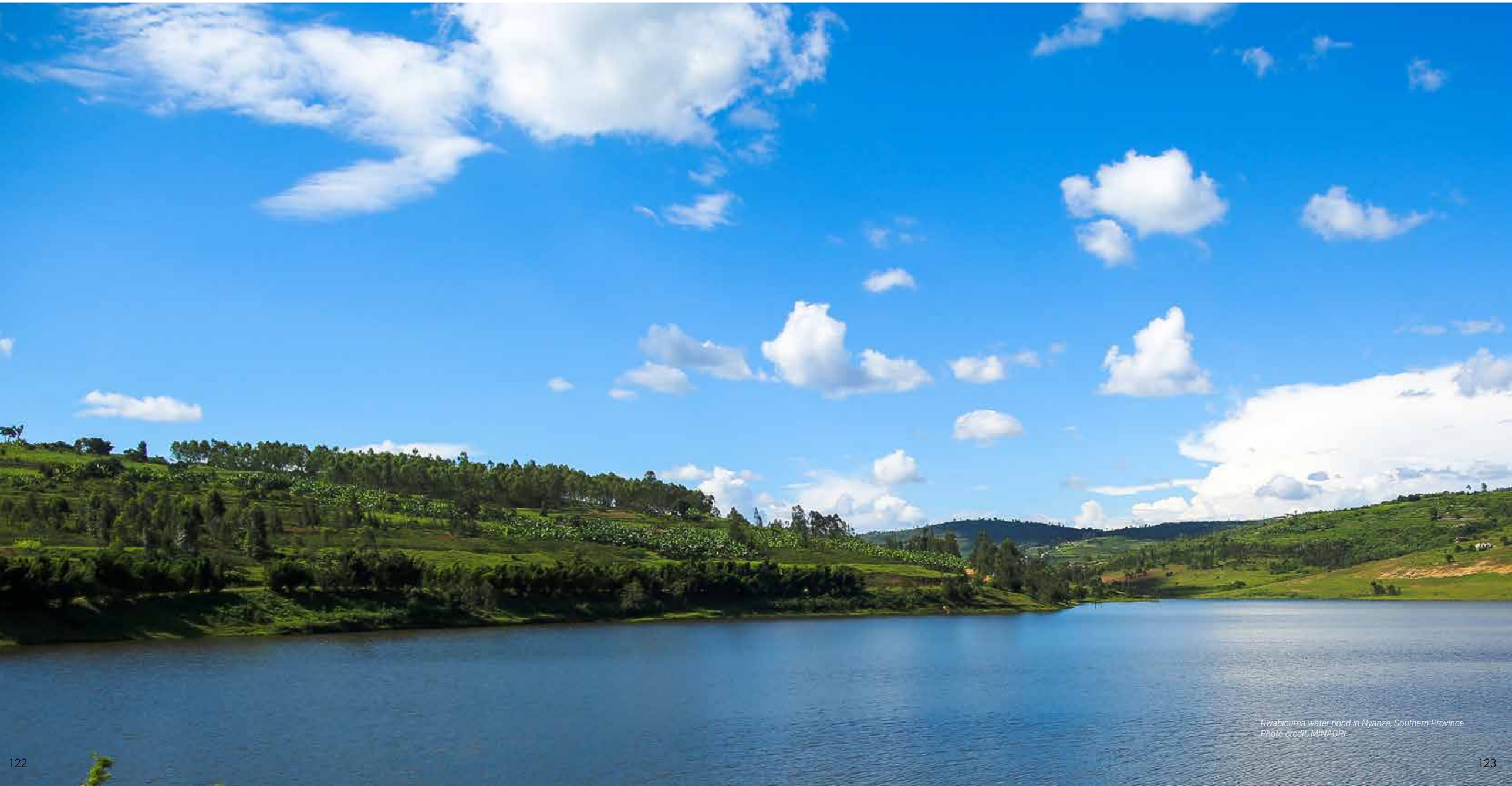
Whyte, C. R., Irakoze, G., Katanisa, P., Desmond, P., Hemkhaus, M., Ahlers, J., . . . Artola, I. (2020). Circular economy in the Africa EU cooperation - Country Report for Rwanda. European Union cooperation. https://circulareconomy.europa.eu/platform/en/knowledge/circular-economy-africa-eu-cooperation-rwanda-report

Ziraba, A. K., Haregu, T. N., & Mberu, B. (2016). A review and framework for understanding the potential impact of poor solid waste management on health in developing countries. Archives of Public Health. https://www.researchgate.net/publication/311360323_A_review_and_framework_for_understanding_the_potential_impact_of_poor_solid_waste_management_on_health_in_developing_countries

Locals participate in landscape restoration under the auspices of the "Green Amayaga Project"
Photo credit: REMA/Flickr

Chapter 8:

Air and Water Quality



Rwabicuma water pond in Nyanza, Southern Province
Photo credit: MINAGRI

8.1 Introduction

Air and water pollution are major environmental problems that contribute to a significant number of deaths and diseases. This chapter reports on the state of air and water quality in Rwanda, it highlights the effects of air and water pollution on health and presents current and future pressures and government responses.

8.2 Air quality

The government is committed to preserving air quality, combating air pollution, and is taking important initiatives to identify sources of air pollution and improve national levels of air quality (REMA, 2020). This commitment is important because good air quality contributes greatly to human wellbeing and the health of the ecosystems.

In Rwanda, air pollutants are emitted from a wide range of economic sectors such as transport, energy, industry, and from natural sources such as volcanic eruptions, dust storms, and wildfires. Once released into the atmosphere, pollutants undergo physical and chemical changes that impact the quality of ambient air and lead to air pollution. This pollution is a complex mixture of particles and gases that exist in our atmosphere at different concentration ranges. The pollutants of greatest concern are particulate matter ($PM_{2.5}$ and PM_{10}), Nitrogen dioxide (NO_2) and ground-level Ozone (O_3). They can be classified as outdoor or indoor air pollutants depending on the source.

Status and trend

For most parts of the country, the concentrations of pollutants in indoor and outdoor air are slightly above or within safe limits of national air quality standards, but above indicative levels of the World Health Organization (WHO) (Figure 8-1). Exposure to poor air is higher in urban than rural areas of the country. Air quality assessments by ground-level monitoring stations and satellite sensing indicate that particulate matter and nitrogen oxides are the main ambient air pollutants that regularly exceed standards that protect human health. Nitrogen oxides are higher than prescribed standards near congested roads, especially in Kigali city, while background particulate concentrations are high both in rural and urban areas of the country (REMA, 2018).

Ambient air pollutants

Ambient air refers to outdoor air and its pollutants and is mainly composed of emissions from the combustion of fossil fuels from industry and transportation. Particulate matter is one of the most harmful air pollutants and is often used as the primary indicator of air quality. Satellite sensing data from 2019, indicated that the annual average concentrations of fine particulate matter ($PM_{2.5}$) in Rwanda was 36.2 µg/m³ (HEI, 2019a). Since 2010, this level has remained slightly above or within the safe limits of the national air quality standard for PM2.5 which is 35 µg/m³. However, it is much above the 10 µg/m³ levels recommended by the WHO. An overview of air quality in the city of Kigali monitored at ground level is presented in Figure 8-2, and a detailed list of national case studies on ambient air, carried out at ground level is given in Table 8-1.

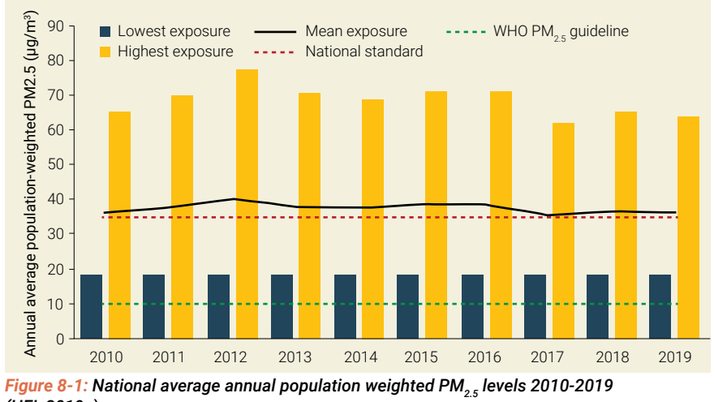


Figure 8-1: National average annual population weighted $PM_{2.5}$ levels 2010-2019 (HEI, 2019a)

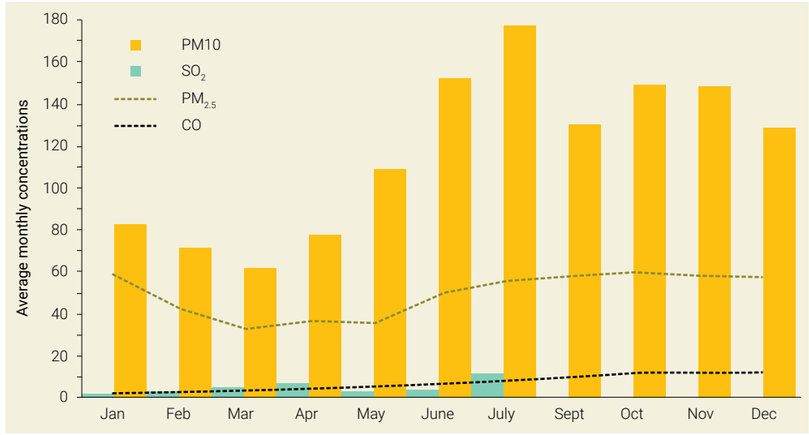


Figure 8-2: Ground-level measurement for air quality in the city of Kigali, during 2020
Note: Data was not available for August. SO_2 measurements were only available for January-July. The units of measurements for PM $_{2.5}$ and PM_{10} are µg/m³ and CO is ppm. Data Source: REMA, data from Kigali reference station 2020

Table 8-1: Studies of ground-level measurements of ambient air in Rwanda 2009-2020 (REMA, 2018), (Subramanian, et al., 2020)

Study	Location	Pollutant	Sampling period	Sampling method	Mean concentration	Notes
Subramanian, et al., 2020	Kigali	$PM_{2.5}$	March 2017-July 2018	RAMP monitors & black carbon monitors	52 µg/m³	$PM_{2.5}$ levels exceeded WHO Guidelines
		Black carbon			4 µg/m³	
Kalisa et al. 2017	Kigali	$PM_{2.5}$	April –June 2017	3 months gravimetric sampling	133µg/m³ and 156µg/m³	$PM_{2.5}$ and PM_{10} levels exceeded WHO guidelines
	Musanze	PM_{10}			45µg/m³ and 54 µg/m³	
Kalisa et al., 2017	Kigali	Ozone	2009-2011	Continuous monitoring	58.3µg/m³	O_3 levels rose, and the maximum temperature coincided with the peak of ozone during all three years studied.
DeWitt, 2016	Musanze Mt. Mugogo	BC	Continuous monitoring	Continuous monitoring	-	Black carbon levels were close to those in major US
Nduwayezu et al., 2015	Kigali-Nyamagabe	O_3, NO_2, SO_2, CO	9 months (2012-2013)	9 months Gray Wolf-Advanced Sense HVAC	NO_2 (0.119-0.050) O_3 (0.033 – 0.009) CO (3.148 – 0.000) All in ppm	Large amounts of released air pollutants were from both petrol and diesel vehicles (Kigali city)
Henninger, 2013	Kigali	PM_{10}	Feb to March 2009	2 months gravimetric and SEM testing	650µg/m³	The concentrations of PM_{10} in Kigali were greater than WHO limits
Nsengimana et al. 2011	Kigali	PM, NO_2, SO_2, CO, O_3	-	Literature review	NO_2 - 15-20µg/m³	The air quality in Kigali City was found to be at a favorable level compared to most countries in the world
Henninger, 2009	Kigali	PM_{10}	Feb 2008	2 months of mobile measurement	1,013µg/m	PM_{10} in Kigali were greater than the WHO limits

Indoor air pollutants

Indoor air pollution is a mixture of particles and gases resulting mainly from the incomplete combustion of fuels used in homes. A survey conducted in July and August 2018 to investigate particulate matter (PM) and carbon monoxide (CO) in 40 households in Nyarugenge district, found that in 90 percent of the households in which monitoring was carried out, the average concentrations of pollutants were 93 µgm^3 and 35.1 ppm for PM2.5 and CO, respectively and exceeded the WHO air quality for 24-hour values (Kabera, Bartington, Uwanyirigira, Abimana, & Pope, 2020). Similar country-wide studies confirm that the level of pollutants in homes is excessively high and that most of the Rwandan population is regularly exposed to dangerous levels of indoor air pollution. The levels of $PM_{2.5}$, are estimated to be between 50 and 200 µg/m^3 in homes using charcoal and wood, and between 40 and 80 µg/m^3 in homes that use propane gas for cooking and kerosene for lighting (Gasore, DeWitt, Safari, & Irankunda, 2018).

Pressures and impact

Air pollution is complex and originates from a variety of sources, including pollutants from neighboring countries such as Uganda and Democratic Republic of Congo (EC, 2018). In Rwanda, the main sources of anthropogenic air pollution are the transport, energy, and industry sectors (REMA, 2018). Other sources include agricultural emissions, charcoal production, brick kilns and kerosene lightning.

Transport sector

The transport sector remains a major source of air pollution in Rwanda, especially in urban areas like the city of Kigali. Vehicles emit a range of pollutants, the main ones being NO_2, PM_{10} and $PM_{2.5}$, CO and unburned hydrocarbons (HC). The main contributor to air pollution linked to transport are the old and used motor vehicles imported with poor or degraded emission control technology (REMA, 2018). Vehicles manufactured before 1999 contribute 58 percent of NOx emissions and 66 percent of PM_{10} emissions (Fabien, 2019).

Energy sector

Despite numerous interventions by the government through the EDPRS II and the Rwanda Energy Group to promote modern fuel-efficient technologies, Rwanda is still among the top ten countries with the highest proportion of households cooking with solid fuels (HEI, 2019a). The use of wood and charcoal for cooking is a significant source of indoor air pollution and contributes to elevated background concentrations of PM_{10} and $PM_{2.5}$ (EC, 2018). More than 80 percent of the population still use either wood or charcoal for cooking and the target is to halve this to 42 percent by 2024 (MININFRA, 2020). It is anticipated that the shift from solid fuels to cleaner energy technologies like liquefied petroleum gas, biogas or solar power generation will potentially lead to reductions in indoor air pollution levels in the country.

Industry sector

Most polluting emissions from the industrial sector come from the manufacturing and construction industries (REMA, 2018). Emissions from the manufacturing industry are mainly associated with dust and particulate matter (PM_{10} and $PM_{2.5}$), while the construction industry generates pollutants such as NO_2 and PM_{10} from its energy consumption. Mines and quarries also generate high emissions, especially dust and PM_{10}. In general, according to the Inventory of Sources of Air Pollution Report, these emissions are local and considered relatively low (REMA, 2018). However, against the background of rapid economic growth, the industrial sector can be projected as a major source of air pollution in Rwanda.

Black smoke emissions from a vehicle's exhaust on a road in Kamonyi district, Rwanda.
Photo credit: Emmanuel

Impacts of air pollution on human health

Even at low doses, major air pollutants (PM, NOx, and ozone) are harmful to human health and ecosystems (WHO, 2016a). Exposure to these pollutants is strongly correlated with an increase in mortality (early death) and morbidity (ill health) caused by cardiovascular and respiratory diseases, such as stroke, ischemic heart disease, cancer, acute respiratory infections, and chronic obstructive pulmonary disease (COPD) (WHO, 2019a). According to the Ministry of Health 2020 report, these non-communicable diseases were the second leading cause of mortality in Rwanda (Figure 8-3), while respiratory diseases were the leading cause of morbidity in Rwanda in 2019 (Table 8-2) (HEI, 2019b) (MoH, 2020).

These trends are reflected at a global level where about seven million people die prematurely each year from the effects of both indoor and outdoor air pollution (WHO, 2018a). This makes air pollution a leading cause of risk of death at the global level after high blood pressure, smoking and unhealthy diet (HEI, 2020).

In 2019 air pollution led to 9,290 deaths in Rwanda (HEI, 2019a) (HEI, 2020). The proportion of the specific causes of premature deaths attributable to air pollution in Rwanda is detailed in Figure 8-4.

Data from the Health Effect Institute (HEI) shows that the proportion of deaths attributable to outdoor air pollution increased by 33 percent between 2010 and 2019. However, the proportion of deaths attributable to household air pollution decreased by around two percent between the same time frame (Figure 8-5). In general, the exposure to air pollution on the Rwandan population represented a loss of almost 11 months of life expectancy for outdoor particulate matter, and a loss of almost one year and six months for the exposure to household air pollution in 2017 (HEI, 2019b). This underscores the importance and growing need to enforce current national and health policies that can mitigate air pollution in the country.

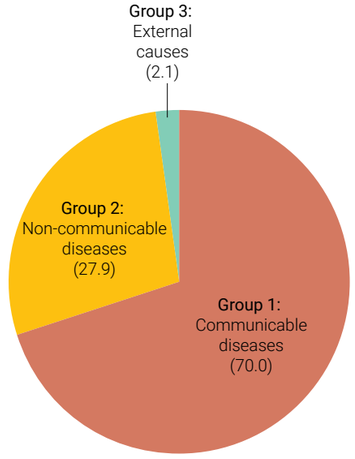


***Figure 8-3:** Percentage distribution of deaths causes by three broad groups in Rwanda, 2019 (MoH, 2020).*
***Note:** Group 1: Infectious and parasitic diseases such as tuberculosis, pneumonia, maternal/perinatal causes. Group 2: Non communicable diseases such as cancer, diabetes, heart disease, stroke; and mental health conditions. Group 3: Injuries such as road accidents, homicide, and suicide.*

***Table 8-2:** Top ten causes of morbidity in health facilities in Rwanda, Jul 2019 to Jun 2020 (MoH, 2020)*

Disease Group	Number of Cases	Percentage
Respiratory disease	4,194,296	24.2
Intestinal parasites	1,291,591	7.5
Malaria cases	1,050,399	6.1
Bone and joint diseases / injuries	1,048,692	6.1
Skin disease	962,833	5.6
Oral disease	905,248	5.2
Gastritis and duodenitis	708,729	4.1
Diseases of the urinary tract system	697,342	4
Eye disease	680,453	3.9
Diarrhea	527,792	3.1
Other diseases	5,235,091	30.3
Total cases	17,302,466	100

47 percent of COPD deaths
19 percent of diabetes deaths
24 percent of ischemic heart disease deaths
40 percent of lung cancer deaths
17 percent of stroke deaths

***Figure 8-4:** Percentage of deaths by cause attributed to air pollution in Rwanda, 2017 (HEI, 2019b).*

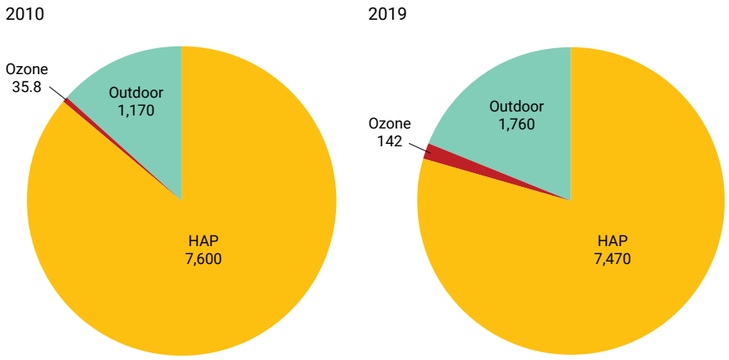


Figure 8-5: Number of deaths attributed to air pollution (ozone, outdoor PM2.5 and household air pollution (HAP) in Rwanda (HEI, 2019a).

Impacts of air pollution on children

The effects of air pollution differ depending on the group of people (Box 8-1). However, the health effects are more severe for people who are already sick or vulnerable - such as children. Air pollution is associated with an increased risk of low birth weight and preterm birth, which are the main risk factors for infant mortality (WHO, 2019a). In 2019, air pollution contributed to an estimated 476,000 infant deaths worldwide, out of which 1,700 infants were in Rwanda (State of Global Air, 2020).

Box 8-1: Indoor air pollution and fatal daily household habits: A report of two cases report in Kigali

The two cases discussed demonstrate the acute and chronic health impacts due to IAP in Kigali. They were investigated during forensic summer school in Kigali, through a cooperation project between the Institute of Legal Medicine in Hamburg, Germany and the University of Rwanda.

Case 1

An unidentified man was found dead near the roadside in Kigali, Rwanda and taken to the Kigali Police Hospital Mortuary for further investigation. No other information was available. There were no signs of trauma or injection marks and no conjunctival or oral mucosa bleeding. The autopsy findings revealed the cause of death was pulmonary insufficiency caused by severe chronic anthracosis, COPD and pulmonary fibrosis, complicated by purulent bronchitis and confluent bronchopneumonia.

Case 2

A father was found close to the entrance of a two-roomed house, while his wife and 7-month-old infant were found in the rear end of the house. The windows and the door were completely closed. Next to the mother and the child, a cooking station that had been prepared with firewood was found. The mother and the child were already dead, and the father died shortly after being taken to the hospital. The autopsy of the father showed no fatal pathologies, except a slightly enlarged heart and a moderate coronary artery disease. The postmortem blood analysis revealed a 77 percent and 40 percent toxic CO-poisoning of the mother and of the child, respectively. The result of COHb analysis of the father was less than 10 percent, as he had survived for several hours. The cause of the death was acute carbon monoxide poisoning. The motive of death was defined as unnatural.

(Antonia, Alexandra, Herbert, Klaus, & Janvier, 2019)

Impact of measures to contain COVID-19 on air quality

The current COVID-19 pandemic has led to observable and positive global effects on air quality (Brunekreef, et al., 2021). The main reasons were due to some of the drastic measures and policies implemented such as the stay-at-home orders. The first stay-at home order in Rwanda was in effect from March 21 to May 4, 2020, and the second in January 2021. The transport, energy as well industrial sectors were among the hardest hit by these lockdowns. In 2020, the number of flight passengers in Rwanda fell by 17 percent and aircraft movements decreased by 12 percent compared to 2019 (MININFRA, 2020). Google mobility data also indicated that most of the Rwandan population stayed away from businesses, parks, shopping centers, and workplaces (Figure 8-6).

These restricted activities resulted in a drastic decrease in both vehicle mobility and the burning of poor-quality fuels across the country (MININFRA, 2020). Thus, during the lockdown period, Rwanda experienced a substantial temporal decrease in air pollution (REMA, 2020). This drop was approximately 20 percent of the monthly average concentrations of $PM_{2.5}$ compared to the same periods in 2017 and 2018. Before the lockdown, in February 2020 average $PM_{2.5}$ concentration was recorded at 43.3 µg/m^3, and this value fell to 36 µg/m^3 during the lockdown period and rebounded to 49.8 µg/m^3 in June 2020 after the lockdown. According to (Kalisa, Sudmant, Ruberambuga, & Bower, 2021) $PM_{2.5}$ emissions dropped by 33 percent with the imposition of the first lockdown (22nd March to 4th May) and dropped by 21 percent over baseline levels during the

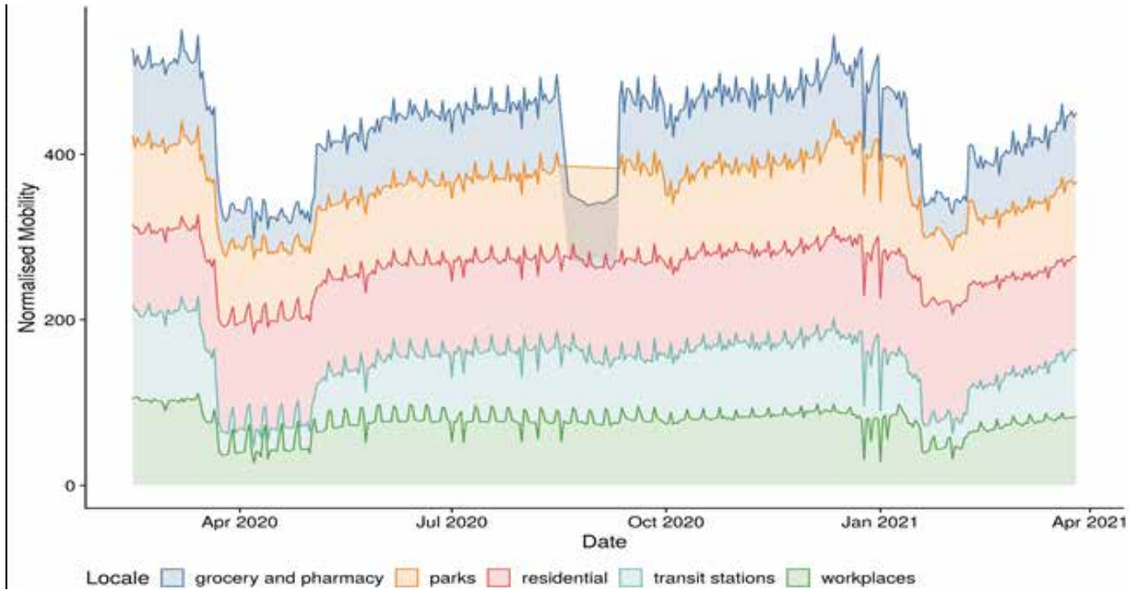


Figure 8-6: Mobility in Rwanda during the COVID-19 pandemic, January 2020 - April 2021 (WHO, 2021)
Note: Data were obtained from Google mobility datasets.

Clean skies in Kigali, Rwanda during lockdown
Photo credit: REMA

partial lockdown (5th May to 3rd June). While these changes in $PM_{2.5}$ concentrations may have been influenced by other factors including the weather conditions, studies across the world have revealed a link between COVID-19 control measures and reductions in air pollution (Venter, Aunan, Chowdhuru, & Lelieveld, 2020). Figure 8-7 and Figure 8-8 show the daily fluctuation in $PM_{2.5}$ concentration in Kigali before, during and after the lockdown periods.

The COVID-19 lockdowns have re-emphasized the impacts of transportation on air quality. To that end, it is important that lessons for best practice in air pollution control be implemented in Rwanda (UNDP, 2020). The following are recommended:

- Enforce bus lanes according to plans and emphasize the use of public transport during peak hours,
- Advocate the use of public transport, for government institutions and other parastatal organizations,
- Develop policy instruments to support the reduction of emissions from the transport sector

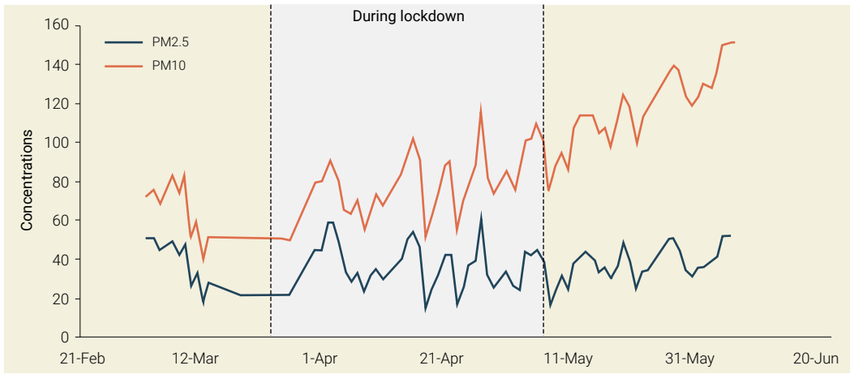


Figure 8-7: Daily $PM_{2.5}$ and PM_{10} concentration in Kigali, before, during and after the full lockdown, 2020.
Source: REMA, data from Kigali reference station 2020.

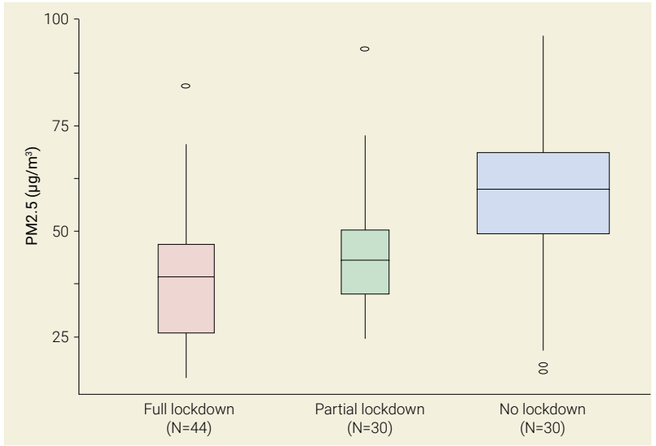


Figure 8-8: $PM_{2.5}$ during full lockdown, partial lockdown and without lockdown in Kigali (Kalisa, Sudmant, Ruberambuga, & Bower, 2021).
Note: Each box covers 50 percent of daily recorded values. The middle line represents the median. The lines extending about and below each box are set to 1.5 times the interquartile range.

Responses

Air quality monitoring

The government has taken several preventative measures to combat air pollution since the publication of the first State of Environment and Outlook Report in 2009. In previous years, the country lacked reliable air quality data due to limited monitoring. However, this changed with the launching of the Rwanda Air Quality and Climate Change Monitoring project in 2018 (EC, 2018) (MINEDUC, 2021). It is a joint project between REMA and the Ministry of Education and had the key objective of establishing an air quality monitoring system in the country. REMA has set up an air quality monitoring instruments system that provides data (real-time air quality index) on air quality across the country. The data is also accessible on the "Rwanda AQI" application so that users can compare ground observation data with satellite data. This development has led to tangible improvements in air quality data ultimately supporting law enforcement activities for air pollution control and enhancing expertise in climate change and air quality research in Rwanda (EC, 2018).

Car free days and electric vehicles

Other government responses have included initiatives in the energy and transport sectors. In the transport sector, the government has recently focused on green cities, sustainable services, and electric mobility. A car-free day was introduced in the city of Kigali. This initiative decreased the concentrations of particulate matter (PM2.5 and PM10) near car-free roads by about 50 percent on car-free days compared to normal days (Subramanian, et al. 2020). The initiative expanded and is now held twice a month to promote the use of non-motorized transport (GGGI, 2019). In 2018, the first electric motorcycles and cars were introduced to the Rwandan market through electric mobility initiatives (REMA, 2020). In April 2021, a transport policy was ratified, and the Cabinet approved an electric mobility strategy that contains tax incentives for electric mobility inputs, lower electricity tariffs and other incentives (Kalisa, Sudmant, Ruberambuga, & Bower, 2021).

Laws and regulations

The 2016 Air Quality Law sets the framework for the regulation and prevention of air pollution and mandates REMA to regulate air quality and improve the health and well-being of its population (REMA, 2020). Within this framework, Rwanda Standards Board (RSB) has adopted the East African Standards (EAS) on air quality and air pollution control as follows:

- EAS750: 2010 Air Quality - Emissions from cement factories - guidelines
- EAS 751: 2010 Air quality - Specification
- EAS 752: 2010 Air quality - Tolerance limits of emission discharged to the air by factories

Air quality and the Sustainable Development Goals

Exposure to air pollution and its impact on health is a measurable and effective indicator for tracking the progress of several Sustainable Development Goals (SDGs) and their associated targets on the goals for health, energy, and cities. The key indicators of interest are mortality due to air pollution (SDG 3.9.1); levels of fine particulate matter (SDG 11.6.2); and the proportion of the population relying on clean fuels (SDG 7.1.2).

According to the Health Effects Institute, Rwanda recorded only 0.6 percent progress in reducing mortality due to air pollution between 2017 and 2019. Further, the percentage of population relying on clean fuels for cooking increased from 0.9 to 2.0 percent between 2013/14 and 2016/17 (Figure 8-9). These findings suggest that Rwanda needs considerable efforts to achieve the air quality related SDGs goals by 2030. This effort will depend, among other things, on monitoring the state of air quality, establishing effective air quality standards, and strengthening the capacity for enforcement and compliance.

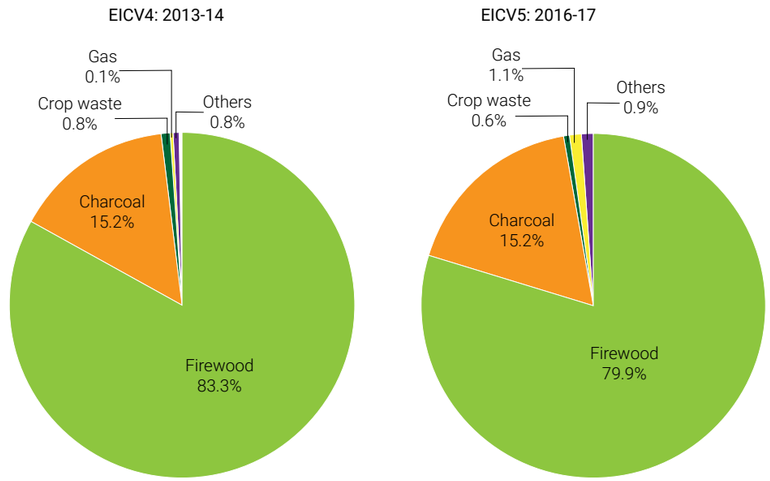


Figure 8-9: Rwanda progress towards Indicator 7.1.2: The proportion of the population relying on clean fuels (NISR, 2016), (NISR, 2018).
Note: Data indicates the proportion of the population relying on clean fuels for cooking.
EICV: Integrated Household Living Conditions Survey.

8.3 Water Quality

Adequate water, of good quality and improved sanitation are essential elements in promoting public health. The government is committed to achieving universal access to safe drinking water and sanitation as guided by Vision 2050 which aims to ensure a high standard of living for all Rwandans; improve quality of life, modern infrastructure, and ensure transformation for prosperity.

The state of water quality in Rwanda

Ambient water quality measurements provide a picture of the health of waterbodies and help identify pollution hotspots. Water quality can be assessed directly by measuring the concentrations of physicochemical and biological pollutants.

The discussion in the sections that follow will report on water quality by focusing on key global indicators that inform water quality: dissolved oxygen, electrical conductivity, hydrogen potential (pH), total phosphorus or dissolved inorganic phosphate and total nitrogen or dissolved inorganic nitrates which are used as common indicators of water quality included in Target 6.3.2 of the Sustainable Development Goals; in addition to *Escherishia coli* (*E. coli*), total suspended solid (TSS), and turbidity which are relevant indicators of sedimentation and contamination of Rwanda's water resources.

These parameters indicate the state of waterbodies (rivers, lakes, and groundwater) in the country with good ambient water quality. The measured parameters are compared to the national target levels, and if values meet targets of 80 percent of permissible values for all the parameters, the water body is classified as good. A "good" water quality indicates an ambient water quality that does not adversely affect the functioning of the ecosystem or human health.

The estimates are based on an index of outcome data on five core parameter groups:

- Oxygen (dissolved oxygen)
- Salinity (electrical conductivity)
- Nitrogen (total nitrogen or dissolved inorganic nitrates)
- Phosphorus (total phosphorus or dissolved inorganic phosphate)
- Acidification (pH)

In 2016/17 and 2018/19, the former Rwanda Water and Forests Authority (RWFA) conducted two national studies to assess the quality of certain waterbodies in Rwanda according to the standard for potable water (RWFA, 2019). The data indicated that for all 36 waters (30 open waterbodies, rivers, and lakes; and six ground waterbodies) monitored in 2018/19, the proportion of waterbodies with good ambient water quality reached an index of 85 percent (RWFA, 2019). However, considering the above five core parameters, in addition to turbidity, TSS and E. coli, which are disturbing for the case of Rwanda, the percentage of water body with ambient water quality was only 18.75 percent (RWFA, 2019). This is because certain water quality parameters such as dissolved inorganic nitrogen, dissolved inorganic phosphorus, electrical conductivity, hydrogen potential (pH), are generally within the acceptable range nationwide, whereas dissolved oxygen (DO), *Escherichia coli (E. coli)*, and turbidity are almost always outside the acceptable range for natural potable water (RWFA, 2019). The main cause is sedimentation and siltation of waterbodies mainly from soil erosion and microbiological contamination linked to poor sanitation systems and practices (RWFA, 2019). A detailed summary of these results is presented in Table 8-3.

Muddy river water is an indication of sediment pollution. River Akanyaru along the border with Burundi (left) and Akagera river (right).
Photo credit: Akanyaru - RWFA, Akagera - Amizero N/EPI

Table 8-3: Summary of water quality for selected waterbodies in Rwanda conducted by RWFA during 2016-2019 (RWFA, 2019) (RWFA, 2017)

Name of sampling sites	Parameter	Water quality
Nyabarongo, Rusizi, Muvumba Catchments	Dissolved Oxygen	2016-2017 2 (Nyabarongo & Rusizi) out of 3 catchments were within lowest allowable 5 mg/L threshold for dissolved oxygen
	Electrical conductivity	All catchments were below the highest permissible limit 1,000 µs/cm for electrical conductivity
	Turbidity	Turbidity was high in all catchments and above highest turbidity limit of 50 NTU
Ruhwa, Rubyiro, Rusizi, Sebeya, Kivu, Mwogo, Mbirurume, Nyabugogo upper, Mukungwa, Nyabarongo valley, Muhazi, Nyabugogo, Akagera, Akanyaru upper, Akanyaru lower, Muvumba	Dissolved Oxygen (DO)	2018-2019 Only Mwogo, Mukungwa, and Akagera exceeded national targets of 68 percent DO
	Electrical conductivity	All waterbodies met standards, 2,500 µs/cm
	Turbidity	Only Kivu and Muhazi were within national standards for turbidity, 150 mg/l
	Hydrogen potential (pH)	All waterbodies met standards 5-9 pH range
	Dissolved inorganic Phosphate	All waterbodies met standards 5mg/l
	Dissolved inorganic Nitrates	All waterbodies met standards 30 mg/l
	E. coli	None met standards of 4 CFU/100ml

Status and trend

Rwanda endeavors to manage and provide water in adequate quantity and quality for all social and economic needs. Drinking water treatment, supply and sanitation services are provided by the Water and Sanitation Corporation company (WASAC). Access to improved water and sanitation have been steadily increasing in Rwanda, however, the level of access to safe water and sanitation are particularly lower in rural areas, and more than half of the population still travel long distances, more than 500 meters to gather water.

A nationally representative household study conducted by the National Institute of Statistics of Rwanda (NISR) in 2017, indicated that 87.4 percent of households in Rwanda have access to an improved source of drinking water. When broken down by location, this translates to 95.8 percent of urban households and 85.4 percent of rural households with access to an improved drinking water source. Urban and rural households depend on different sources of drinking water, which include piped water, a protected source or a well. Trends in the proportion of households obtaining water from improved sources have increased from 84.8 in 2013 to 87.4 percent in 2017 (Figure 8-10) (NISR, 2018).

The trends in access to improved sanitation is like that for water supply. In general, 86.2 percent of households (93.6 percent of urban households and 84.4 percent of rural households) have access to improved sanitation. Trends in the proportion of households using improved sanitation have increased from 83.4 in 2013 to 86.2 percent in 2017 (Figure 8-11) (NISR, 2018). The data suggests that for the three years (2013/14 to 2016/17), the average percentage increase of households using improved water and sanitation facilities was around two percent and three percent, respectively. Thus, a speedier adoption is needed for the country to reach national target of universal coverage (100 percent) in the use of safe water and sanitation in Rwanda by 2024.

Protected springs and public standpipes are important sources of water supply in Rwanda
Photo credit: Amizero Nadege

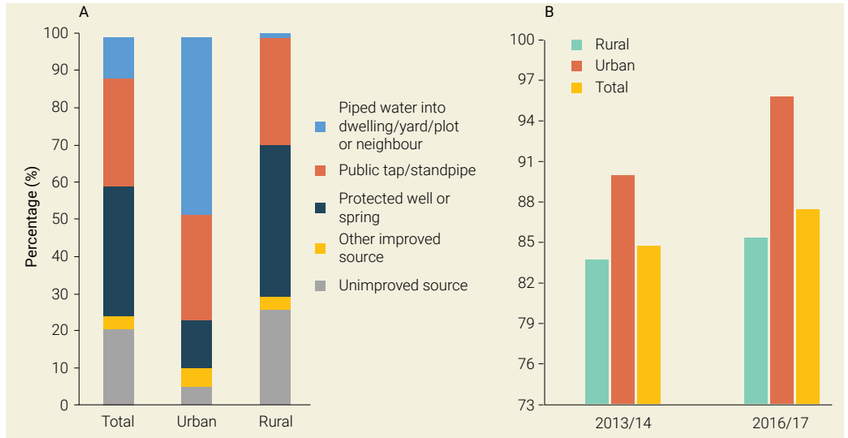


***Figure 8-10**: Distribution and trends in source of drinking water 2013-2017 (NISR, 2018), (RMIS, 2017). Note: A) percent distribution of households by drinking water sources and B) percent of households obtaining drinking water from improved sources.*

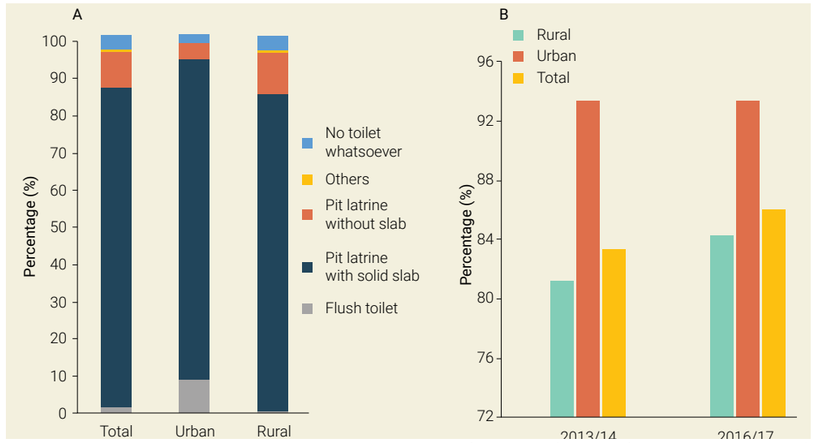


***Figure 8-11:** Distribution and trends in sanitation 2013-2017 (NISR, 2018). Note: A) percent distribution of households by improved sanitation and B) percent of households using improved sanitation.*

The effects of COVID-19 on water and sanitation services

The government reacted promptly to the COVID-19 outbreak putting in place tough measures to stop the spread of COVID-19. In early March, guidelines on handwashing were published and handwashing and hand sanitizers were placed outside all major public buildings and shopping centers in the country (Bower, Apell, Twum, & Umulisa, 2020). The water and sanitation sector were critical in the fight against the spread of COVID-19, but the economic consequences of the pandemic hampered the public access to these services (Albert, et al., 2021). A study found that during the pandemic, around 29 percent of low-income households reported losing their jobs and 40 percent said they made less money, which constrained their ability to afford the cost of water, soap, and other sanitation tools (Albert, et al., 2021). Rural residents were more affected than urban residents. The rural and small-town water suppliers suffered financial and operational challenges during the pandemic, including supply chain difficulties. In urban areas, however, the number of urban and peri-urban water subscribers served by WASAC increased by 1.9 percent, from 225,989 connections in 2019 to 230,190 in 2020 (RURA, 2020) (Figure 8-12).

The effects of COVID-19 did not cause major declines in sanitation service as compared to the pre-pandemic period. Both urban and rural residents did not report increased difficulties in procuring latrine-related products. Further, demand for sanitation products and services is expected to grow as the pandemic may have resulted in a shift in social norms around handwashing and sanitation (Albert, et al., 2021).

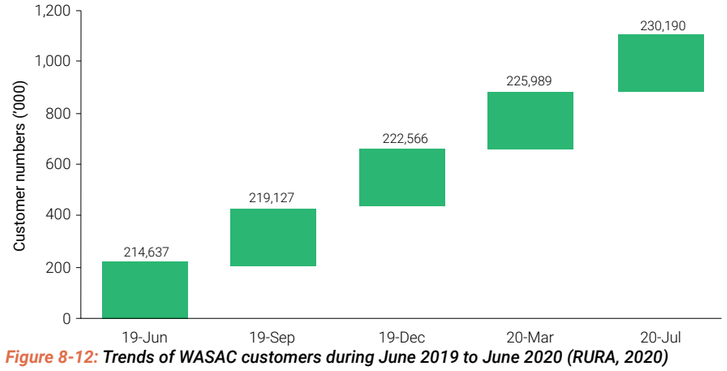


***Figure 8-12:** Trends of WASAC customers during June 2019 to June 2020 (RURA, 2020)*

Handwashing is an important strategy in the fight against COVID-19
Photo credit: Nishimwe I.

Pressure and impact

In general, the quality of any surface water is a function of natural influences and human activities. The main activities that prevent Rwandan waterbodies from maintaining good quality are agriculture, mining activities, poor wastewater management, invasive species, and poor compliance with set standards.

Agriculture, land mismanagement and mining activities

Land degradation due to poor land use practices and inappropriate use of agricultural inputs such as chemical fertilizers and pesticides are a major cause of water pollution in Rwanda. Poor land practices lead to soil erosion resulting in the transfer of soil and runoff from the fields to adjacent water bodies. This may lead to the accumulation of nutrients in waterbodies, resulting in eutrophication, siltation, and sedimentation (Nsanganwimana, Adam, Newete, & Mukarugwiro, 2019). A major risk linked to the eutrophication of waterbodies is the depletion of dissolved oxygen in water which is essential to the life of aquatic organisms.

Unsustainable mining activities are another predominant source of water pollution. Most mine sites contribute heavily to river siltation, resulting in high turbidity. This is persistent concern for all waterbodies in Rwanda, even in the absence of rain which normally carries soil from agriculture and mining to waterbodies (RWFA, 2019).

Water industry (wastewater)

Wastewater discharges from domestic and industrial facilities remain among the main causes of poor water quality in some waterbodies. Although the Ministry of Infrastructure and its affiliated Water and Sanitation Corporation Ltd (WASAC) and the City Council of Kigali are taking measures to manage wastewater in cities, the problem of wastewater effluents continues to affect aquatic ecosystems, reservoirs leading to river siltation, and poor quality of drinking water (RWFA, 2017) (RWFA, 2019).

Compliance and monitoring

Wastewater from industrial activities continues to be a major source of water pollution in Rwanda. REMA, in partnership with the United Nations Development Program (UNDP), conducted environmental compliance audits for five industries in Rwanda on air and water quality. The inspection revealed the impact of these industries on water quality. Two of them are even located in undesignated areas. The details of the findings are shown in Table 8-4.

Table 8-4: Environmental audits of non-compliance of industries on water quality (REMA, 2021)

Industry	Non-compliance
Bralirwa PLC-Rubavu	Inadequacy of the industry in some instances to treat wastewater to levels within national and international tolerable limits of Total Nitrogen (TN), Total Phosphorous (TP), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Oil and Grease (O&G). Discharges waste Kieselguhr directly to Lake Kivu without treatment
SKOL Brewery Ltd.	Inadequacy of the industry at times to treat wastewater to levels under national and international tolerable parameter limits of Ammoniacal nitrogen (NH_3-N), TN, TP, COD, BOD, TSS, O&G, Fecal coliform (FC) and lead (Pb)
Utexrwa Ltd.	Inadequacy in the treatment of its wastewater to levels acceptable for discharge to the environment that are under the national and international tolerable parameter limits of; pH, DO, COD, BOD, TSS, O&G, FC, Pb, Cadmium (Cd), Chromium (Cr) levels. Located in the Rwampara wetland, which is prohibited for industrial use by Environmental law No.48/2018 and an area designated for Wetland rehabilitation zoning (W2) as per the Kigali city master plan 2050
Kigali Leather	Inadequacy of the industry to treat its wastewater to levels under the national and international tolerable parameter limits of O&G, FC, chromium (Cr), and mercury (Hg) Likely to be discharging untreated wastewater directly to the Nyabarongo River and wetland, which could be a potential source of contamination of ground water from which the Kigali Bulk water project will draw raw water for purification before distribution to parts of Kigali and Bugesera Located within a residential area, not in the designated Bugesera Industrial Park
Horizon Sopyrwa	Inadequacy of the industry to treat outlet effluent to reduced levels under national and international tolerable parameter limits of O&G and FC.

Improper disposal of domestic wastewater leads to water pollution. Kicukiro District, Rwanda
Photo credit: Amizero N./EPI

Transboundary water quality

Most of Rwanda's waters are transboundary resources of which 90 percent belong to the Nile Basin and the remaining 10 percent to the Congo Basin. Water pollutants from other countries raise concerns about the sustainable availability of water resources and their quality. This makes national interventions for water improvement more difficult (Box 8-2).

Box 8-2: Monitoring interventions to improve water quality in the transboundary Lake Kivu-Rusizi river basin

The transboundary basin of Lakes Kivu and Rusizi between Rwanda, Burundi and the Democratic Republic of the Congo is important and provides various ecosystem services including the supply of fresh water. This basin has historically been viewed as a hotspot for water pollution resulting from unsustainable agricultural practices, mining, mismanagement of land in the catchment, which continues to pollute the region's waterbodies. In addition, the basin is exposed to natural disturbances from erosion, waste accumulations from winds and waves on the shores of Lake Kivu, landslides, and volcanic eruptions, the most recent of which was the eruption of Nyiragongo volcano in May 2021.

In 2019, the then Rwanda Water and Forests Authority (RWFA) commissioned baseline monitoring studies in the basin region for water quality assessment. Following the Nyiragongo volcano eruption in 2021, REMA conducted a monitoring study, which concluded that there was no imminent risk of gas outburst expected in Lake Kivu and parameters such as temperature, conductivity, oxygen, chlorophyll, and pH remained favorable for aquatic life (REMA, 2021). However, while this monitoring work is commendable, there is a need for regional efforts since progress made on the Rwandan side could be offset by the lack of effort from other countries if no joint monitoring program is developed through transboundary cooperation (GEF, 2020). Lake Kivu and Rusizi River Basin Water Quality Management Project and plans will strengthen the capacity for the three countries to manage water resources and to preserve biodiversity in the basin. More specifically, the project will improve institutional operations, strengthening the capacity for water quality monitoring, among others. This will ultimately improve the water quality, environmental and economic services of the basin through improved transboundary cooperation.

Invasive species

Rwanda is facing considerable pressure from the Water hyacinth (*Eichhornia crassipes*), an invasive aquatic plant species. It has led to declines in water quality, fish production and loss of aquatic biodiversity in the east of the country. There have been efforts to manage small-scale infestations in Lakes Rweru, Ihema and other small lakes. However, these control methods are not viable in the long-term due to their high cost (Nsanganwimana, Adam, Newete, & Mukarugwiro, 2019). REMA has removed weeds and Water hyacinth in Lake Cyohoha. Such interventions are encouraged for other waterbodies, since the spread of the Water hyacinth has persisted, as reported in 2009 and continues to threaten the quality of lakes and rivers in the Eastern Province (Figure 8-13) (REMA, 2009).

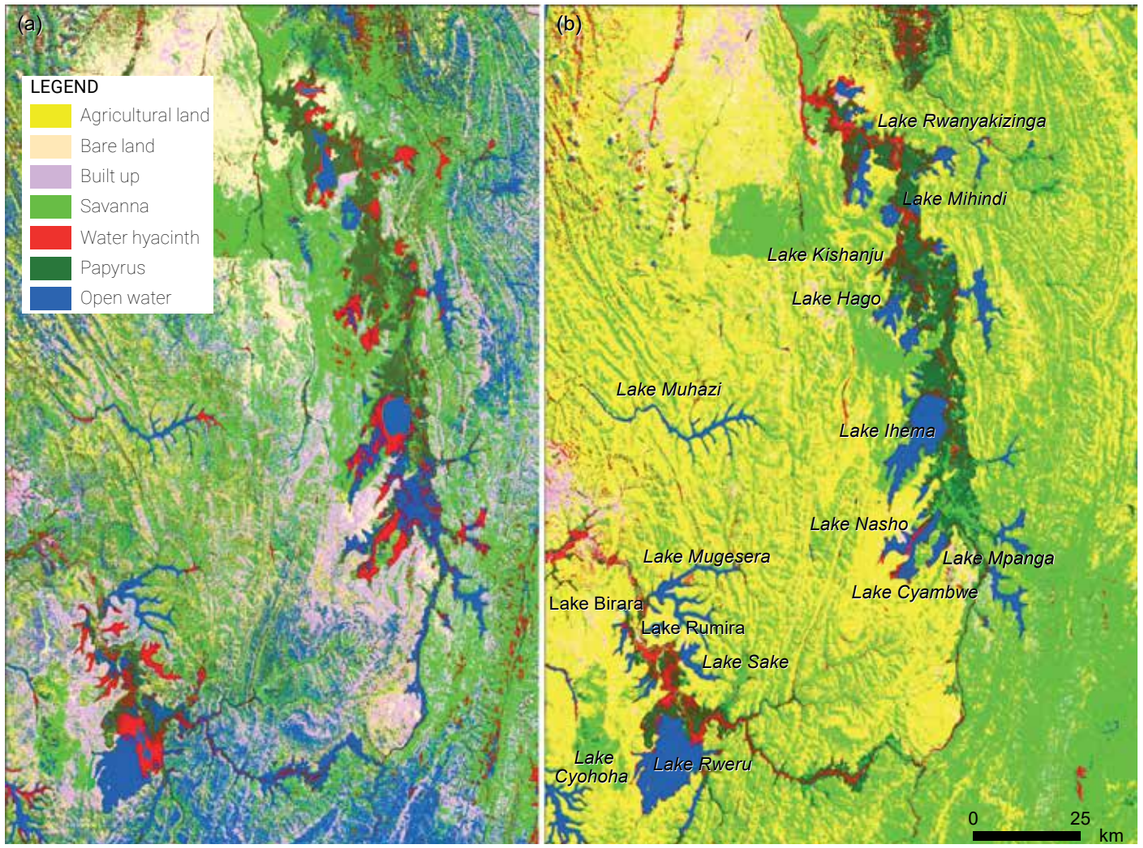


Figure 8-13: Spatial distribution of water hyacinth in Rwanda water system using (a) Random Forest and (b) Support Vector Machine (Nsanganwimana, Adam, Newete, & Mukarugwiro, 2019).
Note: Random Forest and Support Vector Machine are advanced algorithms classifiers with a capability of minimizing misclassification during the process of image classification.

Before and after image of Lake Cyohoha showing the removal of weeds and Water hyacinth

Lake Cyohoha invaded by water hyacinth and other weeds (Dec.2017)
Photo credit: REMA

Lake Cyohoha cleaned (May 2021)
Photo credit: REMA

Health impacts from polluted water and inadequate sanitation

Drinking contaminated water has an important implication for public health. Waterborne diseases due to microbial contamination are one of the leading causes of human death, illness, and disability adjusted life (DALYs) in Rwanda, especially amongst children under the age of five. The use of contaminated water leads to diarrheal diseases, intestinal parasites and environmental enteropathy and has complex and reciprocal links to malnutrition (WHO, 2019b). In Rwanda, the total number of deaths from diarrhea and DALYs due to inadequate water was 1,232 and 72,190, respectively while the total number of deaths that resulted from inadequate water, sanitation and hygiene was 2,306 in 2016 (WHO, 2018b).

Responses

Over the past decade, Rwanda has made progress in improving water quality and access to water and sanitation in rural and urban areas. The country achieved the Millennium Development Goals (MDGs) and is committed to achieving the ambitious SDG targets, on access and sanitation services and on water quality. Several programmes have been put in place as discussed below.

National Rural Drinking Water Supply and Sanitation Program 2009-2020

The program objective was to enable total access to drinking water for the rural populations by 2020 Some of the key pillars included access to adequate water services and sanitation, and the use of water to promote income-generating activities to alleviate poverty. One of the sub-programmes reached a total of 5.05 beneficiaries (out of 12 million in the country). The number of people with new or improved access to water and sanitation services increased from 1,632,000 in 2009 to 1,706,950 in 2016 (AfDB Group, 2020).

National Water Policy 2016

The government has made sustainable water supply one of priorities of the national development agenda and has established supporting policies and legislation, including the National Water Supply Policy. The Policy provided clear direction for the implementation of activities in the water sector (NISR, 2018).

Water Supply Master Plans 2050

Additional efforts are being implemented within the framework of water supply master plans. For example, the water supply master plan of the city of Kigali will focus on Kigali and seven adjacent municipalities (Gahengeri, Muyumbu, Ntarama, Nyakaliro, Runda, Shyorongi and, Rugarika). It has the objective of providing and maintaining universal access to safe drinking water in the city of Kigali to 2050 (MININFRA, 2020).

8.4 Conclusion and recommendations

Air quality

Despite the government's efforts in adopting and implementing policies and measures aimed at reducing levels of air pollution, most of the population continue to be exposed. The impact of air pollution on health persists and thus, robust new interventions in current policies and government measures are needed to address air pollution concerns. The country needs adequate measures that not only tackle air pollution, but also preserve air quality. Some of the recommended actions are:

- Enforce and regulate industrial and vehicle emissions controls: the most effective, efficient approach to protect public health from the adverse effects of outdoor air pollution is to reduce ambient concentrations through emission controls.
- Improve and support the current systems and ground-level air quality stations that monitor air pollution to provide continuous and national air quality data
- Provide further access to clean fuels and technologies for cooking and lighting in accordance with the World Health Organization guidelines for indoor air quality on household fuel combustion
- Conduct a national health-based assessment on the impact of air pollution
- Provide affordable access to public transport and increase green spaces in urban areas
- Develop effective solutions that recognize the disproportionate impacts of air pollution on the Rwandan population due to socio-economic factors. Rural people are more exposed to dangerous indoor air pollution than city dwellers.
- Develop national health-based performance and safety standards for household fuels and energy technologies
- Recognize that the shift to clean household energy will take time; and it will be necessary to prioritize fuels and transition technologies that offer substantial health benefits
- Carry out public awareness campaigns to educate the public to minimize their exposure to highly polluted areas such near roads, industrial and construction areas. These should be carried out by the local authorities and public health organizations.

Water quality

Water pollution in Rwanda is not a critical issue now but improvement is necessary since the pressure of water pollution may increase in the future. Thus, to meet the ambitious national objectives and address the problem of water pollution in Rwanda, additional interventions are necessary. Some of the recommended interventions are:

- Carry out repetitive monitoring at the same sites and sampling locations to detect water quality trends. This will feed into country-wide assessments on the quality of waterbodies.
- Implement systematic monitoring of ground water quality. Groundwater is also an important source of drinking water in Rwanda yet monitoring studies on groundwater sites are still scanty.
- Manage soil erosion and sedimentation as part of a comprehensive water quality management system. This can proceed in tandem with a regular water quality monitoring programme which should also consider pollution from agricultural, urban waste and mining activities.
- Improve the sanitation provision in both urban and rural areas in proximity to waterbodies. It is recommended that urban areas improve the management of wastewater treatment, while in rural areas the most appropriate approach might be the improvement of on-site sanitation systems coupled with education, awareness and behavior change campaigns on sanitation practices.

References

AfDB Group. (2020). Rwanda - National Rural Drinking Water Supply and Sanitation Program (Phase II). Retrieved April 10, 2021, from African Development Bank (AfDB) Group: https://projectsportal.afdb.org/dataportal/VProject/show/P-RW-E00-005?lang=en

Albert, J., Khush, R., Agarwal, R., Krishna, A., Israel, M., & Gupta, H. (2021). Assessing the effects of covid-19 on access to water, sanitation, and hygiene in USAID high priority and strategy-aligned countries: Country Deep Dive Report - Rwanda. Tetra Tech. United States Agency for International Development. https://www.globalwaters.org/resources/assets/washpals/assessing-effects-covid-19-access-water-sanitation-and-hygiene-usaid-high-priority-rwanda

Antonia, F., Alexandra, R., Herbert, M., Klaus, P., & Janvier, B. (2019). Indoor air pollution and fatal daily household habits: two cases report. Public Health Bul., 24-30. https://www.researchgate.net/publication/336567557_Indoor_air_pollution_and_fatal_daily_household_habits_two_case_reports_in_Kigali-Rwanda

Bower, J., Apell, D., Twum, A., & Umulisa, A. (2020). Rwanda's response to COVID-19 and future challenges. Retrieved April 10, 2021, from IGC: International Growth Center: https://www.theigc.org/blog/rwandas-response-to-covid-19-and-future-challenges/

Brunekreef, B., et al. (2021). Air pollution and COVID-19. Including elements of air pollution in rural areas, indoor air pollution and vulnerability and resilience aspects of our society against respiratory disease, social inequality stemming from air pollution. European Parliament, Policy Department for Economic, Scientific and Quality of Life Policies. Luxembourg: European Parliament. https://www.europarl.europa.eu/RegData/etudes/STUD/2021/658216/IPOL_STU(2021)658216_EN.pdf

EC. (2018). Kigali City Air Quality Policy and Regulatory Situational Analysis. Environmental Compliance Institute, Environmental Compliance Institute. United Nations Environment Programme. http://www.eci-africa.org/wp-content/uploads/2019/05/Final-Kigali_AQ-policy-situational-assessment_ECI_31.12.2018rev.pdf

Fabien, N. (2019). Air emissions control and air: Air quality and mobility. Retrieved March 25, 2021, from Air Quality and Mobility: http://airqualityandmobility.org/PDFs/ECOWAS2019/Needtolinkwithvehicleemissions.pdf

Gasore, J., DeWitt, L., Safari, B., & Irankunda, E. (2018). First National Scale Measurements of Ambient and Indoor Air Pollution in Rwanda. American Geophysical Union. https://ui.adsabs.harvard.edu/abs/2018AGUFM.A44B..03G/abstract

GEF. (2020). Lake Kivu and Rusizi River Basin Water Quality Management Project. Retrieved April 10, 2021, from Global Environment Facility: https://gefportal2.worldbank.org/

GGGI. (2019). Three Ways the Global Green Growth Institute is supporting the Government of Rwanda to Reduce Air Pollution. Retrieved March 30, 2021, from Global Green Growth Institute: https://gggi.org/three-ways-the-global-green-growth-institute-is-supporting-the-government-of-rwanda-to-reduce-air-pollution/

HEI. (2019a). Health Effects Institute. (H. E. Study, Producer, & Health Effects Institute) Retrieved March 25, 2021, from State of Global Air: https://www.stateofglobalair.org/data/#/air/plot

HEI. (2019b). State of Global Air 2019/ country profile: Rwanda. Health Effect Institute. Health Effect Institute. Retrieved from https://www.stateofglobalair.org/sites/default/files/2019-09/soga_fact_sheet_rwanda_20190828_v02.pdf

HEI. (2020). State of Global Air 2020 Special Report. Health Effects Institute., Health Effects Institute. Boston: Health Effects Institute. https://www.stateofglobalair.org/sites/default/files/documents/2020-10/soga-2020-report-10-26_0.pdf

Institute for Health Metrics and Evaluation. (2021). Health-related SDGs | Viz Hub. Retrieved March 25, 2021, from Institute for Health Metrics and Evaluation: https://vizhub.healthdata.org/sdg/

Kabera, T., Bartington, S., Uwanyirigira, C., Abimana, P., & Pope, F. (2020). Indoor PM2.5 characteristics and CO concentration in households using biomass fuel in Kigali, Rwanda. International Journal of Environmental Studies. doi: 10.1080/00207233.2020.1732067

Kalisa, E., Sudmant, A., Ruberambuga, R., & Bower, J. (2021). From car-free days to pollution-free cities: Reflections on clean urban transport in Rwanda. International Growth Centre. https://www.theigc.org/wp-content/uploads/2021/08/Kalisa-et-al-June-2021-Policy-Brief.pdf

MINEDUC. (2021). Climate Change Observatory. Retrieved March 30, 2021, from Ministry of Education (MINEDUC), Government of Rwanda: https://www.mineduc.gov.rw/climate-change-observatory

MoH. (2020). Rwanda Health Sector Performance Report 2019-2020. Ministry of Health (MoH). Kigali: Ministry of Health, Republic of Rwanda. https://www.moh.gov.rw/fileadmin/user_upload/Moh/Publications/Reports/Health_sector_performance_Report_FY_2019-2020.pdf

MININFRA. (2020). Infrastructure sector annual report for fiscal year 2019/20. Ministry of Infrastructure (MININFRA), Kigali: Republic of Rwanda. https://www.mininfra.gov.rw/fileadmin/user_upload/Mininfra/Publications/Reports/2019-2020_Infrastructure_sector_Annual__Report___Sept_2020__00000003_.pdf

NISR. (2016). EICV 4 Thematic Report - Environment and Natural Resources. National Institute of Statistics of Rwanda. https://www.statistics.gov.rw/publication/eicv-4-thematic-report-environment-and-natural-resources

NISR. (2018). Integrated Household Living Conditions Survey: EICV5_Thematic Report. National Institute of Statistics of Rwanda. https://www.statistics.gov.rw/datasource/integrated-household-living-conditions-survey-5-eicv-5

Nsanganwimana, F., Adam, E. M., Newete, S., & Mukarugwiro, J. d. (2019). Mapping distribution of water hyacinth (Eichhornia crassipes) in Rwanda using multispectral remote sensing imagery. African Journal of Aquatic Science, 44(4):1-10. doi:10.2989/16085914.2019.1650712

REMA. (2009). Rwanda State of Environment and Outlook Report. Rwanda Environment Management Authority (REMA). https://www.rema.gov.rw/soe/

REMA. (2018). Inventory of Sources of Air Pollution in Rwanda. Rwanda Environment Management Authority. https://rema.gov.rw/fileadmin/templates/Documents/rema_doc/Air%20Quality/Inventory%20of%20Sources%20of%20Air%20Pollution%20in%20Rwanda%20Final%20Report..pdf

REMA. (2020). Clean skies, healthy people... (Rwanda Environment Management Authority) Retrieved March 30, 2021, from Rwanda Environment Management Authority: https://www.rema.gov.rw/index.php?id=77&tx_news_pi1%5Bnews%5D=83&tx_news_pi1%5Bday%5D=7&tx_news_pi1%5Bmonth%5D=9&tx_news_pi1%5Byear%5D=2020&cHash=2fc8660fd6de43d8a7e84ff73481c596

REMA. (2021). Conducting compliance environmental audits for eight industries specific to air and water quality compliance. Kigali, Rwanda: Rwanda Environment Management Authority (REMA) & UNDP.

REMA. (2021). No imminent risk of Gas outburst is expected on Lake Kivu following Nyiragongo eruption – REMA findings. Retrieved June 24, 2021, from Rwanda Environment Management Authority (REMA): https://www.rema.gov.rw/index.php?id=77&tx_news_pi1%5Bnews%5D=117&tx_news_pi1%5Bday%5D=31&tx_news_pi1%5Bmonth%5D=5&tx_news_pi1%5Byear%5D=2021&cHash=f495291e9f1294ec4a58782631655005

RMIS. (2017). Rwanda Malaria Indicator Survey Final Report 2017. Rwanda Biomedical Center, Ministry of Health. https://dhsprogram.com/pubs/pdf/MIS30/MIS30.pdf

RURA. (2020). Water and Sanitation Statistics as of June of the Year 2020. Kigali: Rwanda Utilities Regulatory Authority. https://rura.rw/fileadmin/Documents/Water/statistics/Report_on_water_and_sanitation_statistcs_as_of_June_2020.pdf

RWFA. (2017). Annual Water Status Report 2016-2017. Rwanda Water and Forestry Authority. Kigali: Rwanda Water and Forestry Authority. https://waterportal.rwb.rw/report/annual-water-status-report-2016-2017

RWFA. (2019). IWRM Programme Rwanda Water quality monitoring in Rwanda final report. Rwanda Water and Forestry Authority, https://waterportal.rwb.rw/sites/default/files/2019-05/Water%20Quality%20Monitoring%20phase%20I%20%26%20II%20final%20report%20%2825th%20April%202019%29-2.pdf

State of Global Air. (2020). Impacts on Newborns. (State of Global Air) Retrieved March 30, 2021, from State of Global Air: https://www.stateofglobalair.org/health/newborns#

Subramanian, R., Kagabo, A. S., Baharane, V., Guhirwa, S., Sindayigaya, C., Malings, C., . . . Gasore, J. (2020). Air pollution in Kigali, Rwanda: spatial and temporal variability, source contributions, and the impact of car-free Sundays. Clean Air Journal. doi: 10.17159/caj/2020/30/1.8023

UNDP. (2020). Greening the Economic Recovery Plan. ENR JSR Meeting - 26 June 2020. Kigali, Rwanda, Rwanda: UNDP.

UNEP. (n.d.). Lake Kivu. Environmental Change Hotspots. Division of Early Warning and Assessment (DEWA) Retrieved April 11, 2021, from United Nations Environment Programme: https://na.unep.net/atlas/webatlas.php?id=245

Venter, Z. S., Aunan, K., Chowdhuru, S., & Lelieveld, J. (2020). COVID-19 lockdowns cause global air pollution declines. National Academy of Sciences. https://www.pnas.org/content/pnas/117/32/18984.full.pdf

WHO. (2016a). Ambient air pollution: A global assessment of exposure and burden of disease. World Health Organization. Geneva. https://apps.who.int/iris/handle/10665/250141

WHO. (2016b). A statistical note: Proposal for air pollution as an indicator for tracking progress toward SDGs on health (3), energy (7) and cities (11). World Health Organization, https://www.who.int/airpollution/household/policy-governance/Statistical-note-on-airpollution-indicators-SDGs-10Sept2015.pdf

WHO. (2018a). Burden of disease from the joint effects of household and ambient Air pollution for 2016. World Health Organization, World Health Organization. World Health Organization. Retrieved from https://www.who.int/airpollution/data/AP_joint_effect_BoD_results_May2018.pdf

WHO. (2018b). Global Health Observatory data repository. (W. H. Organization, Producer, & World Health Organization) Retrieved March 25, 2021, from World Health Organization: https://apps.who.int/gho/data/view.main.INADEQUATEWATERv

WHO. (2019a). Non-communicable diseases and air pollution. World Health Organization. Copenhagen. https://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/noncommunicable-diseases-and-air-pollution-2019

WHO. (2019b). Sanitation. (World Health Organization) Retrieved March 30, 2021, from World Health Organization: https://www.who.int/news-room/fact-sheets/detail/sanitation

WHO. (2021). COVID-19 Explorer. Retrieved March 30, 2021, from World Health Organization: https://worldhealthorg.shinyapps.io/covid/

The canopy walk at Nyungwe forest
Photo credit: Xizi Luo/Flickr

Chapter 9:

Energy

Shango substation, a 220/110kV substation that interconnect with Uganda and Northern Eastern DRC networks. Photo credit: REG.

9.1 Introduction

Energy is central to Rwanda's economy and development plans. The Government of Rwanda aspires to provide a reliable, efficient, and affordable power supply to improve the living standards of its population. The government is targeting 100 percent electricity access by 2024. Rwanda is endowed with natural energy resources including hydro, solar, and methane gas. The country is committed to advancing its economy based on, and driven by, the principles of the Sustainable Development Goals (SDGs) of the global Agenda 2030 as well as Agenda 2063 of the African Union. Making safe, clean, reliable, and affordable energy available to all, forms an integral part of this vision (AU, 2021).

9.2 Status and trends

The Government of Rwanda (GoR) is widely recognized as an ambitious reformer with a strong track record in launching a comprehensive economic development agenda. Economic reform has impacted the power sector in two fundamental ways. First, the economic development agenda encompassed radical reforms in the energy sector, particularly the power sub-sector, to the point that the country's national electricity company is now viewed as a model utility in East Africa. Second, the sustained economic growth has triggered a rapid increase in electricity demand.

Rwanda's energy mix

Rwanda's energy mix is is made up of biomass (wood), hydro, diesel & heavy fuel, methane gas, peat, solar and imports as shown in Figure 9-1. The country's abundant renewable energy resources have the potential to replace conventional energy sources completely, however, most of this potential is not realized today.

Rwanda's energy balance shows that about 85 percent of its overall primary energy consumption is based on biomass (99 percent of all households use biomass for cooking), 11 percent from petroleum products (transport, electricity generation and industrial use) and 4 percent from hydro sources for electricity. The main sectors where energy is consumed are households, transport, and industry. Households consume 82 percent of all the energy consumed in the country. This is followed by the transport sector at 8 percent and then the industrial sector at 6 percent (Figure 9-2). The remaining 4 percent of energy consumption is attributed to other miscellaneous sectors.

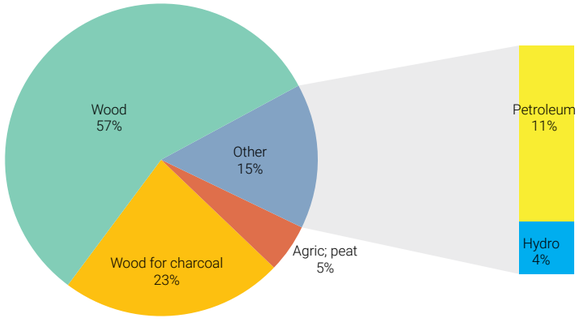


Figure 9-1: Structure of the primary energy mix (MININFRA, 2018)

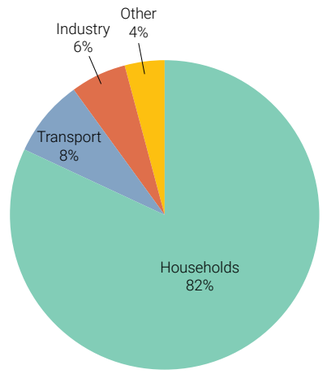


Figure 9-2: Energy Consumption by Subsector (MININFRA, 2018)

Electricity generation in Rwanda

The installed capacity has increased steadily between 2013 and 2021 as demonstrated in Figure 9-3. The current installed capacity for power generation in Rwanda was 238.36 MW by 2021 (REG, 2021).

The fuel mix for electricity generation is dominated by hydropower, accounting for 45 percent of all electricity generated (Figure 9-4). The other predominant fuels include diesel and natural gas, and peat, followed by a small but growing share of solar energy. Given the variable nature of some of the sources, the installed capacity of 238.36 MW does not always generate power at its optimum capacity. The operation of the hydro units, for example, is limited by the upstream water level and availability lowers significantly during the dry season. Similarly, the Solar photovoltaics (PV) capacity is unavailable during the evening peak hours. Further, losses are incurred on the transmission and distribution lines (about 2 percent of the total installed power) and some of the units may be unavailable during certain periods due to maintenance or failure.

9.3 Rwanda's energy transition: targets and resources

Rwanda faces the twin challenges of fostering access to electricity while ensuring renewables play a leading role in the electricity sector expansion. Rwanda's potential for renewable energy - micro-hydro, geothermal and solar - is huge. Hydropower is the foremost energy resource in Rwanda utilized for power generation. At the same time, Rwanda is also endowed with large reserves of methane, which is considered a 'clean transition fuel'. Green energy is the answer to the challenges of climate change and is a critical step for reaching climate neutrality. Without the global transformation of the energy sector, it will be impossible to achieve the 1.5-degree target of the Paris Agreement (GIZ, 2020).

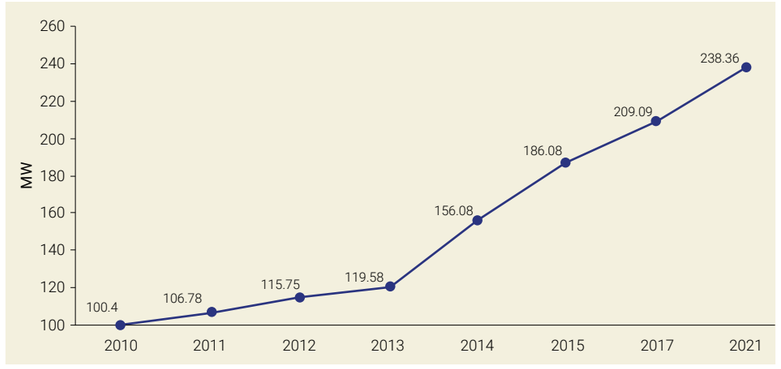


Figure 9-3: Evolution of electricity installed capacity (MININFRA, 2018) (REG, 2021)

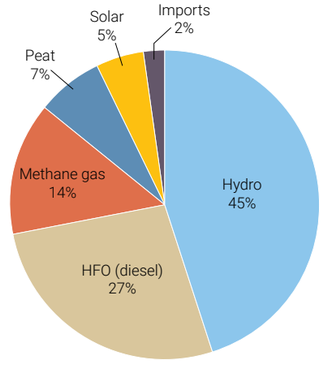


Figure 9-4: Rwanda's current power generation mix (REG, 2021)

Clean energy targets

Diversified energy mix and universal electrification

Rwanda aims to diversify its energy generation mix by 2024 as shown in Figure 9-5. The rapid and responsible deployment of clean, renewable energy is crucial to meet the goals of the Paris Climate Change Agreement.

The government has also set the target for universal electrification by 2024 with 52 percent on-grid and 48 percent off-grid (Phillips et.al, 2019) (MININFRA, 2018). However, the energy sector's growth is hampered by a combination of high tariffs and low demand. Rwanda had planned to have 563 MW of generation capacity by 2018, but these barriers led the country to scale back on its target to avoid over supply issues (MININFRA, 2018). The current generation capacity is 238.36 MW as of May 2021, and by the end of the National Strategy for Transformation-1 (NST-1) period will be at 100 percent for households (MINECOFIN, 2017). Expansion of the grid will continue through the Energy Access Roll-out Program (EARP). However, analysis has shown that grid connections will be economically inefficient in the short-to-medium term for households which use low levels of electricity (MININFRA, 2018). Further, grid expansion is a slow process, and it will take decades to reach all households. Therefore, off-grid solutions, including solar home systems (SHS), will play a key role. Off-grid technologies and commercial structures have developed significantly in recent years and now present a viable alternative to grid connections.

The Rural Electrification Strategy published in June 2016 set out a clear development plan for the off-grid sub-sector. It is expected that 48 percent of all households will have their electricity needs met by off-grid solutions by 2024. Energy access in Rwanda between 2005 and 2019 and the forecast to reach the target for universal access in 2024 is well demonstrated in Figure 9-6 and some of the planned improvements in the energy sector are summarized in Figure 9-7.

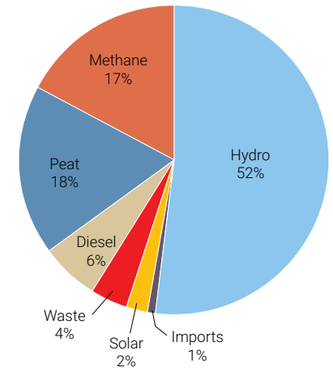


Figure 9-5: Generation mix target 2024 (REG, 2021)

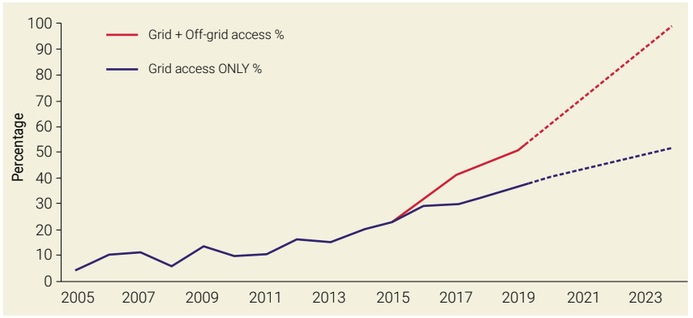


Figure 9-6: Forecast to reach 100 percent access in 2024 (Power Africa, 2019)

100% of productive users will be connected, compared to 72% at present

Expansion of street lights to all new and existing national roads and urban roads

The reliability of electricity supply will be improved significantly

Power outages will reduce from 36h in 2016 to 14.2h in 2024, and av. interruptions/year to reduce from 229 to 91

Improvement in energy efficiency across all sub sectors of the electricity value chain

Shift onto alternate cooking fuels at the household level

Figure 9-7: Planned improvements and targets for Rwanda's energy sector (MININFRA, 2018)

Within the electricity strategic planning, an Energy Efficiency Strategy is being finalized. This sets out a range of initiatives which will improve efficiency across the entire electricity value chain, from generation, through transmission and distribution to end-user consumption. End-user efficiency initiatives, such as the distribution of Light Emitting Diodes (LEDs) and the introduction of standards and labelling on appliances, will result in efficiency savings. Efficiency efforts are represented in the High-Level Targets Objectives (HLTO) through a target to reduce losses in transmission and distribution from current levels of 22 percent to 15 percent. As demand increases, reducing losses will have an increasingly significant impact on the financial performance of Rwanda Energy Group (REG), as well as reducing the environmental impact of the sector.

MININFRA published the 'Biomass Energy Strategy: A Sustainable Path to Clean Cooking 2019-2030' in 2019 to guide developments in the sector. In May 2020, the Government updated its Nationally Determined Contributions under the Paris Agreements which includes promoting the use of efficient cook stoves as a mitigation measure since cooking accounts for 14 percent of the GHG emissions from the energy sector. To achieve the HLTO, households will be shifted onto alternative fuels for cooking, such as highly efficient improved cooking technologies, LPG, and biogas (MININFRA, 2019).

Clean energy resource potential

Hydropower is the only renewable energy source which constitutes a significant part of the total energy mix of Rwanda. There is need to increase efforts to diversify the country's energy sources (REG, 2021). The renewable energy sources that can contribute to the clean energy transition in Rwanda are discussed in the sections that follow.

For electrification

Hydropower

Hydropower currently contributes 45 percent of Rwanda's energy mix and is anticipated to contribute around 52 percent by 2024 (UNFCC, 2018). The topography of Rwanda is the most suited for medium-to-high-head Pico and micro-hydro run-of-the-river schemes. Rwanda's overall technical hydropower potential has been estimated at up to 400 MW. Within the East African region, there are also opportunities for micro and small hydropower projects, as well as in shared regional hydropower projects. Feasibility studies conducted by the Rwanda Energy Group indicated potential for micro hydro power generation in over 40 smaller sites. Currently, twenty-one hydropower plants are grid connected and eleven micro hydropower plants exist in Rwanda as isolated networks. A couple of micro and mini hydropower projects are currently under construction.

However, the development of hydropower does not come without environmental and social costs. Moving towards the goals of the Paris Climate Agreement requires promoting projects where the negative impacts are minimized and compensated for. Environment and social impact assessments should be conducted before constructing hydropower projects, to identify and mitigate the negative impacts of the project. In summary, if implemented in a sustainable manner, hydropower energy presents a great opportunity for climate change mitigation in Rwanda.

The 28 MW Nyabarongo I Hydropower Plant, 2020
Photo credit: REG

Geothermal energy resources

Geothermal energy refers to the heat found within the earth's crust. It is a clean and reliable source of energy that has relatively very low maintenance costs and high productivity. Although geothermal energy itself does not typically release GHGs, many of these gases are stored under the Earth's surface and will be released into the atmosphere during digging. However, these emissions are still far lower than those associated with fossil fuels. The exploration of geothermal energy in Rwanda is still at the early stages. Rwanda's geothermal potential is estimated to be more than 300 MW, and it presents numerous high, medium, and low enthalpy geothermal zones of interest. With extensive exploration and appraisal drilling, geothermal energy is estimated to contribute between 20 MW (minimum threshold) and 300 MW (maximum). Currently, the exact size of the resource is unknown. The development of geothermal resources was to be given the highest priority over the EDPRS II period and among the envisioned developments.

Solar energy

Rwanda is located about 2 degrees south of the equator making it extremely suitable for solar energy development. The country's insolation is between 4.5 and 5 kWh per m^2 per day with 5 peak sun hours. The estimated monthly average global solar radiation was found to vary between 4.3 and 5.2 kWh per m^2 per day over the entire region of Rwanda. Rwanda's Eastern Province has the greatest potential for solar energy generation as depicted in Figure 9-8. Private sector companies in Rwanda are harnessing solar energy to provide solar lighting solutions to remote areas in the country. Thus far, the Independent Power Producers (IPPs) have extended electricity access to more than 258,414 households' nationwide using solar energy.

Nasho solar plant, 2019
Photo credit: REG

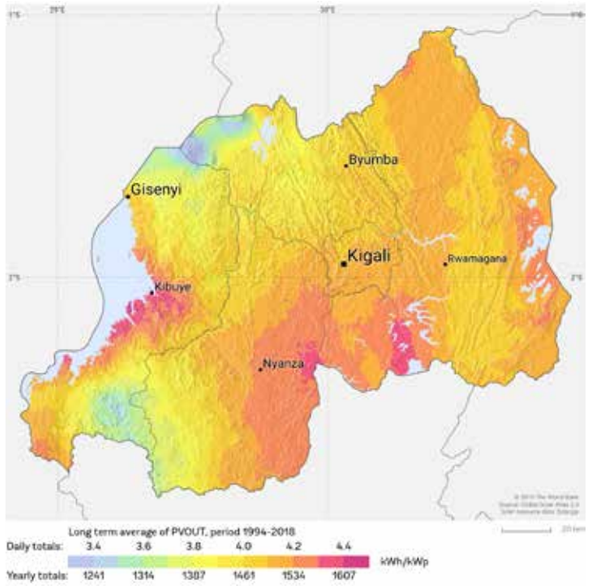


Figure 9-8: Longterm yearly average of Potential photovoltaic electricity production – Rwanda
(© 2020 The World Bank, Source: Global Solar Atlas 2.0, Solar resource data: Solargis)

Wind

Rwanda's resource potential for wind energy is low as it is located close to the equator. Preliminary indications from a wind energy resource assessment identified the Eastern Province as having the greatest potential. More detailed resource assessments and feasibility studies are required to determine the commercial viability of wind energy in Rwanda (MININFRA, 2018).

For clean cooking

Liquefied petroleum gas

More Rwandans are replacing charcoal with LPG as the energy source for cooking. Imports for LPG have increased fourteen times in the last seven years, a trend that the Rwanda Utilities Regulatory Authority (RURA) have interpreted as being the real picture of how fast Rwandans are adopting the use of cooking gas. During the COVID-19 pandemic, price hikes occurred in the LPG sector just like in other sectors, but people continued to buy and use LPG (Epd, 2021). The penetration of LPG in Rwanda is still relatively limited, but its availability and adoption are evolving rapidly. LPG is often used in combination with charcoal mainly for meals that take long to cook such as dried beans and other legumes. Charcoal is still the principal cooking fuel in urban areas.

Compressed natural gas (CNG)

The possibility of using methane in the form of Compressed Natural Gas (CNG) from Lake Kivu in the medium term as cooking fuel has recently been embraced again, particularly considering the increased presence of private investors undertaking energy production activities with the lake gas. The amount of methane in place is estimated at about 60 billion cubic meters (29 million tons oil equivalent) and believed to be economically recoverable.

KivuWatt power plant, 2019
Photo credit: Rugege D./EPI

Biogas

Biogas is a fuel gas - a mixture of 65 percent CH_4 and of 35 percent CO_2. It is a renewable energy source from agricultural crops or animal manure. The use of biogas technology has been recommended and promoted as one of the alternative solutions to alleviate poverty and as a suitable renewable energy to decrease the consumption of wood fuels and reduce indoor air pollution. Different long-term energy related policies in Rwanda such as the Economic Development and Poverty Reduction Strategy and the Energy Sector Strategic Plan have included biogas as one of the sustainable solutions to reduce the reliance on wood-based fuel (Mukeshimana et.al, 2021).

Waste disposal is a major problem for the environment. Biogas production and use is a good way of keeping or avoiding the natural release of methane gas in the atmosphere. Biogas slurry makes good fertilizer, and they can be used on farm fields which reduces on the waste disposal problem.

Pellets and briquettes

Pellets and briquettes are currently the most advanced biomass-based option being implemented of recent in Rwanda. They are produced from by-products of wood processing industries (sawdust or wood shavings) or from forest residues. Woody pellet production, for which forest concessions must be adapted accordingly, is a key solution for replacing charcoal in urban households and providing highly efficient fuel to the wealthier end of rural population. Briquettes made from crop residues and dried grasses (from marshland) represent a sustainable and efficient alternative for households in areas where wood is very scarce and not accessible, but where crop residue or grasses from marshlands can represent an accessible and affordable feedstock (MININFRA, 2019).

9.4 Pressure and impact

Population growth and energy mix diversification

The impacts and pressures of energy resources and consumption on the environment in Rwanda are linked to the dependence of the rural population on biomass energy and socio-economic status. Energy use in Rwanda is dominated by biomass, which accounts for around 86 percent of total energy sources. According to the updated Nationally Determined Contribution report, the average household uses around 1.8 tonnes of firewood each year to meet cooking needs. This dependence on traditional biomass energy, which is exacerbated by the pressures of increasing population growth, represents a direct effect on forests and the environment, and has negative socio-economic and health impacts on the Rwandan population (Figure 9-9).

The projection of the country's energy consumption relative to population growth in Rwanda until 2050 shows that energy consumption will continue to increase as the population increases (Imasiku & Ntagwirumugara, 2019). By 2050, annual energy consumption will be 1,701.19 GWh per year compared to current consumption of 690.77 GWh (Figure 9-10) (Imasiku & Ntagwirumugara, 2019). This projection presents a complex energy mix scenario for Rwanda, which will have to diversify in relation to the current energy mix and dependence on traditional energy sources.

As clean energy sources in Rwanda are dominated by hydropower generation and development, the development of hydropower projects adds to other major environmental impacts associated with sedimentation and water pollution,

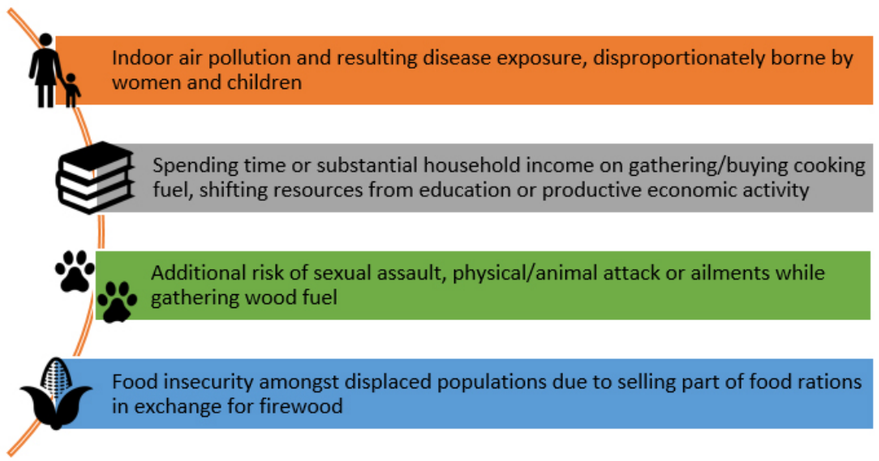


Figure 9-9: Socio-economic impacts of using wood for cooking
Source:

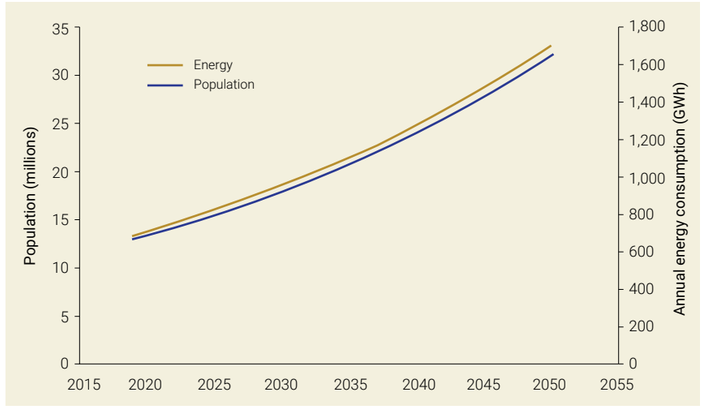


Figure 9-10: Annual energy consumption projection against population growth in Rwanda, 2019–2050 (Imasiku & Ntagwirumugara, 2019)

changing hydrological flow regimes and biodiversity loss (Bimenyimana, Asemota, & Li, 2018). In addition, the latest GHG inventory data from the National GHG Inventory Rwanda indicates that the energy sector ranks second in contributing to greenhouse gas emissions in Rwanda (GoR, 2020). Total emissions excluding forestry in Rwanda were estimated at 5.33 million tCO_2e for 2015, of which energy contributed 31 percent (1.68 million tCO_2e). Carbon dioxide (CO_2) was the main contributor, followed by CH_4, while N_2O had the minimal contribution to total energy sector GHG emissions (Figure 9-11). CO_2 emissions were mainly generated by liquid fuel combustion activities in transport and power generation, while CH_4 and N_2O emissions were mainly generated by biomass combustion activities in households and institutions and business activities (GoR, 2020).

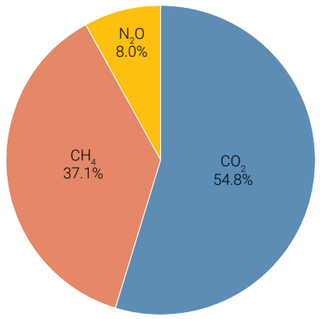


Figure 9-11: Shares of greenhouse gases emissions to the total GHG emission from the energy sector (WVR, 2020)

COVID-19 impact on the energy sector in Rwanda

Like all other sectors of economy, COVID-19 has negatively impacted the energy sector as shown in Figure 9-12. To best address these challenges, it would be important to comprehensively understand the impact of the pandemic and related economic slowdown on the financial performance of the power utility, public-private partnerships in the power sector, and on the investment programmes of power utilities including conventional and renewable energy resources.

Studies to understand these could answer the following questions:

1. Study the impact of COVID-19 on the financial performance of the power utility. The study should also cover the impact of COVID-19 on the following:

   - Decisions by the government for consumers to defer payment of utility bills.

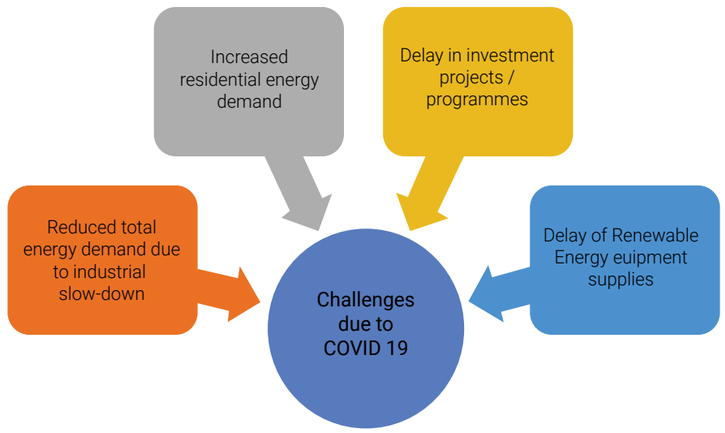


Figure 9-12: Challenges due to COVID-19

- Investigate the impact on utility tariffs and hence power utilities' cash flows.
- How the Government is planning to meet the financing gap for the power utility to ensure financial viability.
- Impact on planned maintenance activities of the power utility and hence on quality of service delivered to consumers of electricity

2. Impact of COVID-19 on Public-Private Partnerships (PPP) on the country's energy sector: Main areas of the studies to include the following, among others:
   - Demand and operational challenges which can lead to revenue losses for PPPs.
   - Mitigation measures for the short, medium, and long terms.
   - Options available to the government and how can it respond
   - The legal obligation to be considered under the current circumstances with respect to force majeure in PPPs.
   - Implications on funding and finances from funding agencies for projects
3. Impact of COVID-19 on the investment programmes of power utilities including conventional and renewable energy resources, as well as other overall capital expenditure. The study could also investigate:
   - Whether in the wake of the current pandemic, the Government can meet its RE targets and obligations as indicated in the national power sector plans.

Potential impact of climate change on energy sector

The energy sector in Rwanda is vulnerable to climate change impacts in two principal ways. First, given the large share of hydropower in the country's electricity mix, increased variability of rainfall (including more frequent drought conditions in eastern and southern Rwanda) poses a risk to the reliability and availability of hydropower. Alongside this, an increase in rainfall intensity which leads to landslides and sedimentation of water bodies could also affect key infrastructure. Secondly, even for thermal power facilities, there may be increased requirements for cooling systems, due to an anticipated rise in average ambient temperature due to climate change.

Beyond these two factors, other potential challenges to the power sector from climate change include an increase in demand for residential and commercial cooling (in response to higher temperatures), which creates pressure on power supply, and extreme weather events, which could damage power sector assets or temporarily disrupt fuel supply chains due to localized disasters such as floods and landslides (The World Bank, 2021). Some of the key challenges and action points for Rwanda are summarised in the Figure 9-13 and discussed below.

Promoting access to energy: Energy transition strategies to effectively fight poverty, enable new economic opportunities and promote equality must prioritize universal access to affordable, reliable, and sustainable electricity in Rwanda by 2030. These efforts need to involve a balance of on-, mini- and off-grid approaches, and must also address the challenges of supply security, overall economic viability, and affordable access.

De-risking private sector investments: The Government of Rwanda and its development partners can facilitate the private sector investments necessary to bridge this gap by building stable, predictable enabling frameworks, identifying a pipeline of viable projects and offering targeted de-risking instruments.

Strengthening and modernizing the grid: To effectively introduce and up-scale inexpensive variable renewable energy (such as solar and wind), the planning, operation and maintenance of electricity grids must be improved in Rwanda. As part of this transition, the expansion of interconnectors for cross-border electricity trade is also needed to support energy security and ensure the flexibility required to accommodate a high share of renewables.

Supporting systemic innovation: To harness the potential of renewable energy, Rwanda will require a system approach underpinned by innovative technologies, business models, hybridization, improved regulatory frameworks, policy support and financing frameworks. Innovations sketched out in this study must go hand in hand to harness their full potential.

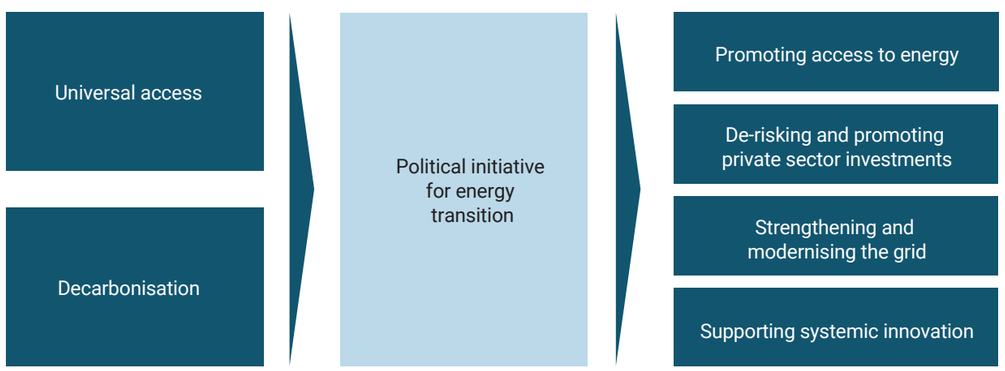


Figure 9-13: Challenges and opportunities in the energy sector. (GIZ, 2020)

9.5 Responses

Policy and institutional framework

Policies and institutional frameworks play an important role in creating an enabling environment for the clean energy transition process. International experience has shown that economic development is impossible without a well-functioning energy sector, and without minimum levels of capacity and consumption. (MININFRA, 2018). To that end, the government has put in place several strategies, policy instruments and projects at the national and sub national levels, in coordination with relevant partners to accelerate the progress on the clean energy targets. These include the National Energy Policy 2015, National Policy and Strategy on Renewable Energy, Vision 2050, NST-1, among others. Table 9-1 elaborates the policies that are in place in the renewable energy sector.

Table 9 1: Summary of energy sector policies, strategies and laws (MININFRA 2018)

Type	Policy / Strategy	Year	Description
Electricity access	SE4All Action Agenda	2016	Presents plan to deliver energy efficiency and renewable energy (biomass, off-grid, and power generation from renewable energies).
	Scaling up Renewable Energy Program (SREP) Investment Plan	2015	Supports implementation of the SE4All Action Agenda, with World Bank funding.
	Rural Electrification Strategy (RES)	2016	Sets out four programs which deliver off-grid solutions (SHS and mini-grids).
	Electricity Access Roll-out Programme (EARP)	2013	Key driver of on-grid access growth, with lots established for electrification to 2017/18.
	National Electrification Plan (NEP)	2018	Detailed plan of on and off-grid expansion.
Energy Efficiency	Energy Efficiency Strategy	2018	Outlines initiatives to improve efficiency across generation, transmission and distribution and end-user consumption.
Technical	Rwanda Master Plan & Least Cost Development Plan (LCDP)	2017	Present detailed analysis of current power system and future growth
	Grid Code	2013	Details the technical running of the power system.
Resources	Management Prescriptions for the Development of Lake Kivu Gas Resources	2009	Sets out required standards and processes for gas extraction. Being updated.
	Peat Resource for Power Generation	2014	Details the peat reserves for power generation across Rwanda.
	Simplified Licensing Procedure	2015	Sets out requirements for small-scale off-grid renewables developers.
Biomass	Biomass Energy Strategy	2018	Forecasts demand and supply balance across scenarios and includes action plan to deliver targets – focused on efficiency.
	National Biomass Program (NBP)	2018	Presents clear initiatives to promote use of efficient and alternative cooking technologies and establish sustainable biomass consumption.
Petroleum	Downstream Petroleum Strategy	2014	Detailed plan to establish effective regulatory and institutional frameworks, coupled with suitable and sufficient petroleum facilities to ensure supply and distribution.
Laws	Electricity Law of Rwanda	2018	Governs activities of electricity production, transmission, distribution, and trading.
	Public Private Partnership (PPP) law	2016	Establishes processes and requirements for entering PPPs (including procurement).
	Radiation Protection Law	2017	Establishes rules and requirements for the use of radiation.
	Renewable Energy and Energy Efficiency Law	2018	Governs renewable energy sources and energy efficiency in Rwanda with the aim of promoting further development, utilization, and sustainability.

The National Energy Policy 2015

The National Energy Policy 2015 guides decisions on the extraction, development and use of Rwanda's energy resources in a transparent and sustainable manner. It sets out governing laws and regulations and strategic sector specific priorities that Rwandan institutions and partners shall adopt and adhere to during policy implementation. It seeks to establish energy as one of Rwanda's most dynamic sectors and attractive investment destinations. It is founded upon three essential principles:

- A resolve for transparent and effective sector governance
- Easing doing business and reducing barriers to private investment
- Enhancing institutional, organizational, and human capacities as well as the legal and regulatory framework.

The National Energy Policy and the Energy Sector Strategic Plan (ESSP) are mutually reinforcing: the policy outlines a long-term vision, provides high-level goals, and recommends clear and coordinated approaches for achieving that vision. The ESSP outlines targets and an implementation framework against which to measure progress towards the realization of the policy (MININFRA, 2018).

East Africa regional integration will increase significantly, with almost full interconnection expected by 2022. Connecting the power systems of regional countries will improve network stability and present opportunities for inter-country trading of power. Rwanda will continue to support regional integration and analyses and assess import and export opportunities as they strengthen generation capacity and related infrastructure.

Sustainable Development Goal (SDGs) and the energy sector

SDG 7 on affordable and clean energy is particularly relevant for Rwanda towards a sustainable future. However, Rwanda faces major challenges in making progress on energy-related targets. The proportion of the Rwandan population that depends mainly on clean fuels and technology in 2019, was less than 5 percent (NISR, 2018). The energy intensity measured in terms of primary energy and GDP was 4.38 megajoules per constant purchasing power parity GDP (UNSTATS, 2021).

Sustainable energy development projects

The Sustainable Energy for All (SE4ALL) initiative is a multi-stakeholder partnership between governments, the private sector, and civil society. It was launched by the UN Secretary- General in 2011, and has three interlinked objectives to be achieved by 2030 (MININFRA, ESSP, 2018):

- Ensure universal access to modern energy services.
- Double the global rate of improvement in energy efficiency.
- Double the share of renewable energy in the global energy mix.

These objectives provide guidance for the energy sector, and an Action Agenda has been incorporated into Rwanda energy sector planning (MININFRA, 2018).

9.6 Conclusion and recommendations

Rwanda is committed to a low-carbon, climate-resilient energy future. However, more than 90 percent of population is using solid fuels for cooking. The Energy Sector Strategic Plan (ESSP) for 2018/19-2023/24 presents a clear plan for the energy sector, covering its three subsectors: electricity, biomass and petroleum. It is mutually reinforcing with the National Energy Policy 2015, which outlines a long-term vision, provides high-level goals, and recommends approaches for achieving that vision.

All sector actors can contribute significantly by advocating for and supporting the development and implementation of harmonized enabling policies for meeting these goals. Key recommendations to consider include:

- Aligning financial flow for charting a path forward for energy priority issues and mobilizing the needed effort for accelerated action to achieve clean and affordable energy for all.
- Accelerate efforts to halve the use of biomass energy, which will tremendously help in reducing the pressure on forests and mitigate climate change impacts in Rwanda.

References

AU. (2021). Agenda 2063: Infrastructure and Energy Initiatives. Retrieved May 5, 2021, from African Union (AU): https://au.int/en/videos/20190101/agenda2063-infrastructure-and-energy-initiatives

Bimenyimana, S., Asemota, G. N., & Li, L. (2018). The State of the Power Sector in Rwanda: A Progressive Sector with Ambitious Targets. Frontiers in energy research. https://www.frontiersin.org/articles/10.3389/fenrg.2018.00068/full#:~:text=The%20Government%20of%20Rwanda%20through,grid%20connections%20by%202023%2F24.

Bimenyimana, S., Asemota, G. N., & Li, L. (2019). Photovoltaic Solar Technologies: Solution to Affordable, Sustainable, and Reliable Energy Access for All in Rwanda. International Journal of Photoenergy, 2019(5984206), 29. Retrieved June 25, 2021, from https://www.hindawi.com/journals/ijp/2019/5984206/

Clean Cooking Alliance. (2021). Rwanda. Retrieved June 27, 2021, from Clean Cooking Alliance: https://www.cleancookingalliance.org/country-profiles/32-rwanda.html

Epd. (2021, March 5th). Retrieved June 27, 2021, from https://www.epdrwanda.com/lpg/

GIZ. (2020). The Renewable Energy Transition in Africa, Powering Access, Resilience and Prosperity. Frankfurt: GIZ, IRENA, KFW. Retrieved June 25, 2021 https://www.giz.de/en/downloads/Study_Renewable%20Energy%20Transition%20Africa-EN.pdf

GoR. (2020). Updated Nationally Determined Contribution. Government of Rwanda (GoR). chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/viewer.html?pdfurl=https%3A%2F%2Fwww4.unfccc.int%2Fsites%2Fndcstaging%2FPublishedDocuments%2FRwanda%2520First%2FRwanda_Updated_NDC_May_2020.pdf&clen=1412889

Imasiku, K., & Ntagwirumugara, E. (2019). An impact analysis of population growth on energy-water-food-land nexus for ecological sustainable development in Rwanda. Food and energy security. doi: https://doi.org/10.1002/fes3.185

MINECOFIN. (2017). National Strategy for transformation-1. Kigali: MINECOFIN. https://www.nirda.gov.rw/uploads/tx_dce/National_Strategy_For_Trsansformation_-NST1-min.pdf

MININFRA. (2018). Rwandan Energy Sector Strategic Plan (ESSP). Kigali. http://www.fao.org/forestry/energy/cataloguе/search/detail/en/c/1382215/

MININFRA. (2019). Biomass Energy Strategy 2019-2030. Kigali: MININFRA. Retrieved June 25, 2021, from https://www.mininfra.gov.rw/digital-transformation-1-1

Mukeshimana, M. C. et al. (2021). Analysis on Barriers to Biogas Dissemination in Rwanda: AHP approach. Renewable Energy, 163(0960-1481), 1127-1137. Retrieved June 25, 2021, from https://www.sciencedirect.com/science/article/abs/pii/S0960148120314713

NISR. (2018). Integrated Household Living Conditions Survey: EICV5_Thematic Report. National Institute of Statistics of Rwanda, National Institute of Statistics of Rwanda. Kigali: National Institute of Statistics of Rwanda. https://www.statistics.gov.rw/datasource/integrated-household-living-conditions-survey-5-eicv-5

Phillips, R.F. et.al. (2019). Energy Access Project. DUKE: Nicholas Institute for Environmental Policy Solutions. https://energyaccess.duke.edu/

Power Africa. (2019). Off-grid Solar Market Assessment Rwanda. USA: Power Africa and USAID. Retrieved June 25, 2021, from https://www.usaid.gov/sites/default/files/documents/1860/PAOP-Rwanda-MarketAssessment-Final_508.pdf

REG. (2021). Facts & Figures Details. Retrieved May 10, 2021, from Rwanda Energy Group: https://www.reg.rw/facts-figures/facts-figures-details/facts/installed-generation-capacity-on-the-national-grid/

The World Bank. (2021). Rwanda - Energy Sector. Retrieved January 2021, from Climate Change Knowledge Portal: https://climateknowledgeportal.worldbank.org/country/rwanda/climate-sector-energy

The World Bank. (2020). Source: Global Solar Atlas 2.0, Solar resource data: Solargis. Retrieved from https://solargis.com/maps-and-gis-data/download/rwanda

UNFCC. (2018, November 18). How Hydropower Can Help Climate Action. Retrieved April 3, 2021, from United Nations Climate Change: https://unfccc.int/news/how-hydropower-can-help-climate-action

UNSTATS. (2021). Rwanda. Retrieved August 9, 2021, from SDG County Profile: https://country-profiles.unstatshub.org/rwa#goal-15

WHO. (2021). Global Health Observatory data repository. Retrieved March 17, 2021, from World Health Organisation: https://apps.who.int/gho/data/view.main.GSWCAHv

Chapter 10:

Climate Change and Natural Disasters

Flood damage after heavy rainfall, 01 May 2020. Northern Province, Rwanda
Photo credit: MINEMA

10.1 Introduction

Climate change is widely recognized as the most significant challenge of our time. Increases in greenhouse gas (GHG) concentrations in the atmosphere originating from human (anthropogenic) activities are discernable causes of the changes to the climate system. The impacts of climate change are particularly disadvantageous to areas such as sub-Saharan Africa. Rwanda, for example, ranks 185 out of 188 countries in per capita GHG emissions (MoFA, 2018), but the Global Climate Risk Index (CRI) included Rwanda in the top-10 countries most affected by climate change in 2018 (Germanwatch, 2019).

Every year, in different parts of Rwanda, natural disasters such as drought, floods and ensuing landslides result in loss of life, damage to infrastructure, property and crops, soil erosion and water pollution. Additionally, small but incremental climate changes negatively affect water resources, agricultural production, biodiversity, human health, fish and forestry and other vulnerable ecosystems, with further impacts on the economy.

10.2 Climate change

Status and trends

The evaluation for the state of climate change in Rwanda was done using anomaly and trend analysis using 40 years rainfall data from 1981 to 2020 and 37 years for temperature data from 1983 and 2020 provided by Rwanda Meteorology Agency (Meteo Rwanda). The anomaly analysis was done by comparing climatology long term averages (39 years for rainfall and 36 years for temperature) with climate data from 2020. The year 2020 was also compared to the most recent years for rainfall for their impact observed.

Results from analysis show that the year 2020 was characterized by wetter weather conditions with above-normal rainfall in most parts of the country. Eleven out of 14 weather stations recorded rainfall above the Long-Term Average with the highest increase of 461 mm above climatology at Rubengera station (Karongi District). This corresponded to a 38 percent increase in rainfall. Only three out of the 14 stations recorded rainfalls below climatology with the decrease of -427 below climatology at Bugarama station (Rusizi District), corresponding to a 23 percent decrease in rainfall. Compared to the past recent years, 2020 is ranked first and second at many stations for receiving higher amounts of rainfall in the year.

Annual mean temperature trend analysis shows that 11 stations out of 14 experienced an increasing trend while only 3 stations showed a decreasing trend.

Temperature assessment

Data from the Rwanda Meteorology Agency shows that the average annual temperature is about 20°C, varying with topography and elevation. The warmest temperatures are found in the south-eastern Bugarama valley of Rusizi district (23.5°C) and the eastern plateau (20.5°C), while cooler temperatures are common in the higher elevations near the volcano region and near Nyungwe National Park averaging 18°C.

Floods destroy infrastructure in Nyabihu, 2020
Photo credit: Urugwiro Village/Flickr

Maximum temperature assessment

Daily data from 14 weather stations around the country show that, on average, the maximum temperature has been increasing over the last 40 years (Figure 10-1).

Maximum temperature anomalies

The maximum temperature anomalies were calculated using deviations of temperatures over the 1983-2019 period from temperatures in 2020 (Figure 10-2).

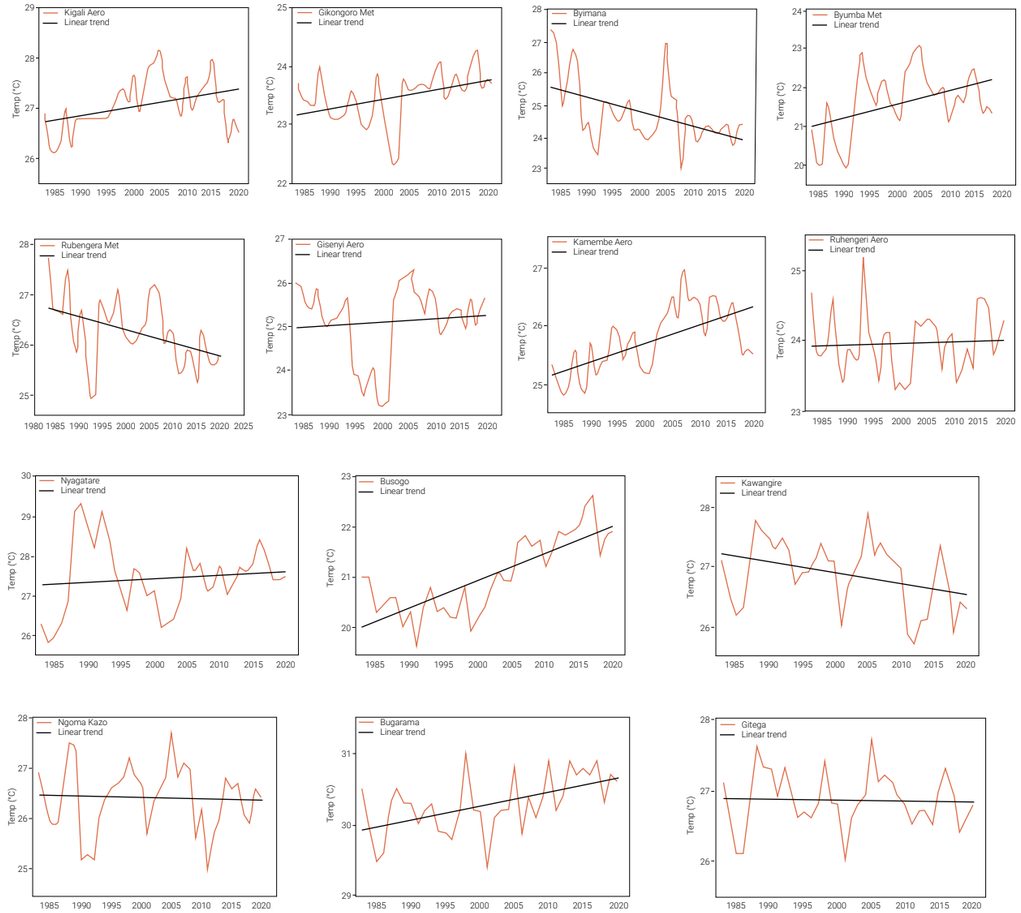


Figure 10-1: Trend analysis of maximum temperature (Meteo Rwanda)

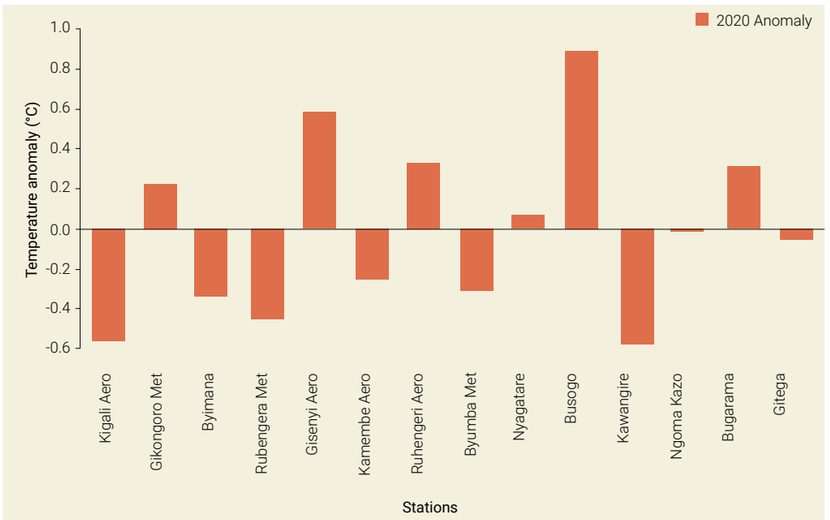


Figure 10-2: Maximum temperature anomalies (Meteo Rwanda)

Minimum temperature trends

The 40-year analysis of daily minimum temperature records showed an increasing trend (Figure 10-3).

Minimum temperature anomalies

Minimum temperature anomalies in 2020 presented positive anomalies (increase) from all 14 weather stations. These ranged from 1.2°C recorded at Bugarama station to 2.3°C observed at Busogo weather station (Figure 10-4).

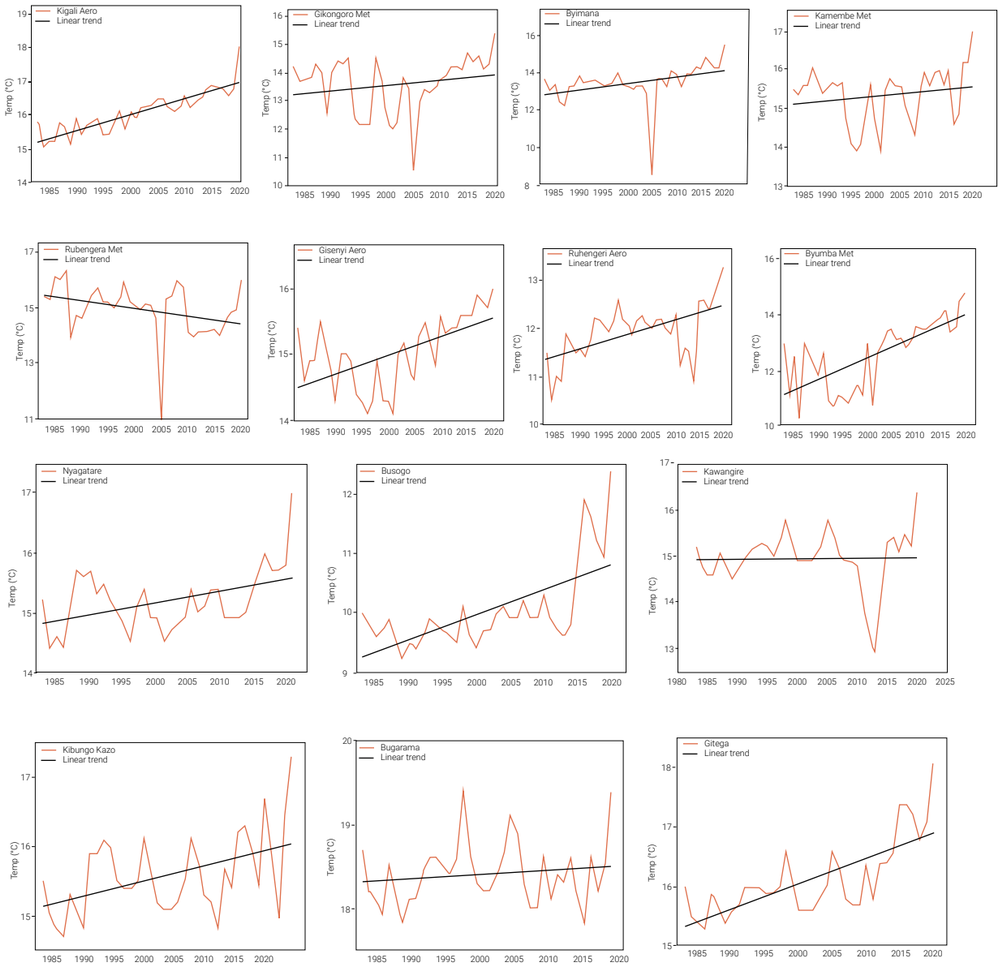


Figure 10-3: Trend analysis of minimum temperature (Meteo Rwanda, 2020)

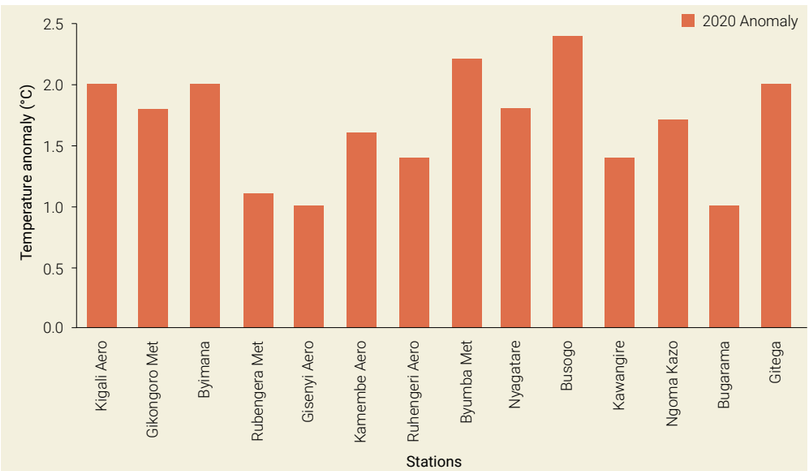


Figure 10-4: Minimum temperature anomalies (Meteo Rwanda, 2020).

Mean temperature trend

There has been an increasing trend in mean temperatures over the last 40 years. Only three stations (Rubengera, Byimana and Kawangire) showed a decreasing trend (Figure 10-5).

Mean temperature anomalies

Generally, the mean temperature anomalies of 2020 showed a positive deviation from the normal mean (1981-2019), except for Rubengera weather station, which showed a negative anomaly (decrease) of 0.1°C (Figure 10-6).

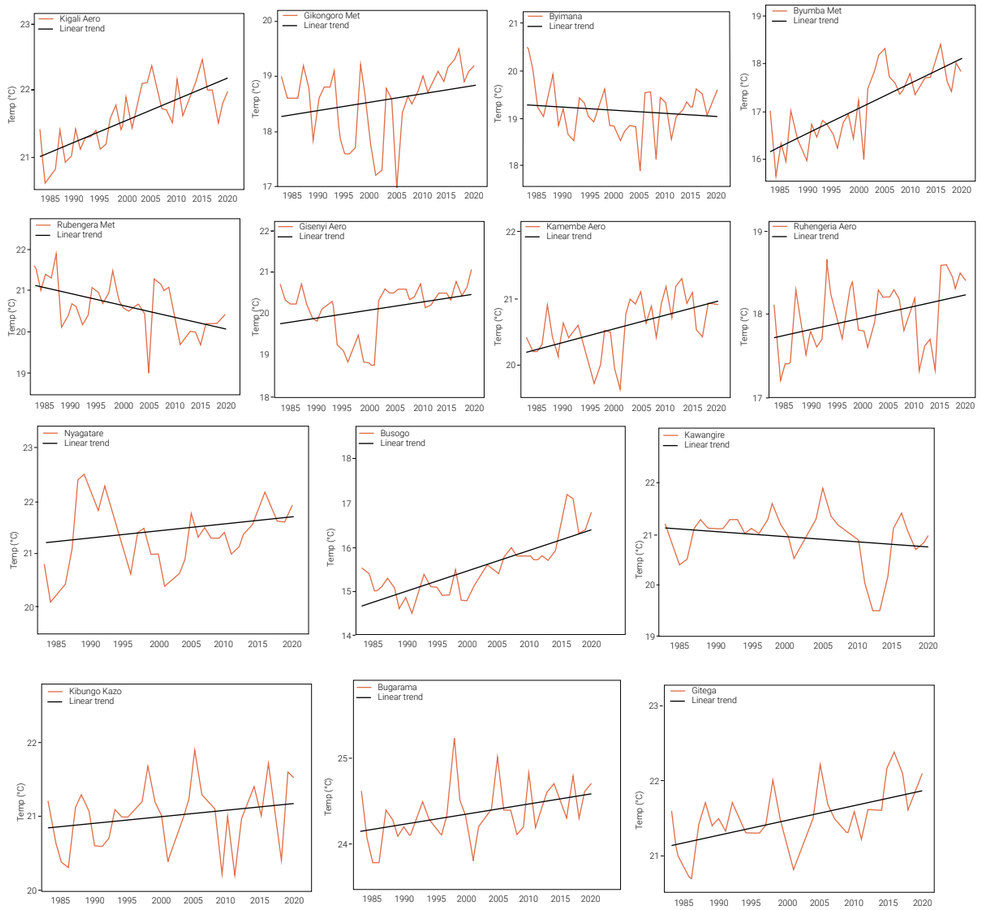


Figure 10-5: Mean temperature trend (Meteo Rwanda)

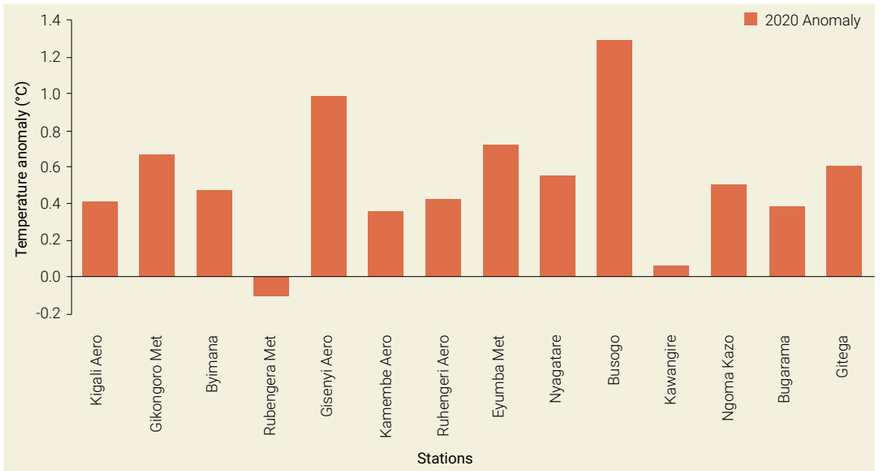


Figure 10-6: Mean temperature anomaly (Meteo Rwanda)

Rainfall assessment in 2020

Rainfall trend analysis

Rainfall assessment was performed for 14 stations using annual data for a 40-year period (1981 to 2020). The analysis showed an increasing annual trend in eight out of the 14 stations. Kigali and Kamembe stations showed a decreasing trend, while the others were steady (Figure 10-7).

Rainfall anomalies

The rainfall anomaly was performed by comparing rainfall recorded in 2020 with the long-term average (1981 to 2020). The departure from normal was done in terms of amount of rainfall (mm) and percentage. The results are presented in Table 10-1 and Figure 10-8. Only three out of 14 stations recorded below climatology rainfall in 2020, while 11 stations recorded above climatology rainfall. Seven stations recorded rainfall anomalies higher than 200mm (above 20 percent increase) over climatology.

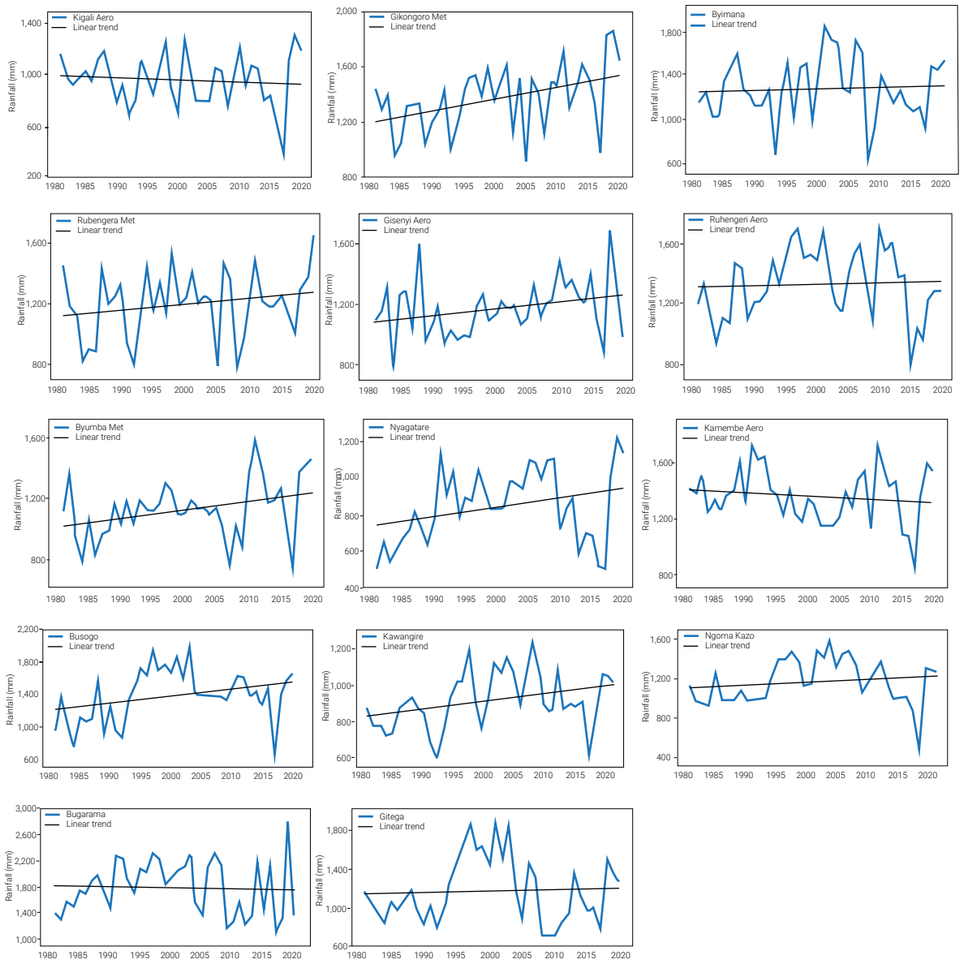


*Figure 10-7: **Rainfall trend (Meteo Rwanda)***

*Table 10-1: **Rainfall anomaly in millimeters and percentage (Meteo Rwanda)***

Station	2020 Anomaly (Mm)	2020 Anomaly (%)
Kigali Aero	226	24
Gikongoro Met	270	20
Byimana	254	20
Rubengera Met	461	38
Gisenyi Aero	-195	-17
Kamembe Aero	179	13
Ruhengeri Aero	-48	-4
Byumba Met	332	30
Nyagatare	287	34
Busogo	281	20
Kawangire	82	9
Ngoma Kazo	104	9
Bugarama	-427	-23
Gitega	78	6

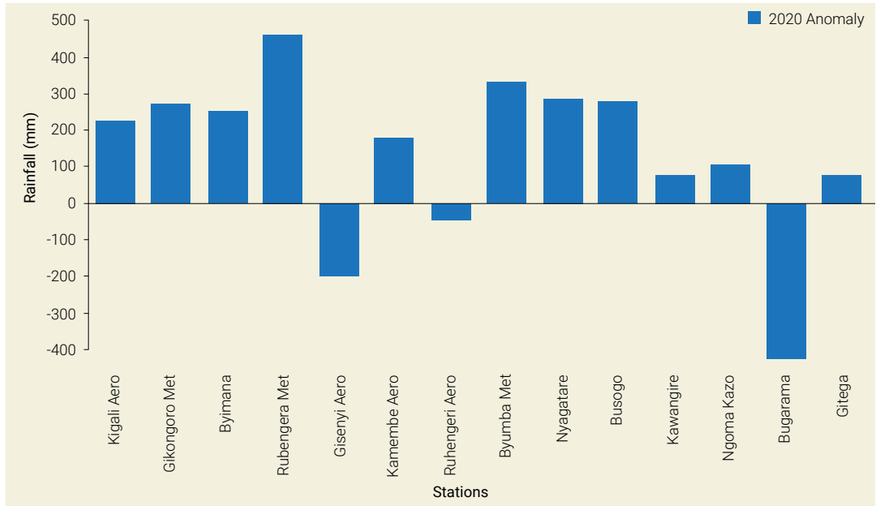


*Figure 10-8: **Rainfall anomaly (Meteo Rwanda)***

Flooded areas in Nyabihu, 2020
Photo credit: Urugwiro Village/Flickr

Comparison of 2020 rainfall with most recent past years

Rainfall recorded during 2020 was compared with data from the four most recent past years (2016, 2017, 2018 and 2019) in terms of annual total amount of rainfall and associated impacts (Figure 10-9). Many weather and related impacts have been observed since 2016. For instance, serious landslides associated with loss of lives, properties and infrastructure were observed in Rulindo and Gakenke districts during 2016, in Karongi and Ngororero districts in 2018, in many parts of the country in 2019 and in Nyabihu, Gakenke, Ngororero, Kigali and Muhanga in 2020. Overall, 2020 was characterized by increased rainfall ranking first over the five years at four stations, second after 2019 at 4 stations, and third at three stations.

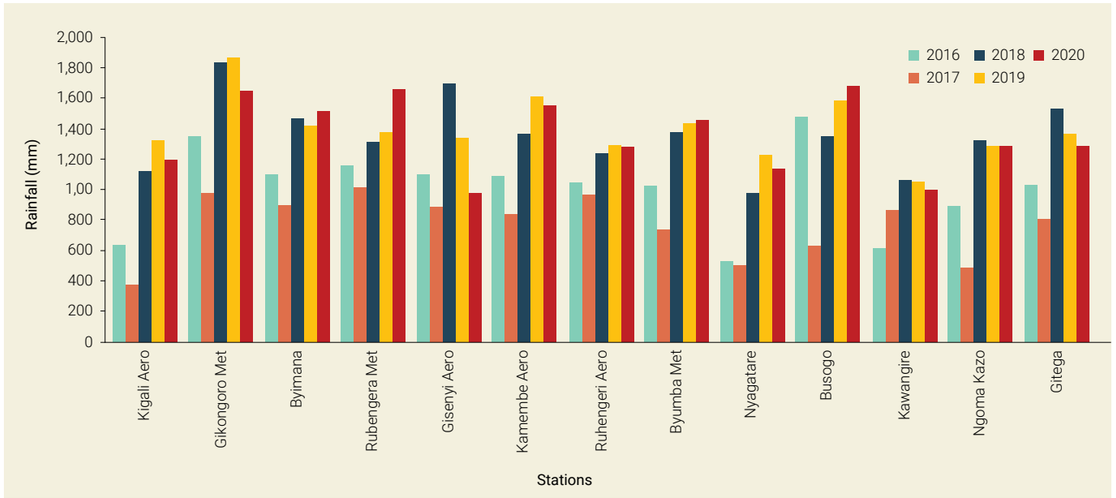


*Figure 10-9: **Comparison of 2020 rainfall with the last four recent years 2016-2019 (Meteo Rwanda)***

Greenhouse gas (GHG) emissions

In the updated Rwanda Nationally Determined Contributions (NDCs), taking 2015 as the base year, total emissions, excluding forestry, were estimated at 5.3 million tCO_2e. Under a Business as Usual (BAU) projection, Rwanda's total emissions were forecast to more than double over the 2015-2030 period, rising from 5.3 million tCO_2e in the base year to 12.1 million tCO_2 e in 2030. The forecast indicates the growing contribution from fossil fuels to national emissions, arising from increasing demand for power generation, road transport and other modern energy uses (RoR, 2020b). Figure 10-10 presents the GHG emissions by source in 2015.

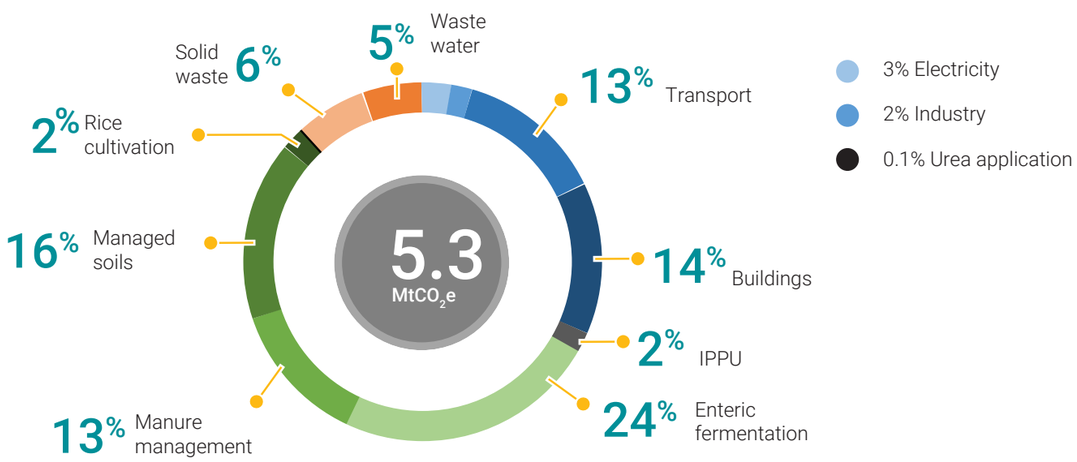


*Figure 10-10: **Rwanda's GHG emissions by sources in 2015, $MtCO_2e$ (RoR, 2020b).***
Note: Data from GHG inventory forestry excluded.

Vulnerability to the impacts of climate change

The economic impacts of extreme weather events in Rwanda - and their negative impacts on growth and development - are already significant. Some of the key vulnerable sectors include agriculture, water, health, and energy as summarized in Figure 10-11.

Food production

Changes in rainfall and temperature with the heightened frequency of floods and droughts impact food security and water availability in Rwanda. An assessment of the influence of climate change on crop productivity concluded that Rwanda, along with neighbouring countries, may be hotspots for food insecurity in the future. This may limit opportunities for food imports into Rwanda (MoFA, 2018).

Climate change has different effects on the production of different crops. In 2009, cassava, one of the main foods and income generating crops, was reported to be suffering declining yields due to the combination of low soil moisture and declining soil organic matter. However, since the onset of the national Crop Intensification Programme, cassava production tripled between 2009 and 2012. Table 10-2 shows the expected future climate-related impacts on the country's main staple crops (MoFA, 2018), in order of importance.

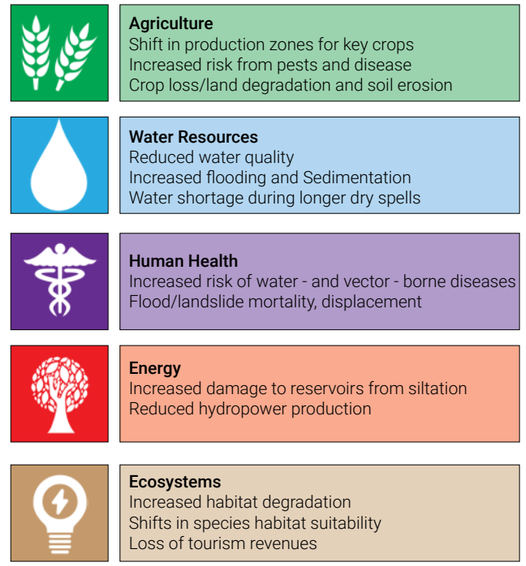


*Figure 10-11: **Sectors with key impacts from projected climate change in Rwanda***

*Table 10-2: **Expected future impacts on countries staple crops (MoFA, 2018)***

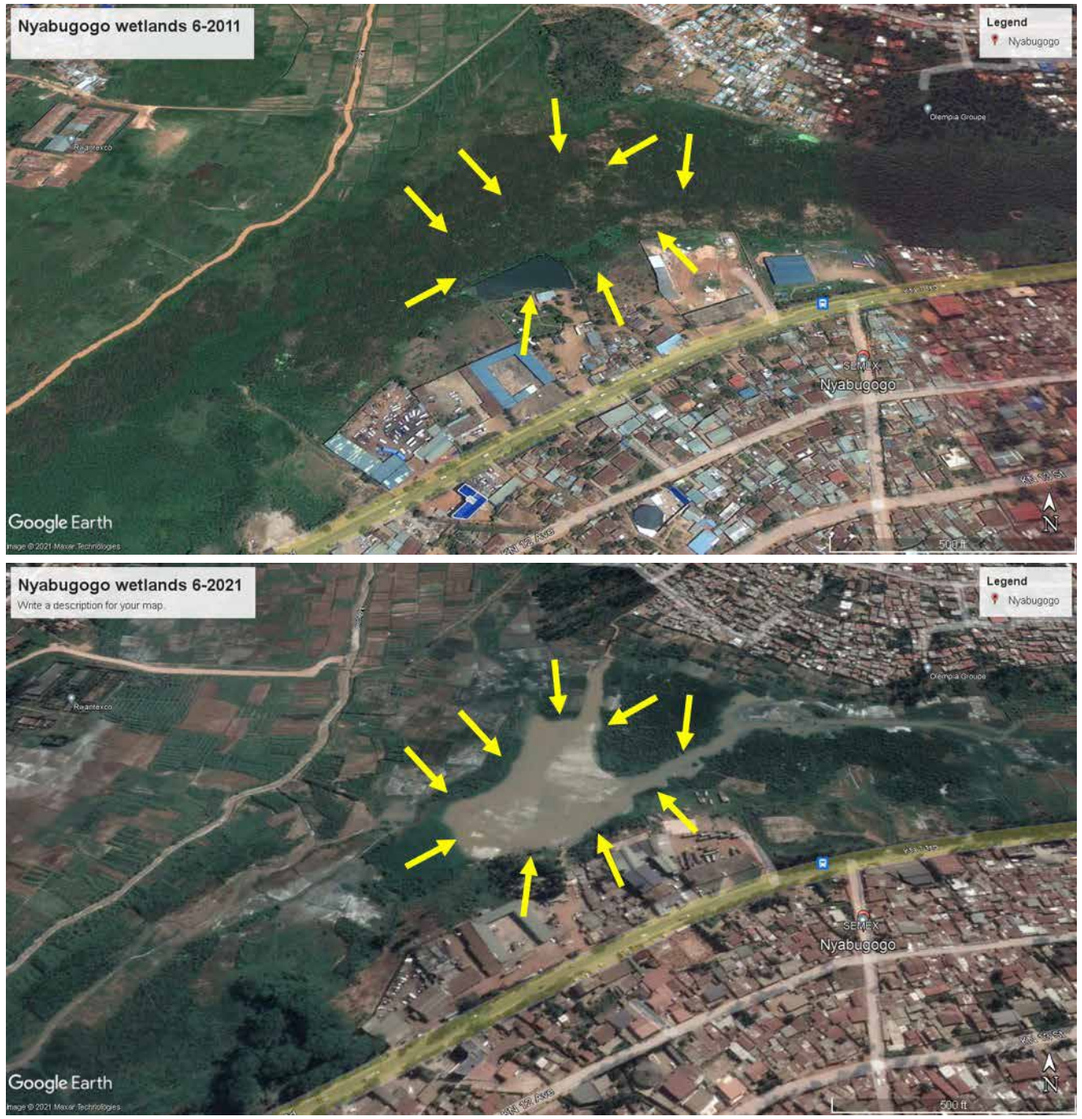
Crop	Impact	Rationale
Banana	No change	Grows well in higher temperatures
Beans	Significant decline	Negatively affected by higher temperatures. Low soil moisture will further depress yields
Sorghum	Slight increase	Will become suitable for some areas in the north and west, which are currently too cold
Potatoes	Significant increase	Yields are expected to increase (25-90 percent between 2010 and 2050) which will result in Rwanda able to meet all domestic demand and to supply an export market by 2050
Coffee & Tea	Slight Decline	Coffee is especially sensitive to climatic factors - temperatures above 25˚C as well as atypical rainfall patterns will have adverse effects. Higher temperatures will force coffee producers to cultivate at higher elevations, more prone to erosion, and this may lead to potential land-use conflicts (Tenge, Alphonse, & Thomas, 2012).

Water

Most parts of Rwanda are projected to experience an increase in average precipitation with more intense rainfall, particularly in the rainy seasons. This is likely to increase the intensity and frequency of floods and landslides. The probable impacts may include erosion, damage to roads, bridges, and other infrastructure along with heightened health issues, including water borne diseases. Thus, greater attention to water management and options for water storage, irrigation infrastructure and water monitoring are needed to cope with future water demands in all regions of the country.

Energy supply

Energy security will also be at risk. Hydropower contributes 41.5 percent of the nation's electricity and will be vulnerable to variations in rainfall and evaporation. Droughts reduce hydro generating capacity, and floods increase soil erosion and siltation, which can damage dams and other generation, transmission, and distribution systems. Severe floods can damage run-of-river hydropower installations. For instance, in 2004, drought reduced hydroelectric generation in the country forcing the government to rent diesel power plants to meet domestic demand (Byamukama, Darey, Cole, Dyszynski, & Warnest, 2011).



Before and after satellite images of Nyabugogo wetland (2011-2021)
Note: Papyrus has been removed in the wetland (green to grey color). The Nyabugogo Lower wetland is located at the confluence of the main Nyabugogo and the Rwenzangoro rivers. The wetland sits in the flood plain which is gently sloping to the south-west. Both rice paddies and ridge-furrow plots can be found in the wetland. Periodic flooding of the wetland occurs during the rainstorms, which mainly affects the agricultural plots. More significant flooding occurs on the roads and bus station at the confluence with the Mpazi Channel.

Forest and biodiversity

The quality of Rwanda's forests, biomass, and biodiversity will likely be negatively affected. As highlighted in June 2021, the impacts, and risks of plausible future changes in climate (for example, at different time horizons and for different levels of warming such as 1.5°C, 2°C, 3°C and 4°C compared to pre-industrial) is associated with irreversible changes in the climate system and ecosystems (IPBES-IPCC, 2021). Hence climate-informed strategic plans are required to ensure forests and biodiversity in Rwanda are protected for the long-term and able to make the transition to a warmer climate. Important choices about reforestation (including species-site mapping), forest rehabilitation and conservation need to be fully climate informed.

Human health

Interlinkages between climate change and human health include the following:

- Rising numbers of Extreme Weather Events (EWE) may lead to food shortages and malnutrition.
- Changes in temperature will have impacts on the yield and distribution of staple crops.
- Rising numbers of extremes weather events along with more densely distributed populations will result in injuries, disease and mortality.
- Warmer ambient temperatures will extend weather-sensitive diseases, for example malaria and Rift Valley Fever, to previously disease-free zones such as the highland areas.
- Frequent flooding will contribute to the spread of waterborne diseases, such as cholera and parasitic infections.
- More severe droughts may lead to conflicts over scarcer natural resources including water, forests, and pasture.

National and subnational vulnerability indicators

The government assesses its vulnerability to climate change to monitor progress in addressing the impacts of climate change and building adaptive capacity (REMA, 2019). The latest assessment was carried out in 2018. The assessment presents and analyzes a total of 37 indicators in three groups - Exposure, Sensitivity and Adaptive Capacity - with the direction of change indicated by the symbols provided for each indicator (Table 10-3). In summary, 17 indicators (↓)show reduced vulnerability, 11 indicators show increased (↑) vulnerability, 5 (↔) show no change in vulnerability and four lack enough data to make an assessment (na).

Responses to climate change

National Adaptation Programme of Action (NAPA-2006)

Rwanda was one of the first in Africa to submit a National Adaptation Programme of Action (NAPA-2006) to identify its priority activities to respond to the needs for adaptation to climate change. The NAPA identified six priority adaptation focus areas:

- Integrated water resources management (IWR).
- Early warning systems and rapid intervention response.
- Promotion of sustainable income-generating activities.
- Promotion of intensive sustainable agriculture and animal husbandry.
- Introduction of crop varieties resistant to environmental conditions; and
- Development of energy sources alternative to firewood.

The first and second focus areas have been taken up by a programme under the Least Developed Country Fund (LDCF), by the Global Environment Facility (GEF), under the UNFCCC. The six objectives are also addressed by Rwanda's Green Growth and Climate Resilience Strategy (GGCRS) which was launched at COP 17 in Durban, South Africa in 2011.

Rwanda Green Growth and Climate Resilience Strategy (GGCRS)

Adopted in 2011, the specific purpose of the GGCRS is to:

- Guide national policy and planning in an integrated way.
- Mainstream climate change into all sectors of the economy.
- Position Rwanda to access international funding to achieve climate resilience and low carbon development.

The GGCRS is aligned with Vision 2050 ensuring that Rwanda's development pathway is climate resilient and harnesses green economic innovation for a low carbon economy through to 2050. The GGCRS (2011) "under review" comprises eight Programmes of Action aligned to four Thematic Programme Areas which are: Green Industry and Private Sector Participation, Urban Transition and Integration, Sustainable Land Use and Natural Resource Management and Vibrant resilient green rural livelihoods.

Table 10-3: Summary of change in Rwanda's national indicators (REMA, 2019)

Indicator No.	National Indicator	Trend
	Exposure Indicators	
1.1	Projected change in population growth to 2032	↓
2.1	Annual frequency of warm days (above 30 °C) per year	↓
2.2	Current mean annual temperature; annual change in temperature	↓
3.1	Change in agricultural production	↓
4.1	Annual precipitation run-off rate	↓
4.2	Annual ground water recharge	na
5.1	Change in number of deaths from diarrhea diseases and malnutrition	na
5.2	Change of malaria hazard	◄►
6.1	Change in % of national forest cover	◄►
7.1	Change of hydropower generation capacity	↑
	Sensitive Indicators	
1.2	Age dependency ratio	↑
1.3	Total urbanized population	↓
1.4	Effectiveness of Rwanda's social safety net / social protection system	↑
2.3	Annual loss due to damage caused by hazards, particularly weather-related	↓
3.2	Rural population as % of total population	◄►
4.3	Fresh water withdrawal rate	↓
5.3	Dependency on external resources for health services	↑
5.4	Proportion of urban population living in slum areas	↓
6.2	Change in size (ha or km^2) of natural habitats or critical ecosystems	↓
7.2	Level of dependency on imported fuel	↓
	Adaptive Capacity Indicators	
1.5	Level of education attained by women	↑
1.6	Strength of government capacity and coordination to mainstream climate change	na
2.4	Access to improved climate-related early warning info/systems – for extreme weather	↑
2.5	Percentage of the area of Rwanda covered by the Rwanda Meteorology Agency	↑
2.6	Extent of use of climate info products and services in decision-making in climate sensitive sectors	↑
3.3	Extent of fertilizer use	↑
3.4	Level of severe child malnutrition	◄►
4.4	Change in future water demand	na
4.5	Capacity of dams and lakes to store water	↑
4.6	Access to reliable drinking water	↑
5.5	Change in access to health care facilities	↑
5.6	Access to improved sanitation facilities	↑
6.3	Proportion of land area protected to maintain biodiversity and natural ecosystems	↑
6.4	Engagement in international environmental conventions	↑
7.3	Quality of trade and transport infrastructure	↑
7.4	Length of paved roads	↑
7.5	Proportion of population with access to electricity for lighting	↑

Climate finance

The government continues to develop its activities on climate change and funding. Over the past decade, it has achieved exceptional successes, integrating climate-related aspects into its interventions for sustainable socio-economic development. The country benefits from several external and internal funding sources, such as the National Green Fund (FONERWA), the World Bank, the Global Environment Facility (GEF), the Green Climate Fund (GCF). The total GCF financing in Rwanda represents expenditure of US $50.8 million on six national projects, including the Transformation of the Eastern Province through Climate Change Adaptation Project which was approved in July 2021 (GCF, 2021).

The Rwanda Green Fund (FONERWA), locally known as FONERWA was created in 2012 to respond to the environment and climate change-related financing needs. Since its establishment, investments have resulted in the creation of green jobs, implementation of measures to reduce soil erosion, improvements in households' access to off-grid clean energy, and an overall increase in the funding mobilized for climate resilience investments.

Nationally Appropriate Mitigation Actions

Nationally Appropriate Mitigation Actions, or NAMAs, are voluntary climate change mitigation measures proposed and taken by developing country governments to reduce greenhouse gas emissions and to contribute to domestic sustainable development (Box 10-1). NAMAs can take the form of regulations, standards, programs, policies, or financial incentives.

Nationally Determined Contributions (NDCs)

As a party to the Paris Agreement, Rwanda submitted its first Nationally Determined Contributions (NDCs) to the UNFCCC in 2015 and updated in May 2020. Mitigation targets have been set through the 2011 Green Growth and Climate Resilient Strategy (RoR, 2020b). The NDC is built upon the GGCRS, and the priority actions outlined in GGCRS have both adaptation and mitigation dimensions (Figure 10-12 and Figure 10-13). Full implementation of the NDCs will require predictable sustainable and reliable support in the form of finance, capacity building and technology transfer. The funding requirements associated with all identified NDCs mitigation options is estimated at US $5.7 billion through to 2030, while the total amount of adaptation interventions to 2030 are over US $5.3 billion (RoR, 2020b).

Rwanda is going through a national medium- and long-term adaptation planning (NAP) process. The project "Building the capacity of Rwanda's government to advance the National Adaptation Planning process (NAP) project" is focusing on strengthening technical and institutional capacity for the national adaptation planning process in Rwanda including capacity in developing downscaled catchment-level climate projections, in undertaking climate risk assessments, designing climate change adaptation options and strategies and development of adaptation plans. REMA is establishing a programme to generate long-term research and knowledge systems that will be used to inform future adaptation planning and budgeting. A monitoring framework to track and review the effectiveness of the NAP process will also be established.

Box 10-1: Push for E-mobility in Rwanda

E-mobility refers to clean and efficient transportation, using electric vehicles backed up by a robust ICT infrastructure. The transformation to e-mobility is driven by the health effects of urban air pollution, international commitments to cut GHG emissions, the need to reduce dependency on oil, and a drive to tap the benefits of developing Electric Vehicle (EV) technology. Currently, Rwanda has 221,000 registered vehicles consisting of 52 percent of motorcycles and 38 percent passenger vehicles, of which at least 30,000 are in Kigali. The number of electric vehicles is increasing by almost 12 percent per year and the fuel import bills are approximately 12 percent of total imports (Bajpai, J., & Bower, 2020).

Mitigation Measures	• Increased use of renewables • Climate compatible mining • Improved livestock husbandry • Energy efficiency in agro-processing • Off-grid and rooftop solar electrification • Soil and water conservation • Promotion of electric vehicles and public transport infrastructure • Promotion of on-farm biogas for energy

*Figure 10-12: **Mitigation measures under Rwanda's NDCs (RoR, 2020b).***

Adaptation Measures	• Integrated Water Resources planning and management • Diversity in local and export agricultural markets • Sustainable forestry, agroforestry & biomass energy • Institutional capacity development • Vector-based disease prevention • Climate sensitive integrated land use planning and spatial planning • Disaster preparedness and emergency response • Climate data and projections for EWS

*Figure 10-13: **Adaptation measures under Rwanda's NDCs (RoR, 2020b)***

Kigali Amendment to the Montreal Protocol on substances that deplete the ozone layer

The Kigali Amendment to the Montreal Protocol, entered into force in January 2019, following ratification by 65 countries, including Rwanda. Action under the Kigali Amendment will help reduce the production and consumption of hydrofluorocarbons (HFCs), industrial chemicals primarily used for air conditioning and refrigeration. These are powerful, man-made GHGs and are rapidly building up in the atmosphere (CCAC, 2020). Countries have committed to reduce the production and use of HFCs by 85 percent by 2050. This is expected to avoid global warming of up to 0.4°C by 2100 (CCAC, 2020).

10.3 Natural disasters

Natural disasters are major adverse events resulting from natural processes of the Earth; examples include floods, hurricanes and tornadoes or cyclones, volcanic eruptions, earthquakes, and other geologic processes. A natural disaster can cause loss of life and typically leaves some economic damage in its wake, the severity of which depends on the affected population's resilience and on the infrastructure available.

Status and trends

Rwanda has been experiencing an increasing number of natural disasters in recent decades, causing physical, social, and economic damage and losses. These include the droughts that occurred in 1989, 2000, 2005-2006 and 2014; the devastating landslides that occurred in 1988, 2006, 2010, 2011 and 2020 mainly in the northern and western provinces; the increasingly common floods across the country; the earthquake of 2008; and the windstorms that intermittently hit different parts of the country. The Sendai Framework on Disaster Risk Reduction is an ambitious agreement, associated with the SDGs, with the overall objective of substantially reducing disaster risk and loss of life, livelihoods, and health and in the economic, physical, social, cultural and environmental assets of persons, businesses and communities. Rwanda was one of the first countries globally to adopt the Sendai Framework Monitor when it was introduced in March 2018 (UNDRR, 2018). This was made possible due to its development of a national disaster loss database, supported by the UN International Strategy for Disaster Reduction.

10.4 Pressures and impact

Impacts of natural disasters on the economy and environment

Every year, millions of people are affected by both human-caused and natural disasters. In a disaster, people face the danger of death or physical injury, and may also lose their home, possessions, and community. Between 2016 to 2020, floods, landslides, droughts, and earthquakes directly affected over 90,000 people per year as highlighted in Table 10-4.

Rwanda's National Risk Atlas, launched in September 2015, is the first-ever comprehensive disaster risk profile developed in Africa to enhance disaster risk management and provide risk-informed guidance to national planning and policymaking processes including mainstreaming with respect to disaster risk reduction. The Atlas presents a comprehensive and nationwide assessment of natural hazard risks focused on the five major natural hazards (droughts, floods, landslides, windstorms, and earthquakes) that occur in Rwanda. The at-risk elements that are considered include population, agriculture, health, education, housing, and transportation (roads). The risk profile is analyzed and presented at both the national and district levels thus informing programme implementation. Table 10-5 presents key statistics on Rwanda's disaster losses.

*Table 10-4: **Impacts of disasters on people and infrastructure 2016-2020 (RoR, 2020a); (Nkurunziza, 2021)***

Disaster Effects	2016	2017	2018	2020
Deaths		82	254	290
Injured	72	151	346	398
Houses damaged	5,821	5,802	15,910	
Crops (ha lost)	7,449	5,277	13,337	5,968
Forests (ha damaged)				458
Livestock	932	590	815	
Classrooms	82	203	73	
Health Centers	2	3	3	
Roads	2	13	32	
Churches	6	37	27	
Bridges	40	49	64	
Admin Offices	13	18	12	
Water supply systems	39	10	1	
Electricity transmission lines	2	79	26	

*Table 10-5: **Rwanda disaster and losses from 1974 to 2018 (RoR, 2020a); (Nkurunziza, 2021)***

Hazard	Occurrences	Deaths	People affected	Damage ($ mil)
Flood	16	305	2,012,150	22
Landslide	5	117	11,949	28
Storm	2	3	6,553	
Drought	6	237	4,156,545	
Earthquake	2	81	2,286	

Disaster effect, 01 May 2020. Northern Province, Rwanda
Photo credit: MINEMA

Floods

Rwanda is threatened mainly by riverine floods, or floods caused by rivers running outside of their natural courses. Of the five hazards examined, floods have been responsible for the second highest mortality rate in the past 45 years, and have affected more than two million people, mostly in the western and southern provinces (UNDRR, 2018). The flood hazard assessment revealed that floods are most prevalent in areas around the five catchments of Nyabarongo, Sebeya, Nyabisindu, Mukungwa, and Kagitumba (MIDIMAR, 2015). In recent years, Rwanda has been experiencing regular heavy flooding caused by severe torrential rains. In addition to the human costs, flooding and erosion negatively impact Rwanda's agricultural sector and damage villages. In November-December 2019, approximately 1,000 households were affected whereas in March 2020, extreme rainfall in Kigali City and the Eastern Province impacted 1,300 households. In May 2020, flooding and landslides in the north and west affected 3,300 households (IFRC; RCS, 2020).

Landslides

Landslides are a major hazard and result in loss of life, shelter, livelihoods, and injury. Mass movements of land can be triggered by either hydro-meteorological or seismic events. About 40 percent of the country's population are vulnerable to landslides. Population exposure to landslides is particularly prevalent in the highlands of the northern and western provinces (MIDIMAR, 2015). The housing exposure to landslides is highest in Nyabihu, Burera and Ngororero, where slopes are extreme and in Kigali City. One hundred sixteen (116) schools are exposed to landslides at extremely high susceptibility – about 5 percent of the total schools in the country. Five hundred fifty-three (553) kilometers of paved national roads and 691 km of unpaved national roads are also exposed to landslides. These figures represent, respectively, 45 percent and 39 percent of total (classified) national paved and unpaved roads in the country. The total of district roads exposed to landslides is 2,003 km, representing about 74 percent of the total length of all (classified) district roads. In 2016, at least 100 people were killed by landslides, mostly in the northern hills and mountainous areas (MIDIMAR, 2015).

Windstorms

Windstorms in Rwanda regularly reach up to 20-25 knots, damaging roofs, crops, and facilities such as schools and health centers, downing electric lines and causing power outages. In 2011 and 2012, windstorms and heavy rain severely affected western districts, damaging buildings and banana plantations and other crops impacting a total of 3,600 people (MIDIMAR, 2015).

Approximately 500,000 Rwandans are exposed to extreme windstorms (strong gale) across 13 districts. More than 140,000 houses are exposed, 140 schools (about 10 percent of all schools) and 23 health centres (5 percent of all health facilities). The windstorm hazard assessment showed that the areas which are most prone to strong windstorms are those found within a belt from the southwest through the extreme northwest (MIDIMAR, 2015).

Flood damage after heavy rainfall, 01 May 2020. Northern Province, Rwanda
Photo credit: MINEMA

Disaster effect (landslide), May 2020. Northern Province
Photo credit: MINEMA

Droughts

Rwanda's drought vulnerability is high. Prolonged dry seasons or delays in the onset of rainy seasons are the main triggers for droughts in Rwanda. In 2016, the country experienced its worst drought in 60 years in two consecutive planting seasons.

Despite its fertile ecosystem, food production often does not keep pace with demand. Periodic droughts in the east of the country significantly undermined agricultural production between 1999-2000 and 2005-2006, in turn posing a risk to the economic outlook of the country. About 100,000 people are vulnerable to severe drought, with the most vulnerable populations in districts in the eastern province. Banana, potato, cassava are the most vulnerable crops (MIDIMAR, 2015).

Earthquakes

The eastern Lake Kivu border fault (part of the East African rift system) in western Rwanda is the main area of seismic activity in the country. The recent volcanic eruptions of Mount Nyiragongo on May 22nd, 2021, caused fissures and earthquakes on the south side of the volcano in neighboring districts, including Rubavu. This eruption event resulted in the death of at least 31 people, damage to infrastructure and the displacement of people (REMA, 2021).

The three districts of Rubavu, Rusizi and Nyamasheke in the western province of Rwanda are typically the most affected by earthquake events along with some districts in the south and north. Thirty percent of the schools georeferenced are particularly exposed to earthquake damage and a total of 1,211 km of national paved roads, 1,539 km of national unpaved national roads, and about 3,899 km of district roads are also highly vulnerable (MIDIMAR, 2015).

10.5 Responses: Disaster Risk Management in Rwanda

Pre-disaster planning and risk reduction

In the last five years the government has significantly increased resources to support disaster risk reduction and management. Between 2016-2017 and 2018-2019, DRR investments in Rwanda were channeled largely through the Ministry of Health, with 17 sub-programmes, and the Ministry of Environment (13), Ministry of Agriculture (12) and Ministry of Infrastructure with 7 programmes. The Ministry of Infrastructure received the largest financial allocations (US $71 million), followed by the Ministry of Health (US $39 million), Ministry of Agriculture (US $31 million) and the Ministry of Local Government (US $12 million) (UNDRR, 2020).

Although disaster risk management (DRM) is not explicitly documented in the programmes and activities of the national budget, the use of OECD DRR markers, points to 284 programmes relevant to DRR in 11 ministries, and in local development plans in 24 out of 30 districts (UNDRR, 2020). Over the 2016-2019 period, the overall estimate of DRR investments was about 8.5 percent of the national budget, comprising US $224 million. Domestic resources made up the largest portion of DRR investments at 54 percent (US $120 million) between 2016-2017 and 2018-2019. External resources contributed 46 percent.

Rwanda has also put in place environmental regulations and standards to enforce proper design, construction and use of disaster-resilient building materials and ensure compliance with building codes, which have been updated to take disaster risk reduction elements into consideration. As part of a broad public awareness campaign, MIDIMAR regularly undertakes

media and social media campaigns. Rwanda celebrates the International Day for Disaster Reduction every year, as a curtain raiser for a Disaster Risk Reduction Week.

Policies and legal framework

The evolution of the disaster management system in Rwanda can be traced back to 2010 when the Ministry of Disaster Management and Refugee Affairs (MIDIMAR) was formed, and subsequently renamed MINEMA in 2018. The institutional framework at the national level includes the National Disaster Management Committee (NDMC) chaired by the Minister in charge of Emergency Management and the technical committee - the National Disaster Management Technical Committee (NDMTC).

At the district level, the District Disaster Management Committee (DDMC) is chaired by the mayor of the district and, at the lower level the Sector Disaster Management Committee (SDMC) is chaired by the Sector Executive Secretary. The National Platform for Disaster Management (NPDM) includes government institutions, UN Agencies, NGOs, Private Sectors, Academia, and CSOs. Its objectives include strengthening networking and sharing information, experiences, and technical expertise nationally, regionally and internationally; reviewing policies and relevant plans; ensuring a multi-stakeholder participation in the development, updating, and sharing of a Disaster Risk Reduction and Management Information System among others.

In accordance with Africa Programme of Action for the Implementation of the Sendai Framework for Disaster Risk Reduction (2015-2030), the following are strategic directions of the National Strategy for Disaster Risk Reduction of Rwanda:

- Coherence in implementation
- Local action and
- Gender and inclusiveness in disaster risk reduction.

The institutional framework seeks to ensure coherence among the different institutions and stakeholders.

Rwanda has a disaster management response coordination mechanism that incorporates all relevant sectors and institutions of government as summarized in Table 10-6. A lead organization from each relevant sector is mandated to coordinate the response.

A solar field at the Agahozo Shalom Youth Village in Rwanda
Photo credit: Semeer Halai/USAID/Power Africa/Flickr

Table 10-6: Disaster clusters and sectors matched with lead government institution

Disaster Sector	Lead Institutions
Disaster and refugees' management	Ministry of Emergency Management
Recovery	Ministry of Finance and Economic Planning
Education	Ministry of Education
Emergency shelter	Ministry of Local Government
Food security	Ministry of Agriculture
Health and nutrition	Ministry of Health
Logistics	Ministry of Emergency Management, Ministry of Defence
Water and sanitation	Ministry of Infrastructure
Search, rescue, and evacuation	Ministry of Defence

10.6 Conclusion and recommendations

Rwanda is an agriculturally dependent and less-diversified economy making it highly vulnerable to the impacts of changing climate. Recognizing the consequences of inaction, Rwanda remains steadfastly committed to the Paris Agreement and has dedicated the resources required to achieve substantial emissions reductions. The challenge comes at a time of multiple, competing priorities requiring government funding and coordinated response. However, the path towards low-carbon, climate resilient development has been prioritized by the government along with the leadership required to leave a better future for the generations that follow. In this context the following recommendations are made for climate change and disaster risk reduction.

Climate change

- The government needs to be prepared for disease outbreaks and changes in land use and cropping patterns associated with the higher temperatures projected.
- There needs to be greater attention given to water management and options for water storage, irrigation infrastructure and water monitoring are needed to cope with future water demands in all regions of the country.
- More effort is required in the preparation of climate-informed analyses on reforestation (including species-site mapping), forest rehabilitation, and forest conservation, as well as community outreach to raise awareness, inform management decisions, and more widely promote sustainable forest management.
- National reporting based on credible science should be strengthened.

Disaster risk reduction

- Improvements to the hydrological infrastructure network should focus on flood-prone areas as per hazard assessments.
- Close to half of the total schools in the country and many health facilities are exposed to some sort of natural hazard. Despite updated environmental regulations, standards and building codes, older schools and health facilities remain at risk. A national retrofit upgrade programme focused on older schools and health facilities may be warranted.
- Economic losses associated with windstorm damage to electric transmission and distribution systems could be mitigated by a broad infrastructure upgrade programme.
- As of 2018-2019 only 24 of the 30 Districts had DRR-relevant programs in their Local Development Plans. District Disaster Management Plans should be updated and integrated into local development plans for all the 30 districts in Rwanda.
- There is need to update the latest five-year strategic plan of the Ministry of Disaster Management and Refugee Affairs (2012-2017) and the current version of the National Natural Hazard Risk Atlas (2015).

References

Bajpai, J., & Bower, J. (2020). A road map for e-mobility transition in Rwanda. International Growth Centre (IGC). Retrieved March 19, 2021, from https://www.theigc.org/wp-content/uploads/2020/05/Bajpai-and-Bower-2020-policy-brief.pdf

Byamukama, B., Darey, C., Cole, M., Dyszynski, J., & Warnest, M. (2011). Baseline Report - National Strategy on Climate Change and Low Carbon Development for Rwanda. Smith School of Enterprise and the Environment. Retrieved from https://www.smithschool.ox.ac.uk/publications/reports/Rwanda-baseline-final.pdf

CCAC. (2020). Hydrofluorocarbons (HFCs). Nairobi: Climate and Clean Air Coalition (CCAC). Retrieved March 23, 2020, from https://www.ccacoalition.org/fr/slcps/hydrofluorocarbons-hfcs

FONERWA. (2019). The Green Fund provides expert technical assistance to ensure the success of its investments. Kigali: Rwanda Green Fund (FONERWA). Retrieved June 24, 2021, from http://fonerwa.org/?q=about

GCF. (2021). Transforming Eastern Province through Adaptation. Green Climate Fund (GCF): International Union for Conservation of Nature (IUCN), Rwanda. https://www.greenclimate.fund/project/fp167

Germanwatch. (2019). Climate Risk Index 2020. Germanwatch. Retrieved March 21, 2021, from https://germanwatch.org/sites/germanwatch.org/files/2019-12/climate_risk_index_2020_table_1999-2018.jpg

IPBES-IPCC. (2021). IPBES-IPCC Co-sponsored Workshop Report on Biodiversity and Climate Change. The Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). https://doi.org/10.5281/zenodo.4659158

IFRC; RCS. (2020). Final Report - Rwanda: Floods. International Federation of Red Cross (IFRC); Red Crescent Societies (RCS). Retrieved March 17, 2021, from https://reliefweb.int/sites/reliefweb.int/files/resources/MDRRW018dfr.pdf

Meteo Rwanda 2020. Rwanda Meteorology Agency (Meteo Rwanda) Data. Kigali, Rwanda https://www.meteorwanda.gov.rw/

MIDIMAR. (2015). The National Risk Atlas of Rwanda. Kigali: Ministry of Disaster Management and Refugee Affairs (MIDIMAR). Retrieved March 19, 2021, from https://gfdrr.org/sites/default/files/publication/National_Risk_Atlas_of_Rwanda_01.pdf

MININFRA. (2019). Energy Division. Kigali: MININFRA. Retrieved June 24, 2021, from https://www.mininfra.gov.rw/digital-transformation-1-1

MoFA. (2018). Climate Change Profile - Rwanda. Ministry of Foreign Affairs (MoFA), The Netherlands. Retrieved March 13, 2021, from https://reliefweb.int/sites/reliefweb.int/files/resources/Rwanda_3.pdf

Niyonsaba, B. (2016). Improving the adaptive capacity of Rwandan agriculture to climate change. Environmental Systems Analysis Group. Wageningen University. Retrieved March 23, 2021, from https://edepot.wur.nl/528017

Nkurunziza, M. (2021, March 9). Government to build houses for over 14,000 households displaced by disasters. The New Times. Retrieved March 24, 2021, from https://www.newtimes.co.rw/news/government-build-houses-over-14000-households-displaced-disasters

REMA. (2018). Inventory of Sources of Air Pollution in Rwanda - Determination of Future Trends and Development of a National Air Quality Control Strategy. Kigali: Rwanda Environment Management Authority (REMA). Retrieved March 17, 2021, from https://rema.gov.rw/fileadmin/templates/Documents/rema_doc/Air%20Quality/Inventory%20of%20Sources%20of%20Air%20Pollution%20in%20Rwanda%20Final%20Report..pdf

REMA. (2021). No imminent risk of Gas outburst is expected on Lake Kivu following Nyiragongo Eruption – REMA findings. (Rwanda Environment Management Authority (REMA)) Retrieved September 8, 2021, from Rwanda Environment Management Authority (REMA): https://www.rema.gov.rw/index.php?id=77&tx_news_pi1%5Bnews%5D=117&tx_news_pi1%5Bday%5D=31&tx_news_pi1%5Bmonth%5D=5&tx_news_pi1%5Byear%5D=2021&cHash=f495291e9f1294ec4a58782631655005

REMA. (2019). Assessment of Climate Change Vulnerability in Rwanda - 2018. Kigali: Rwanda Environment Management Authority (REMA). Retrieved March 19, 2021, from https://rema.gov.rw/cc_vulnerability_Rwanda(2018)-Final_report.pdf

RoR. (2018). Third National Communication: Report to the United Nations Framework. Kigali: Republic of Rwanda. Retrieved March 13, 2021, from https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

RoR. (2020a). Vision 2050. Kigali: Republic of Rwanda. Retrieved March 13, 2021, from https://www.minecofin.gov.rw/fileadmin/user_upload/Minecofin/Publications/REPORTS/National_Development_Planning_and_Research/Vision_2050/English-Vision_2050_Abridged_version_WEB_Final.pdf

RoR. (2020b). Updated Nationally Determined Contribution. Kigali: Republic of Rwanda (RoR). Retrieved June 24, 2021, from https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

Safari, B. (2012, June). Trend Analysis of the Mean Annual Temperature in Rwanda during the Last Fifty-Two Years. Journal of Environmental Protection, 3(6), 538-551. doi:10.4236/jep.2012.36065

Tenge, N., Alphonse, M., & Thomas, T. (2012). East African Agriculture and Climate Change: A Comprehensive Analysis — Rwanda. International Food Policy Research Institute. Retrieved March 13, 2021, from https://media.africaportal.org/documents/aacccs_rwanda_note.pdf

UNDRR. (2018). RWA: Rwanda Risk Profile - Floods & Droughts (2018). United Nations Office for Disaster Risk Reduction (UNDRR). Retrieved March 19, 2021, from http://riskprofilesundrr.org/catalogue/csw_to_extra_format/fb230b8c-b6d0-11e8-beb3-02f25c5c7296/RWA:%20Rwanda%20Risk%20Profile%20-%20Floods%20&%20Droughts%20(2018).html

UNDRR. (2018). Rwanda advances with Sendai Framework. United Nations Office for Disaster Risk Reduction (UNDRR). Retrieved March 14, 2021, from https://www.undrr.org/news/rwanda-advances-sendai-framework

UNDRR. (2020). Rwanda - Risk-sensitive Budget Review. United Nations Office for Disaster Risk Reduction (UNDRR). Retrieved March 14, 2021, from https://www.undrr.org/media/46969/download

Baskets weaved by women in a handicraft Cooperative
Photo credit: Andrew Tobiason/USAID/Flickr

Chapter 11:

Mainstreaming Environment for Achieving Sustainable Development Goals (SDGs)

Sorghum cultivation and various agricultural plantations on a gently rolling landscape in Nyagatare
Photo credit: RDB

11.1 Introduction

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests (UNDESA, 2015).

Rwanda has integrated the Africa Agenda 2063 and the SDGs into its national development agenda through the draft Vision 2050, National Strategy for Transformation (NST1, 2017-2024) and related strategies at different levels. Furthermore, on the theme of Environment and Climate Change the 2019 Rwanda National Voluntary Review targets to become a green, climate resilient and low carbon economy by 2050. A green fund (FONERWA) has been in place since 2012 to mobilize resources. The National Disaster Management Policy has been revised in line with the Sendai Framework, and there has been a shift towards more integrated and anticipatory disaster risk management system in Rwanda (UNDESA, 2019).

11.2 Tracking progress towards environmental SDG indicators

Rwanda has made impressive progress on many indicators (Table 11-1). However, lack of up-to-date statistical data remains a major challenge for which the capacity of statistical data collection agencies needs to be strengthened.

The UN Sustainable Development Goals (SDGs)

Table 11-1: Progress for Rwanda's applicable SDG indicators 2000-2020 (UNSTATS, 2020)
*** Progress – Green is positive, Red is negative, Yellow is insufficient data, and White is no progress.*
Value in italic bold is national data.

Goal	Indicator (Unit)	Base Value (Year)	Latest Value (Year)	Progress	Data Source
3	**3.9.1** Mortality rate attributed to household and ambient air pollution (Deaths per 100,000 population)		49 (2016)		UNSTATS
6	**6.1.1** Proportion of population using safely managed drinking water services (Percentage)	***84.8 (2014)***	***87.4 (2017)***	***+3.4***	***NISR***
	6.2.1 Proportion of population using (a) safely managed sanitation services (Unit: % of population), (b) Proportion of population with basic handwashing facilities on premises by urban rural (percent)	***a. 83 (2014)***	***a. 86 (2017)***	***+2.8***	***NISR***
		b.3.3 (2010)	b. 4.6 (2017)	+1.3	UNSTATS
	6.3.2 Proportion of bodies of water with good ambient water quality (*Percentage) *proxy: river bodies		30 (2017) *37.5 (2017)		UNSTATS
			85 (2019)		***RWFA***
	6.4.1 Change in water use efficiency over time (United States value/Volume)	24 (2010)	31.5 (2017)	+7.5	UNSTATS
	6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources (Percentage)	5 (2000)			UNSTATS
		2 (2000)	***8.9 (2019)***	***+6.9***	***NISR***
	6.5.1 Degree of integrated water resources management (Percentage)		35.0 (2018)		UNSTATS
	6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation (Percentage)		***100 (2020)***		***RWFA***
	6.6.1 Change in the extent of water-related ecosystems over time (land area)	6.05(2000)	6.13(2018)	+0.08	UNSTATS
7	**7.1.2** Proportion of population with primary reliance on clean fuels and technology (Percentage)*Proxy: Primary reliance on clean fuels for cooking energy		5(2018)		UNSTATS
		0.9 (2014)	***2.0 (2017)***	***+1.1***	***NISR***
			****53(2018)***		***MININFRA***
	7.2.1 Renewable energy share in the total final energy consumption (*Percentage)*Proxy: Renewable energy share in the total final electricity generation	90.7(2010)	86.7(2017)	-4	UNSTATS
	7.3.1 Energy intensity measured in terms of primary energy and GDP (MJ/constant purchasing power parity GDP)	8.44(2000)	4.38(2017)	-4.06	UNSTATS
12	**12.** Joined international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement (% average)				Yes
	12.4.2. Electronic waste generated per capita (Kg)	0.215(2010)	0.567(2019)	+0.352	UNSTATS
	12.5.1. Electronic waste recycling rate (percent)		11.1(2018)		UNSTATS
13	**13.1.1** Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population (Number)	***Deaths:183. Affected:16,645 (2016)***	***Deaths: 273 Affected:80,164 (2017)***	***+90 +63,519***	***MINEMA***
	13.1.2 Adopted and implemented national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030				Yes
	13.1.3 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies. *Proxy: number of districts	***22/30 (2017)***	***29/30 (2020)***	***+7***	***MINEMA***
	13.2.1 Developed nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications				Yes

Goal	Indicator (Unit)	Base Value (Year)	Latest Value (Year)	Progress	Data Source
15 LIFE ON LAND	**15.1.1** Forest area as a proportion of total land area (Unit: % of land area)	10.7(2010)	11.2(2020)	+0.5	UNSTATS
		11.6(2000)	***30.4(2019)***	***+18.8***	***RWFA***
	15.1.2. Proportion of important sites for Terrestrial and Freshwater Biodiversity Areas covered by protected areas (percent)	a.29.2(2010) b.51.7(2010)	a.29.2(2019) b. 51.7 (2019)		UNSTATS
	15.2.1. a. Progress towards sustainable forest management (Unit: Percentage)	0(2000)	9.8(2020)	+9.8	UNSTATS
	15.2.1.b. Above-ground biomass stock in forest (tonnes per hectare)	145.5(2010)	146.1(2020)	+0.6	UNSTATS
	15.2.1.c. Forest area under an independently verified forest management certification scheme ('000 of hectares)	0(2010)	9.78(2019)	+9.78	UNSTATS
	15.2.1.d. Forest area annual net change rate (percent)	-0.79(2010)	0.4(2020)	+0.39	UNSTATS
	15.2.1. e. Proportion of forest area within legally established protected areas (percent)		78.2(2020)		UNSTATS
	15.3.1. Proportion of land that is degraded over total land area (Percentage)		12(2015)		UNSTATS
	15.4.1 Coverage by protected areas of important sites for mountain biodiversity (Percentage)	33.3(2010)	33.3(2020)		UNSTATS
			11.9(2018)		***RWFA***
	15.5.1 Red List Index (Index)		0.9(2020)		UNSTATS
	15.6.1.a. Total reported number of Standard Material Transfer Agreements (SMTAs) transferring plant genetic resources for food and agriculture to the country (number)	62(2012)	113(2020)	+51	UNSTATS
	15.6.1.b. Rwanda has adopted legislative, administrative and policy frameworks to ensure fair and equitable sharing of benefits	Yes			
	15.8.1 Rwanda adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species	Yes			
	15.9.1 (a) Progress towards national targets established towards Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020 in their national biodiversity strategy and action plans and the progress reported towards these targets	Yes			
	15.a.1 and **15.b.1 (a)** Official development assistance on conservation and sustainable use of biodiversity; and **(b)** revenue generated and finance mobilized from biodiversity-relevant economic instruments (millions of constant 2016 US dollars)	a. 0.4(2002)	a. 16.2(2018)	+15.8	UNSTATS

Nzove 2 Water Treatment Plant, Kigali
Photo credit: Urugwiro Village/Flickr

11.3 Mainstreaming environment through Green Growth and Climate Resilience Strategy (GGCRS)

The GGCRS is the unifying strategy to meet Rwanda's long-term development goals. The Global Green Growth Institute (GGGI) defines green growth as "balanced economic growth that results in a broad-based improvement in key aspects of social performance, such as poverty reduction, job creation and social inclusion, and environmental sustainability, such as mitigation of climate change, conservation of biodiversity and security of access to clean energy and water" (GGGI, 2020).

The essence of mainstreaming green growth is captured in the government's efforts to ensure that environmental sustainability initiatives are reflected in each relevant sector's strategies and plans. Mainstreaming is an on-going process and cannot be achieved within a single policy since new gaps will inevitably arise over time. Mainstreaming has another important dimension, which is to avoid duplication of effort within different sectors. For example, forestry, biodiversity, and wildlife management should host species habitat policies which are mutually beneficial and yet not overlapping, if nothing more than to avoid wasting scarce budgetary resources.

The Rwandan Environmental Policy in 2003 was one of the first efforts to secure environment as a key component of Rwanda's development agenda. Although successful in putting environment on the national map, the 2003 policy offered a minimum of institutional capacity and legal frameworks, as the level of awareness was still nascent. With time and growing understanding of the importance of the environment, the need to focus on regulation, protection, preservation, environmental awareness, education, and research was recognized and led to a series of institutional reforms, new laws, and policies to "mainstream green".

The growing awareness triggered new developments and associated reforms which have changed the institutional landscape and with new laws being formulated. Pivotal reforms include the establishment of the Rwanda Environment Management Authority (REMA), a green fund (FONERWA), establishment of regulatory structures such as the Rwanda Water Resources Board (RWB) and Rwanda Forestry Authority (RFA), Rwanda Land Management and Use Authority (RLMUA), and the re-alignment of institutions such as the Rwanda Meteorology Agency (RMA) which is now under Ministry of Environment. Chapter 3 provides a history of the improvements in environmental governance in Rwanda.

Changes in governance structures were occasioned by several factors. First, as new science on threats such as climate change or public health (such as COVID-19) were assessed, Rwandan institutions mitigated the risk or, in the case of unavoidable climate change impacts, started the process of adaptation to new patterns of temperature change or precipitation variability. As the institutional configuration evolved, it was logical that policies should also change to match new mandates. In an iterative manner, as environmental awareness increased, knowledge of new linkages and gaps highlighted the need for further changes. In the case of Rwanda, environmental authorities recognized the need to engage new themes such as meteorological and climatological sciences which are crucial for understanding environmental trends.

Other factors have influenced Rwanda's environmental governance structures. The government's acceding to multilateral environmental agreements such as UNFCCC, UNCBD, UNCCD and others and regional developments requires their domestication into national policy with changes to strategies and action plans. Box 1-11 highlights high level commitments for achieving green growth.

Key message: Rwanda's successes in bringing environment into the national development agenda are impressive. To relax efforts now would waste a great opportunity for environmental sustainability derived from these investments.

Box 11-1: High level commitments for achieving green growth.

Rwanda's commitment to achieving green growth and reaching other international goals has received support at the highest political level. Speaking at the summit for Partnering for Green Growth and the Global Goals 2030 under the theme of "Green Recovery and 2050 Carbon Neutrality" President Kagame stated that accelerating market-based partnerships to build sustainable and resilient economies means incentivizing renewable energy options and reducing subsidies for fossil fuels. Support from the highest levels of government means that Rwanda's green growth and climate resilience strategy will flourish, as public and private financing for environment and climate action can be mobilized and global opportunities available in environment and climate change finance can be accessed. Indeed, the transition to electric vehicles in Rwanda is one example of this in the country's journey towards carbon neutrality (New Times, 2021a) (MoE 2018).

The government has set out on a strategic initiative to create low-carbon, climate-resilient energy, and transport networks. Policies to facilitate adoption of electric vehicles will be implemented by introducing physical infrastructure to charge electric vehicles and "de-risk" private investment through proof of concept. New technologies such as e-motorbikes and electric buses will be scaled up in the coming decade, while increasingly strict energy efficiency standards for internal combustion engine (ICE) private cars will be implemented (GoR 2021a). To this end, the Government of Rwanda through REMA in partnership with UNDP and the Poverty-Environment Action for SDGs project, launched a ground-breaking pilot project intended to put more electric motorcycles on Rwanda's roads. The project aims to gradually phase out the use of traditional petrol or diesel-powered internal combustion engine (ICE) motorcycles by converting them to electric, which will reduce air-polluting emissions as well as cut fuel costs (REMA) (Ntirenganya, 2021).

Other forces acting on Rwanda's pathway to environmental governance exist. Knowledge from international partnerships on the use of norms and standards on environmental and social safeguards can help protect vulnerable populations from environmental degradation. New regulatory systems and accounting procedures such as the Payment of Ecosystem Services (PES) and Natural Capital Accounts which have been incorporated in other countries are being integrated into Rwanda's development planning and monitoring frameworks. These initiatives have the overall goal of including attempts to value environmental services in development planning.

New conceptual and yet practical approaches such as the Circular Economy can be underpinned by new technologies to reduce costs of production and improve resource efficiency. Such programmes are already being initiated in Rwanda, with new technologies driven by environmental research and innovation contributing to solutions for air and water pollution control and household waste management. When planning for Green Growth to support Vision 2050, authorities set three axes:

- Urban growth based on green jobs and technology.
- A rural economy with focus on agriculture, forestry, land use, and mining
- Water, energy, and transport infrastructure

A fourth axis includes the principles: Inclusion, Ecosystems, Connectivity, and Actions that intentionally go beyond the baseline in terms of greening and climate resilience (GoR, 2021a). Figure 11-1 portrays how the axes of Green Growth support the achievement of the 2050 Vision.

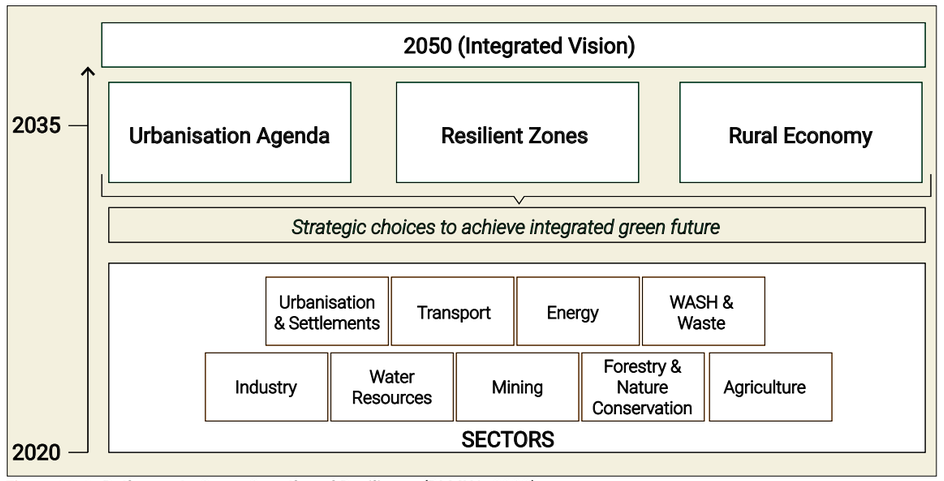


Figure 11-1: Pathways to Green Growth and Resilience (RLMUA, 2020)

An electric car at a charging station at Kigali Convention Centre, 2021
Photo credit: The New Time, Craish

A farm in Rwanda uses solar panels combined with sprinkler and drip irrigation to grow cash crops
Photo credit: Frances Hayes/Daugherty Water for Food Global Institute/Flickr

11.4 The Green Growth and Climate Resilience Strategy

Rwanda's Green Growth and Climate Resilience Strategy (GGCRS) is the government's centerpiece for mainstreaming environment into each relevant environment and natural resources sector. The strategy was adapted in 2011 and reviewed in 2018, with a vision for Rwanda to evolve into a climate-resilient and low-carbon economy by 2050. To achieve this vision, the GGCRS aims for energy security based on a low carbon supply that supports green growth (MoE, 2019). The 2011 Green Growth Strategy comprised 14 Programmes of Action (PoAs) (GoR, 2021a). Figure 11-2 depicts the key products that informed the GGCRS.

The GGCRS (2011) "under review" comprises eight Programmes of Action (PoAs) (Figure 11-3) which are the vehicle for mainstreaming Green Growth to reach Vision 2050 (GoR, 2021a). Each of these new PoAs includes Environment and Climate Change (ECC) indicators proposed by REMA by sector (in draft as of July 2021). Selected examples of ECC indicators for the new PoAs by sector are indicated in Table 11-2.

The initial 14 PoAs aimed to diversify energy sources within a low carbon grid. They promoted resource efficiency in the primary sector such as in agricultural production, mining, and manufacturing industries; and in industrial activities in the secondary and tertiary sector, targeting both public and private entities. These 14 PoAs promoted sustainable land and natural resources use, food security, preservation of biodiversity, social protection, improved health, and disaster risk reduction which also reduces vulnerability to climate change (MoE, 2019).

An important component of any strategy such as the GGCRS and its associated programmes is to have a system in place for results-based management and evaluation (RBME). Specific objectives of the RBME System within the GGCRS (Rugege, 2018) include:

- To ensure that Ministry of Environment and its sister institutions at the national level and the districts have the capacity to ensure the on-going and sustainable operation, maintenance, and refinement of the RBME System.

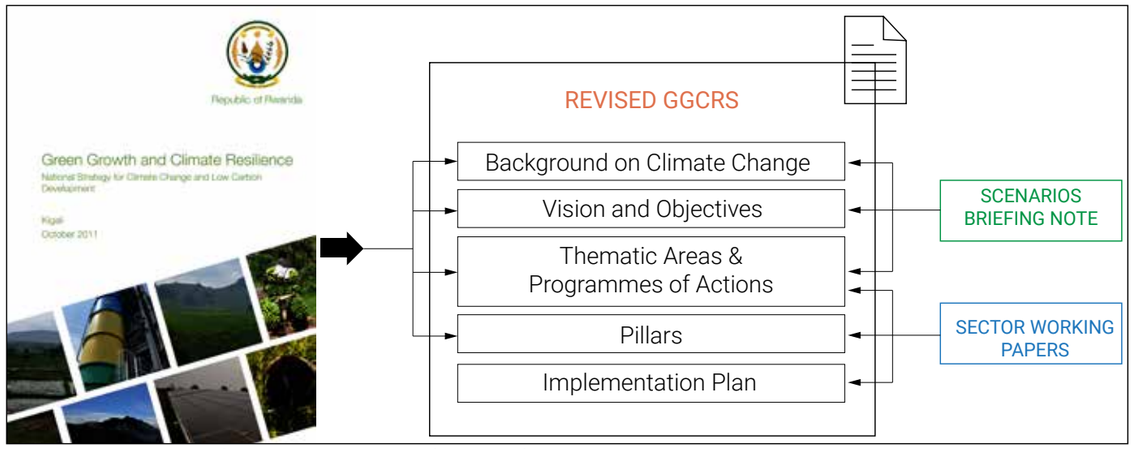


Figure 11-2: Key products informing the revised GGCRS (GoR, 2021a). Note the GGCRS is still under review

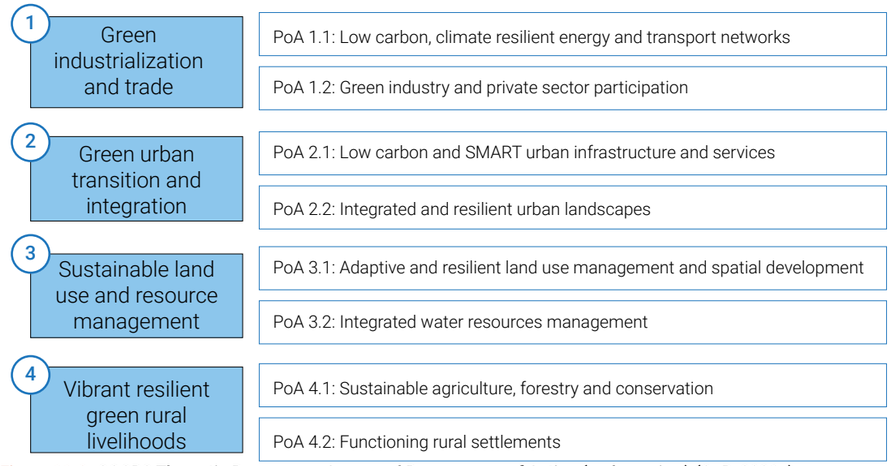


Figure 11-3: GGCRS Thematic Programme Areas and Programmes of Action (under review) (GoR, 2021a)

- To ensure a fully functional M&E System which monitors progress of the Environment and Natural Resources (ENR) Sectors and then contributes to the achievement of the initial GGCRS target through the Economic Development and Poverty Reduction Strategy (EDPRS II) (2013-2018).

- To ensure that Natural Capital Accounts and other key environmental indicators and indices are calculated and reported on a regular basis.

The Environment and Climate Change (ECC) Implementation Assessment Report 2019-2020 provides the status on early efforts at mainstreaming implementation. Table 11-3 below gives a summary for the implementation of ECC key performance indicators in all sectors for the Fiscal Year 2019/2020.

Overall, in the 2019-2020 financial year, the outputs that were on track accounted for 61.6 percent of the total while the remaining 31.7 percent were mostly outputs that were not reported. A small fraction of the total was occupied by outputs on watch (6.7 percent) while there were no outputs off track. The success rate for outputs on track has remained relatively stable over time (Figure 11-4).

While the results above show evidence of Rwanda's partial success in mainstreaming, they also highlight the need for further effort, and perhaps, greater attention required in certain sectors. For instance, more work is needed in sectoral activities such as the sustainable use of wetlands, sustainable land use and farming systems, response to initiatives that promote green technologies, and environmental budgeting in the sectoral plans and budgets. These requirements must be captured in new policies and strategies such as the updated GGCRS which is still in draft form.

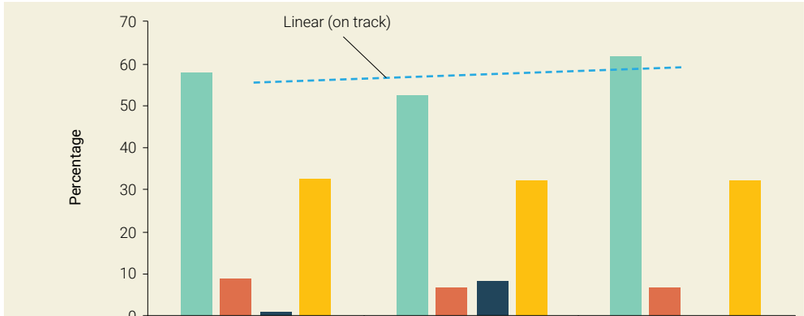
Overall, these results show that, the process of identifying weaknesses, targeting actions, and reporting progress in meeting environmental objectives is functioning, even if not all projects were compliant.

Table 11-2: Selected examples of Environment and Climate Change (ECC) indicators for proposed, new PoAs (GoR 2021a)

Sector Programme	Strategic Intervention	Key Indicator
Green Industry and Private Sector Participation	Green SEZs and Industrial Parks	Emission intensity per output (tonnes/US $ million values added)
Urban Transition and Integration	High quality, affordable housing, and dense cities	Decreasing percentage of urban population living in informal settlements
Sustainable Land Use and Natural Resource Management	Development of sustainable sectoral land use strategies and National Spatial Data Infrastructure (NSDI) including information management and sharing policy.	Percentage of operational integrated geospatial information framework integrated with environmental and socio-economic statistics

Table 11-3: Overall Implementation of ECC KPIs in all Sectors, FY 2019/2020 (GoR, 2021b).

Sectors	On track (%)	On watch (%)	Off track (%)	Not reported (%)
Agriculture	71.40	0.00	0.00	28.60
ENR	53.30	0.00	0.00	46.70
Energy	66.70	33.30	0.00	0.00
Transport	66.70	0.00	0.00	33.30
WATSAN	0.00	50.00	0.00	50.00
Urbanization	66.70	0.00	0.00	33.30
PSD&YE	50.00	0.00	0.00	50.00
Health	60.00	0.00	20.00	20.00
Education	50.00	0.00	0.00	50.00
Overall Avg.	**61.60**	**6.70**	**0.00**	**31.70**



	2017/18	2018/19	2019/20
On track	57.80%	52.50%	61.60%
On watch	8.70%	6.70%	7.00%
Off track	1.00%	8.50%	0.00%
Not reported	32.50%	32.30%	32.00%

Figure 11-4: Comparison of ECC KPIs achievements 2014-2019 (GoR, 2021b)

Key Message: Although there are still gaps to be addressed, there is a robust, iterative targets to policy actions to reporting process that is updated as new goals are set. M&E is working in Rwanda.

Reservoir used for crop irrigation. Rwanda
Photo credit: ILO/Flickr

11.5 Lessons learned

Implications for going forward with the private sector

Although it was not possible to fully evaluate the initial GGCRS' impact in terms of behaviour change within the private sector, there are early indications that the business community is embracing potential new opportunities presented by green growth as reported in the achievements of GGCRS Programme of Action Number 7. PoA 7 seeks to implement four actions: Resource Efficient Industries by measuring GHG emissions and water usage; Greening the Special Economic Zone by measuring the number of green technology companies started; Promoting Green Technologies by measuring the number of new green technologies employed; and Building Carbon Trading Capacity by measuring number of carbon projects operational (Rugege, 2018). Table 11-4 shows progress by the business community in the adoption of green technologies and practices.

These results show that, although baseline information from 2012 about the status of green technology and industries was missing, reporting on the level of private sector engagement is now firmly part of the monitoring process and initial measures of GHG reduction are promising. Proposed refinements of the monitoring indicators will ease the reporting, although clarifications about what is or is not a green technology may continue to require reflection.

Table 11-4: Summary performance evaluation for POA 7: Green Industry and Private Sector Development (Rugege, 2018)

Action1/Indicator	Baseline (2012)	Achievements (2018)	Key Observations (Gaps, Challenges, Lessons)
GHG emissions reduced	6,690 kt CO_2eq (WB, 2012)	• 22.437kt CO_2eq • Water usage reduced (44,195 m^3)	Suggest changing to No. of new green technologies adopted by industries
No. of green companies established	To be confirmed	47	Suggest changing indicator to No. of new green technologies adopted by industries
No. of new green technologies adopted	To be confirmed	247	Suggest changing indicator to No. of best green production practices implemented by companies
No. of companies implementing green production practices	To be confirmed	18	Suggest changing indicator to No. of companies implementing green production practices in Special Economic Zones

Key Message: Overall, the institutional configuration including structures, management, and procedures to implement the GGCRS objectives is functioning.

GGCRS alignment with SDGs, NDCs, environment & climate change policy

Mainstreaming the environment through the GGCRS also embraces the Sustainable Development Goals (SDGs) and Nationally Determined Commitments (NDCs) to the UNFCCC. A comprehensive analysis and documentation of GGCRS-NDC-SDG alignment was carried out as part of the Implementation Plan of Rwanda NDCs. (REMA, 2019). For commitments to reduce GHGs, the NDC Plan (Table 11-5) shows the alignment of NDCs with GGCRS-PoAs in adaptation and mitigation measures as well as mapping of relevant stakeholders for implementation.

In addition to the above mapping, Rwanda's NDC Implementation Plan proposes a unit within REMA or the Ministry of Finance and Economic Planning (MINECOFIN) to support the preparation and access to funding of bankable NDC projects. In addition, the unit would assume the responsibility of inter-ministerial coordination on Green Growth. The Plan also proposes the development of a detailed NDC financing strategy. Further alignment of GGCRS with the NDCs will encourage sectors to define environment and climate change quality standards for transitioning their programmes to a Circular Economy. Figure 11-5 shows the GHG reduction targets by sector, compared to the Business as Usual (BAU) patterns. Implementing the GGCRS will contribute to achieving these targets.

Table 11-5: Linkages between GGCRS, NDCs and SDGs (Rugege, 2018)

GGCRS POA	NDC Measures	Aligned Key SDG Goals
	Adaptation	
POA 1: Sustainable intensification of agriculture	Mainstreaming agro ecology	Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
	Utilizing resource recovery and reuse	
	Using fertilizer enriched compost	
	Mainstreaming IPM	
POA 2: Agricultural diversity in local and export markets	Add value to agricultural products	
POA 3: IWRM and Planning	Establish IWRM framework	Goal 6. Ensure availability and sustainable management of water and sanitation for all
	Develop a National Water Security Plan	
	Develop water source models	
POA 4: Integrated LUP and Management	Integrated planning and sustainable LUM	Goal 11. Make cities and human settlements inclusive, safe, and resilient
	Harness ICT and GIS technologies	
POA 11: Ecotourism, Conservation and PES	Maximize business tourism	Goal 12. Ensure sustainable consumption and production patterns
POA 12: Sustainable Forestry and Agroforestry	Promote afforestation/ reforestation	Goal 15. Protect, restore, and promote sustainable use of terrestrial ecosystems
	Employ Improved Forest Management	
POA 13: Disaster and Disease Prevention	Risk assessments and vulnerability mapping	Goal 13. Take urgent action to combat climate change and its impacts
	Integrated EWS and disaster response plans	
	Employ community-based disaster risk reduction	
POA 14: Climate data and Projections	Improve observation facilities	
	Mitigation	
POA 5 Low Carbon Energy Mix Powering the National Grid	Establish renewable on-grid electricity	Goal 7. Ensure access to affordable, reliable, sustainable, and modern energy for all
POA 6: Small Scale Energy Installations in Rural Areas	Rural installation of solar PV mini grids	
POA 10: Low Carbon Urban Systems	Increase energy efficiency and grid-loss reduction	
	Promote sustainable use of biomass fuels	
	Utilization of urban waste stream	Goal 12. Ensure sustainable consumption and production patterns
	Scale up resource efficiency	
POA 7: Green Industry and Private Sector Development	Establish Eco-industrial park	
POA 9: Efficient resilient transport systems	Promotion of bus public transport	Goal 11. Make cities and human settlements inclusive, safe, resilient, and sustainable
	Improve transport infrastructure	
	Setting vehicle emission standards	Goal 13. Take urgent action to combat climate change and its impacts
POA 12: Sustainable Forestry and Agroforestry	Mandate licensing of charcoal production	

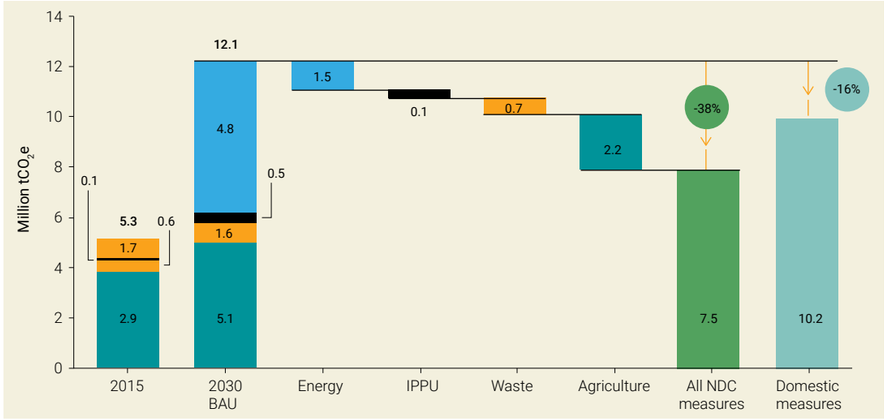


Figure 11-5: Rwanda's NDC commitments by sector, to reduce GHG emissions from 2030 BAU levels (UNFCC, 2020)

Funding mechanisms to implement the GGCRS

As noted above, Rwanda has invested in policies, institutions, and legal instruments to ensure that its economic development is conditioned by its environmental and natural resources endowment. A review of available information on the government's environmental funding allocation to support this mission also shows this commitment, although gaps exist. Budget allocations and expenditure are a means of measuring the government's commitment to environmentally sustainable development.

Rwanda's National Fund for Environment – FONERWA, also known as the Green Fund, is a government initiative to support environment protection and minimize the impact of climate change. The development objectives focus on achieving environmentally sustainable, climate resilient and green economic growth. FONERWA is a cross-sectoral financing mechanism between the government and its development partners. GoR has contributed US $4 M (Rugege, 2018). Other funding sources include:

- Revenue from assessed fines
- User fees from specific environmental resources such as forestry and water
- Administrative fees from Environmental Impact Assessment (EIA) projects
- Other environmental revenue and seed financing from domestic partners such as NGOs or private sector.

Since the Green Fund originates from GoR's own revenue sources, it is less vulnerable to the political vagaries of foreign aid. Therefore, it should be increased and used to attract further financial investments with a multiplier effect by linking international funding to national priorities. An example of GoR's ability to work with international assistance to prioritize the environment follows from an analysis of USAID (2019) support to Rwanda. The USAID review found that, while some attention was given to biodiversity, more effort was needed to include biodiversity actions within the overall USAID/Rwanda portfolio, especially in economic growth and strengthening of development objectives. This analysis recommends that "*USAID/Rwanda consider the USAID Biodiversity Policy to integrate tropical forest and biodiversity conservation to increase the effectiveness and sustainability of sectoral development objectives as well as an opportunity to allow sectoral programs to contribute to the identified actions necessary to conserve tropical forests and biodiversity in Rwanda*." The key point here is that there is an opportunity for the GoR to encourage donors and partners to prioritize Green Growth and biodiversity protection in their assistance by increasing internal budget allocations to Green Growth.

REMA authorities recognize the funding gaps and are trying to quantify them. For instance, the costs for the 10-year climate programme to 2030 are estimated at US $11 billion but costs up to 2050 are still being calculated. REMA is also working on the financial and technical requirements of the energy and transport sectors. Low-carbon climate-resilient energy and transport systems require US $6,875 million from public sector funding and US $3,400 million in private sector investment by 2050 as a long-term transition (The New Times, 2021).

The opportunity to attract outside funding is further demonstrated by the steady increase (2 percent) in the overall national budget spent on environment and natural resources from 2.6 percent in 2018-2019 to 4.6 percent in 2019-2020 (Figure 11-6). This increase is a result of commitments to key sectors like agriculture and infrastructure where environment and climate change are central to Rwanda's development agenda.

In its Compendium of Environment Statistics (2018), REMA further notes difficulties in disaggregating environmental from other expenditures, as any given initiative may have several objectives that are partly environmental or social in nature. Indeed, environment is cross-cutting in nature and touches multiple sectors.

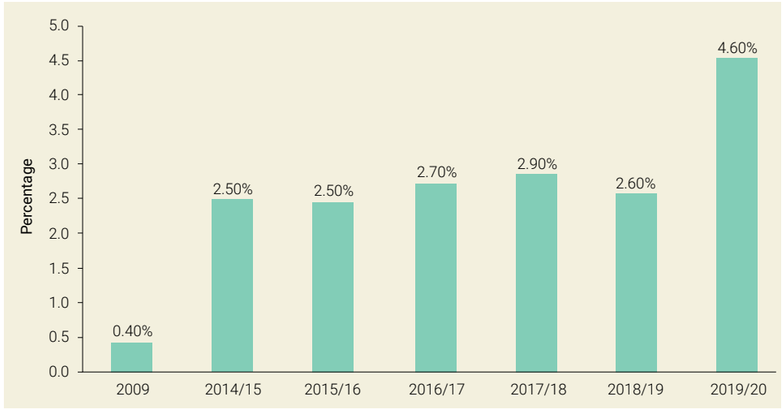


Figure 11-6: Comparisons of ECC budget expenditures (2009-2020) (GoR, 2021b).

In summary, although the assessment of financial resources allocated to environmental management is conditioned by available information on budget decisions, a general finding is that combined funding from both national and international resources has not met targets. Going forward, the GoR must continue to prioritize budget resources for the environment and work with its donors to multiply financing options as well.

Institutions, coordination and compliance

REMA's compendium on statistics indicates that in Rwanda, 7 national policies, 8 strategic national regulations, 15 laws and 25 Ministerial orders or instructions are in place for environmental governance and regulation and have given rise to the responsible institutions. USAID (2019) notes that coordination mechanisms and communication channels among these institutions at the national (horizontal) level remain poorly defined and overlap. This is particularly the case for RDB and REMA on one hand and between REMA and the Rwandan Natural Resources Authority (RNRA) on the other hand. This confusion leads to wastage of already scarce resources and duplication of efforts.

Vertical coordination between national and district authorities is a critical component of effective mainstreaming. A good case study for assessing institutional effectiveness is provided by the National Land Use and Development Master Plan 2020-2050 (NLUDMP). The initial NLUDMP was first adopted in 2011 by the Cabinet to support Vision 2020. Its purpose was to assess land use and guide land development through 2020. After review in 2018, it was found not to be in step with Vision 2050 and other national goals and plans and thus required revision (RLMUA, 2020).

The new National Land-Use Development and Master Plan 2020-2050 (NLUDMP) was crafted to respond to Vision 2050. It has the goal of finding the best land allocation based on economic and spatial needs. Not only does the plan set land allocation targets, but it also provides guidelines and action plans for authorities to implement, with the necessary mandates, including enforcing compliance. The new NLUDMP recognizes that the current legal structure is inadequate for its implementation and notes the following shortcomings:

- Gaps in implementation, for example, in coordination across sectors,
- District level plans are not always well coordinated with the NLUDMP,
- Conflicting laws and ministerial orders across sectors which may impact implementation
- Land use planning is sectoral and not integrated (RLMUA, 2020)
- The need to engage landowners at all stages of NLUDMP implementation, and not just at the plan formulation stage.

Compliance and monitoring at different levels – district, village and the national (across sectors) levels is weak and should be improved (RLMUA, 2020). To strengthen compliance, for example, the Rwandan Land Use Authority exercises regulatory power through non-objection to development initiatives. However, this authority needs to be strengthened to allow for the provision of more guidance, and not just a non-objection. Other efforts to improve mainstreaming and cross-sector implementation of the GGCRS are underway. For example, to improve cross-sector policy implementation, the GGCRS stipulated the establishment of a Technical Coordination Committee (TCC) whose mission is to identify possible gaps or conflicts in cross sector activities and work with relevant institutions to resolve them. The TCC needs to evolve with a clearly defined mission, organisation and functioning supported by a legal instrument (Rugege, 2018).

Community participation and education

Community participation is essential for effective environmental mainstreaming, governance, and green growth. The community must have an active voice in environmental affairs – particularly for those that impact their health (such as energy for cooking) and livelihoods (access to resources).

A review of land conservation initiatives in the above GGRCS interventions (USAID, 2019) made a few key recommendations concerning citizen participation in environmental conservation initiatives. Most important is that, since many initiatives have impacts on surrounding communities, authorities should support inclusive land governance and tenure systems, so that forests and biodiversity hotspots can benefit from co-management approaches with the affected communities. Future programmes should build capacity for local business associations, CSOs, and women cooperatives to support development of alternative livelihoods in case of displacement or other change of livelihood. For example, communities living next to protected forests such as Gishwati may be affected by conservation efforts which prevent entry and use of fuelwood. As their livelihoods are impacted, they may require compensation for this loss. It also recommended improvements that would allow farmer and community groups to change fuelwood consumption patterns and move to alternative sources of energy.

As new environment policies and initiatives are put in place, public participation is essential for their acceptance and uptake. For example, in sustainable land management, the creation of Village and Grievance Redress Committees is key to resolving conflicts over farms between neighbours and within families over asset ownership or social issues. Such is the case when compensation funds are received by people following changes in land use (Rugege, 2018). Additionally, new policies such as the National Land Use Development Master Plan should include mechanisms for citizens to resolve grievances out of court (RLMUA, 2020).

GoR's efforts to promote environmentally sustainable development are demonstrated by an increase in public participation. Indeed, since 2007, there has been a growing number of national level NGOs active in environmental matters, reaching a total of 69 by 2017 (REMA, 2019). NGOs are engaged in most of the major towns and cover a range of themes such as agriculture, environmental protection, training of cooperatives, gender, poverty reduction, agroforestry, hygiene and sanitation and watershed protection. They are organized under the umbrella of the Rwanda Environmental NGOs Forum (RENGOF). There are also 85 Community Based Organizations (CBOs) in Rwanda working on environmental education, public awareness and climate change and development growth in addition to agricultural business opportunities.

By leveraging the growing interest in NGOs and CBOs, communities can play a lead role in implementing environmental programmes, so they must be the focus of awareness campaigns, education, clean-up days, data collection and monitoring, economic opportunity. GGRCS policies should encourage community groups, particularly within the urban sector, to play their role through such initiatives. Environmental Education continues to be an important area for mainstreaming as school children readily incorporate lessons from the classroom into their daily home lives. It is of great import that a child learns about personal hygiene as this is knowledge that can continue into their adult lives and, in a larger sense, create a growing awareness for the need for community health and cleanliness.

Rwanda promotes environmental educational programmes so that its youth may learn principles of recycling and conservation to protect and restore the country's natural resources and environmental assets. Platforms include a strategy for Environmental Education for Sustainable Development (EESD) and a five-year Action Plan. The Greening Schools Programme uses EESD as a tool to mainstream environment and climate change for sustainability within the education system (Rugege, 2018). Approaches that create awareness at grass root levels and in schools are a clear sign of Rwanda's commitment to green growth.

Although gender was built into educational programmes, further improvements are possible through integrating gender into each of the 14 PoAs with the necessary targets and performance indicators. Similarly, programmes that target youth could be further developed by identifying activities to promote youth participation in multiple PoAs.

Community members participate in the Green Gicumbi Project in Northern Rwanda
Photo credit: Ministry of Environment - Rwanda/Flickr

11.6 Conclusion and recommendations

Rwanda has done well in raising public awareness about its environment, evolving from an initial understanding of environment, considering only forest cover and wildlife, to a much broader and deeper understanding of the complexity of the environment and its importance for Rwandans' livelihoods and health. One milestone in this growing awareness was achieved when Rwanda showed global leadership by becoming one of the first countries in the world to ban plastic bags in September 2008. These have since been replaced by biodegradable bags made from materials such as cotton, banana fibre, papyrus, and others (UNESCO, 2016).

The following recommendations may be considered:

- **Address existing technical and coordination weaknesses:** Mainstreaming Green Growth will be crucial to achieving Vision 2050. The current institutional configuration is generally strong enough to support this. However, certain weaknesses do exist. For instance, in technical coordination across institutions, integration of Circular Economy into industrial processes, and further alignment with the SDG agenda. It is important that these be addressed.

- **Address funding gaps:** The gap in costing and funding remains a top concern. The gap is reflected not only in sectoral planning, but also in fully costing Green Growth through 2050. This gap also applies to NDCs which need to be fully costed and integrated with the GGRCS, through 2035 and on to 2050. As Rwanda demonstrates such prioritization in national budgeting processes, the message can be used to attract international funding sources with a multiplier effect.

- **Strengthen the Monitoring and Evaluation function:** Mainstreaming integrates all sectors and will require that communication networks responsible for statistical data collection, monitoring and evaluation talk efficiently to each other. To strengthen these, training at the individual level, and capacity building by bringing institutions together to share data and information must be carried out.

- **Implement responsive environmental actions:** The growing awareness of the need to account for the environment is reflected in how well Rwanda has responded to emerging environmental issues such as energy, air and water pollution. Over the years, the development and implementation of the various policies, instruments, and institutions generally showed a successive recognition of the threat followed by a policy response. The awareness was evinced by the periodic and regular review of policy effectiveness, and the successive SOERs which demonstrated the commitment to identify trends and inform the decision-making bodies. The growing awareness is also reflected in the successful efforts to mainstream Green Growth across all relevant sectors. Some green actions for consideration as the country continues to 'build back better' after the COVID-19 Pandemic include:

  - Transition away from fossil fuel dependency.
  - Invest in renewable energy.
  - Expand power grid capacity and resiliency to support increased electrification.
  - Build infrastructure that is sustainable, technologically advanced, and resilient.
  - Retrofit buildings.
  - Finance green and clean development, green jobs, and climate-smart technology
  - Promote sustainable consumption.
  - Facilitate trade in environmental goods.
  - Reconfigure the tourism sector to prioritize high value for the environment.
  - Shorten and diversify supply chains.
  - Promote and invest in Electric Vehicle technologies

Overall, the achievements by Rwanda to integrate environment into its development planning through mainstreaming Green Growth is impressive. It is important that the momentum be maintained since the impacts of climate change are becoming increasingly apparent, and the importance of the environment can no longer be questioned.

References

GGGI. (2020). 2020 Annual Report- Accelerating Climate Ambition and Build Back Better. Retrieved June 24, 2021, from Global Green Growth Institute: https://gggi.org/

GoR. (2021a). Revised Green Growth and Climate Resilience Strategy of Rwanda. Government of Rwanda. Retrieved from Personal Communication

GoR. (2021b). Assessment Report for the Implementation of Environment and Climate Change activities by Sector Ministries and Districts -Fiscal year 2019-2020. Republic of Rwanda, Ministry of Finance and Economic Planning.

MoE. (2019). National Environment and Climate Change Policy. Government of Rwanda, Ministry of Environment (MoE). Retrieved June 24, 2021, from http://www.fonerwa.org/sites/default/files/Rwanda%20National%20Environment%20and%20Climate%20Change%20Policy%202019.pdf

Ntrirenganya, E. (2021, June 10). FEATURED - E-mobility: Rwanda moves to convert fuel motorbikes to electric. Retrieved June 24, 2021, from The New times: https://www.newtimes.co.rw/featured/e-mobility-rwanda-moves-convert-fuel-motorbikes-electric

REMA. (2019). Rwanda Compendium of Environment. REMA. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/viewer.html?pdfurl=https%3A%2F%2Funstats.un.org%2Funsd%2Fenvironment%2FCompendia%2FCompendium%2520of%2520Environment%2520Statistics%2520of%2520Rwanda%25202018.pdf&clen=6938168&chunk=true

RLMUA. (2020, October 07). National Land-Use and Development Master Plan 2020-2050. Retrieved June 24, 2021, from Republic of Rwanda, Rwanda Land Management and Use Authority: https://rlma.rw/index.php?id=41&tx_news_pi1%5Bnews%5D=375&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Baction%5D=detail&cHash=a0f94d3902d3b4f56dd34bb1861878d3

Rugege, D. (2018). Evaluation of the Green Growth and Climate Resilience. Government of Rwanda, Ministry of Environment. Kigali: Government of Rwanda. Retrieved June 24, 2021, from https://www.environment.gov.rw/fileadmin/user_upload/Moe/Publications/Reports/GGCRS_-_Final-Evaluation_Report_-_Oct_2018.pdf

The New Times. (2021, June 09). Rwanda revises green growth strategy. Retrieved June 24, 2021, from The New Times: https://www.newtimes.co.rw/news/rwanda-revises-green-growth-strategy

UNDESA. (2015). Transforming our world: the 2030 Agenda for Sustainable Development. Retrieved June 24, 2021, from United Nations Department of Economic and Social Affairs: https://sdgs.un.org/2030agenda

UNDESA. (2019). Sustainable Development Goals, Knowledge Platform. Retrieved June 24, 2021, from United Nations Department of Economic and Social Affairs: https://sustainabledevelopment.un.org/memberstates/rwanda

UNESCO. (2016, November 07). Rwanda integrating environmental protection in its growth strategy. Retrieved June 24, 2021, from UNESCO Media services: http://www.unesco.org/new/en/media-services/single-view/news/rwanda_combining_its_growth_strategy_with_environmental_prot

UNFCC. (2020). Nationally Determined Contribution (updated). Republic of Rwanda. Retrieved June 24, 2021, from https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

UNSTATS. (2021). Rwanda. Retrieved June 16, 2021, from SDG County Profile: https://country-profiles.unstatshub.org/rwa#goal-15

USAID. (2019). Rwanda Tropical Forest and Biodiversity. Rwanda: Three Stones International. doi:June 2019

Chapter 12:

Future Scenarios

Scenic landscape of a road to Nyagatare Secondary City
Photo credit: RDB

12.1 Introduction

Scenarios are narratives in words and numbers, concerning the way in which a plausible future could unfold. They offer lessons on how to direct the future flow of events towards desired pathways and away from unsustainable ones (UNEP, 2002). Scenarios are not predictive, but give accounts of plausible futures (Peterson, Cumming, & Carpenter, 2003). Kok, Biggs, & Zurek (2007) noted that scenarios envision various plausible pathways through which the future might develop thereby accounting for critical uncertainties. They deal with the question "What might happen, if ?" and they do not predict what will happen in the future. Scenarios are not policy analyses, and neither do they seek to critique government strategies. Rwanda proposed three scenario pathways towards the achievement of green growth and climate resilience strategy (GoR, 2011). As such, scenario building is not new to Rwanda's planning.

Scenario development is characterized by identifying the main drivers and exploring the critical uncertainties around them and developing assumptions about how these will evolve. The broader implications of each scenario in the future are explored. In the conceptual framework below (Figure 12-1), the main drivers of environmental change include demography and urbanisation of Rwanda, the country's Green Growth and Climate Resilience Strategy (GGCRS), its economic development, regional integration, and governance and institutions.

Energy and food security is a major constraint to Rwanda's green growth aspirations against an expanding population and low agricultural productivity. With only 800 MW of electricity earmarked for generation by 2040 against demand of above 7,000 MW, the effect of the energy sector in driving Rwanda´s green growth cannot be over-emphasized. Similarly, food production requires a big boost given that the required food needs for the country by 2050 is only achievable if the country produces food at levels 15 times more than current levels. As such the Crop Intensification Programme (CIP) will require continuous improvement over the years.

12.2. Drivers of Rwanda's environmental change

Rwanda´s future state of the environment will largely be shaped by the country´s aspirations to achieve higher income country status by 2050 while being food and energy secure. Other important factors that define Rwanda´s future is its youthful population, rapid economic development, regional integration through the East African Community and African Union, and good governance and strong institutions. Of major significance to Rwanda's future is its expanding population and small land holdings which continue to get smaller while agricultural productivity remains low. The large-scale dependence on biomass fuel also implies the country has big hurdles to overcome to achieve green growth.

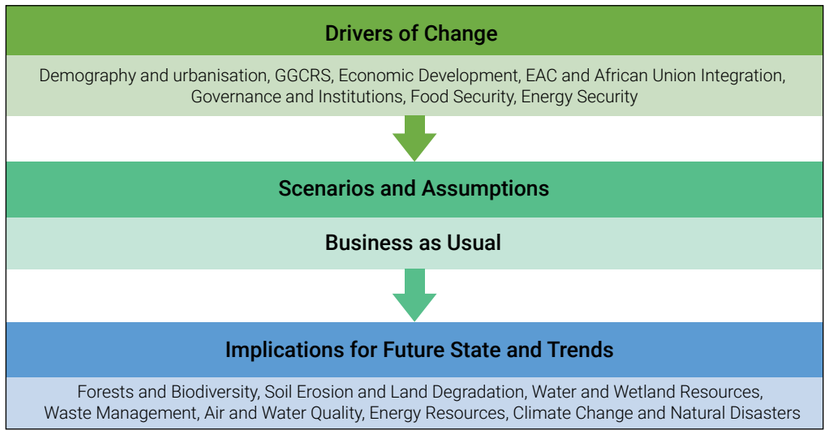


Figure 12-1: The conceptual framework for scenarios development

Green growth and climate resilience strategy

The Green Growth and Climate Resilience Strategy provides the trajectory for Rwanda´s Vision 2050, including integrated planning for a low-carbon future with a clean and healthy environment (GoR, 2021). The strategy seeks "to achieve energy security and low carbon energy supply that supports the development of green industry and services and avoids deforestation; to achieve sustainable land use and water resource management that results in food security, appropriate urban development and preservation of biodiversity and ecosystem services; and to ensure social protection, improved health and disaster risk reduction that reduces vulnerability to climate change impacts" (GoR, 2021).

Food security

The quest for food security by increasing food production can have significant impacts on the environment, including on land through exposure to soil erosion which leads to siltation of water bodies. With Rwanda's small land holdings, the temptation to encroach into wetlands and forests is high, with negative results on the environment such as deforestation and loss of habitats for aquatic life, birds and other biota. The livestock sector, which is raised on zero grazing, further strains land availability for cereals production as the available land is also reserved for pasture production.

The most cultivated crops in Rwanda are beans, cassava and maize in that order. The country's crop productivity per unit area is increasing but remains relatively low, with cereals averaging 1.4 tonnes per hectare (FAO, 2021). Despite the low agricultural productivity, an estimated 81.3 percent of the country's households are food secure (WFP, 2018), with 90.2 percent of the country's food provided through local production (Rukundo, et al., 2018). Rwanda's agricultural sector, which has recently been growing at an annual rate of 6 percent (GoR, 2019), is constrained by the country's hilly terrain which exposes the country to soil erosion and landslides, as well as the high population density which limits access to land for food production. Over the years, available land for farming has not only become smaller, averaging 0.76 ha per farm household in 2016, but has also become more fragmented with each of the household landholdings fragmented into as many as five pieces (NISR, 2018).

The CIP was introduced in 2007 to, among others, increase productivity using improved and high yielding seeds, use of fertilizers and irrigation, as well as better post-harvest and storage services (Cantore, 2011). Four years after its introduction, the CIP is credited with a sixfold increase in wheat and maize yield and a threefold increase in Irish potato yield. Other benefits include reduced transport costs, better access to markets, greater farm mechanisation and improved access to extension services (MINAGRI, 2011).

As Figure 12-2 shows, Rwanda's use of fertilizers is increasing in tandem with increased productivity. There are incremental benefits brought in by the CIP. For instance, as much as 89.2 percent farmers can now afford to buy their own inputs while 75.3 percent of the farmers have stable household food security (IRDP, 2018).

Due to the country's hilly terrain, most of the farmed land has slopes that are greater than 18 percent (Bagstad, et al., 2019) and are prone to soil erosion. Agroforestry and terracing are promoted to address the problem of soil erosion.

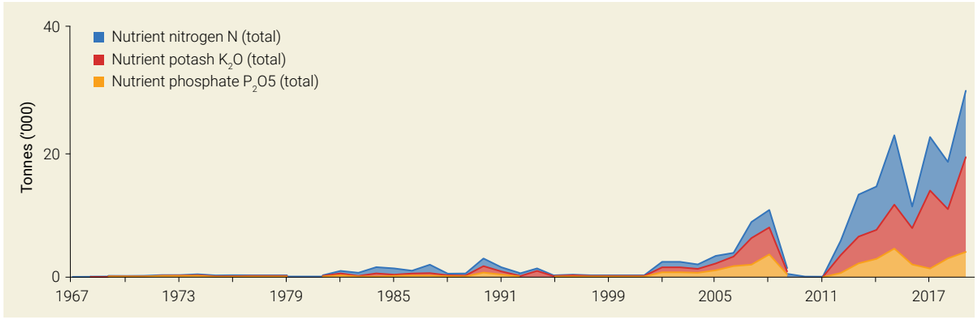


Figure 12-2: Fertilizer use in Rwanda 1961 - 2019 (FAO, 2021)

Energy security

Part of Rwanda's green growth strategy is built around a significant shift away from the use of fossil fuels, including firewood. However, the migration towards solar and hydro-power is constrained by current large dependence on firewood and the country's low potential for hydropower.

Rwanda's energy consumption pattern includes 85 percent biomass, 11 percent petroleum and 4 percent hydroelectricity and has largely remained the same since 2011 (RoR, 2018). The country had set target to reduce biomass consumption to 55 percent by 2018, but this was not successful. However, Rwanda managed to increase electricity generation from 87 MW in 2011 (GoR, 2020) to 221.9 MW in 2019 (REG, 2019), and this was projected to increase to 238.36 MW in 2021 (MININFRA, 2018). However, the new electricity generation capacity is still not enough to accommodate a significant switch from biomass to electricity.

At current trends of industrialisation, commercialisation, and urbanisation, and using a 10 percent annual growth in demand scenario, Rwanda's projected electricity demand is set at 2,468 MW by 2030 and 7,043 MW by 2040 (REG, 2019). Such demand comes at a time when the country's electricity generation capacity is expected to increase to 400 MW by 2025 and to 800 MW by 2040 as Figure 12-3 shows (REG, 2019). While the country has many options to increase electricity generation, including thermal sources, hydropower and solar, there are also insurmountable socio-economic and geographical conditions that the country faces. The country has a much smaller energy potential than its growing demands. The energy potential includes 700 MW from peat, 750 MW from methane gas, 320 MW from geothermal and 400 MW from hydropower (REG, 2019). As a result, biomass sources, as well as solar energy, will continue to play a significant part in Rwanda's energy mix.

Demographic trends

The estimated population of 12.9 million in 2020 is expected to reach 15.7 million by 2030 and 23.2 million by 2050 (NISR, 2017a). The country's population is youthful, with 68.7 percent under the age of 30. This gives Rwanda a very high total dependency burden that was estimated at 76 per 100 people of working age in 2015 (RoR; UNFPA, 2017). While a large ratio of 70 percent of Rwanda's population lives in rural areas, the country's annual urbanization growth trend is very high at 5.9 percent. In 2012, only 17 percent of the country's population lived in urban areas as shown in Figure 12-4, and this ratio is expected to increase to 30 percent by 2032 (RoR; UNFPA, 2017).

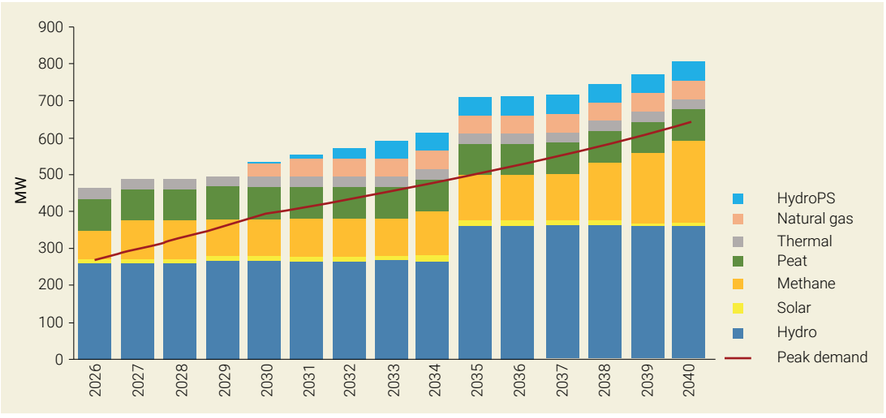


Figure 12-3: Projected installed electricity capacity 2026 -2040 (REG, 2019)

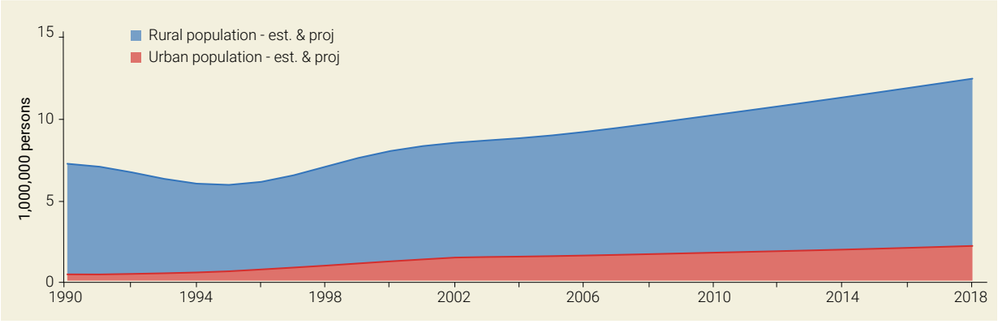


Figure 12-4: Ratio of rural and urban population 1990-2018 (RoR; UNFPA, 2017)

Economic development

Rwanda has been experiencing steady economic growth in recent times averaging 8 percent per year between 2001 and 2015 (NISR, 2015). Per capita GDP grew from US $288 in 2000 to US $820 in 2020 (World Bank, 2021a). The country managed positive economic growth of 0.2 percent in 2020 despite the significant impact of COVID-19 (World Bank, 2021b). The economy is driven by the service sector which contributes 48 percent of GDP, while agriculture and manufacturing contribute 31 percent and 16 percent, respectively (NISR, 2017b). However, agriculture is the country's major employer at 68 percent of the workforce (NISR, 2016).

The steady economic growth has seen the percentage of Rwanda's population living below poverty line fall from 56.7 percent in 2005 to 39.1 percent in 2014 (RoR; UNFPA, 2017). Despite the growth in GDP, as well as the fall in the ratio of people living below the poverty line, Rwanda faces challenges of poor infrastructure, including access to electricity. The country faces high levels of unemployment and underemployment, especially among women and the youth. The country is also highly dependent on donor support, with as much as 16 percent of its 2016/17 budget funded through foreign aid grants (RoR; UNFPA, 2017).

Regional integration

Rwanda is an active Member State of the East African Community and the African Union. The East African Treaty provides for cooperation in the use and management of natural resources and the environment, with priority areas being climate change adaptation and mitigation, biodiversity conservation, disaster management, pollution control and waste management (EAC, 2021). At the continental level, the African Union's Agenda 2063 seeks to accelerate Africa's political, social, economic and technological transformation. Rwanda derives part of its policy direction from the aspirations of both the East African Community and the African Union.

Rwanda is a member of the Eastern Africa Power Pool. The Kawanda-Birembo High Voltage Power Line joins Rwanda to the pool through its interconnection with Uganda. As much as Rwanda envisages little to zero imports of electricity in future, the country's electricity potential is not enough to meet its growing demand. At the same time members of the pool such as Ethiopia and Uganda are likely to have excess power in the near future.

Governance and institutions

Rwanda is making big strides on the governance front with positive scores in the containment of corruption, as well as ensuring transparency and accountability. The country has a decentralised system of government, with its 30 districts (akarere) as the main levers of local governance with financial autonomy and oversight over villages (imidugudu). The districts are run by mayors who are engaged on yearly performance contracts (imihigo). The decentralisation of governance in Rwanda is credited with improved service delivery and poverty reduction (Chemouni, 2017), and this has downstream benefits for the environment.

12.2 Scenario's assumptions

The ***Business-as-Usual Scenario***, whose assumptions are presented in Figure 12-5, is discussed in the chapter, while a set of options are proposed to bring on track the country´s Vision 2050. A timespan to 2050 is used to discuss the pathway that the scenarios will follow in shaping the state and trends in forests and biodiversity; soil erosion and land degradation; water and wetland resources; waste management; air and water quality; energy resources; and climate change and natural disasters.

The Business-as-Usual Scenario is defined by the IPCC as "the reference state against which an alternative outcome can be measured" (IPCC, 2019). Other terms for the Business-as-Usual Scenario are baseline scenario, "Laissez-faire", "Orthodox Growth" and "Current scenarios". The Business-as-Usual Scenario is not usually accompanied

Main Scenarios Assumptions and Options for Action

Business as Usual			*Options for Action*		
Devolution of authority to Districts	Slowly increasing food productivity hampered by high population density	Improving economy challenged by inadequate capacity to generate clean energy	Land consolidation is supported by large-scale farm mechanization and specialization	High urbanization supported with urban job opportunities, resulting in decongestation of rural areas	Improved, but diverisfied economy

Figure 12-5: Scenario's assumptions and options for action

by major policy changes. However, in order to bring Rwanda´s Vision 2050 on track some adjustments in policy are needed, while new technologies and market practices are needed in the face of sideswipes that can cause a change in the direction of the Business-as-Usual trends.

Under the Business-as-Usual Scenarios Rwanda will develop under devolved authority, with much focus on increasing agricultural productivity. Using current trends, the country's economy will continue to grow rapidly driven by the services sector while at the same time population will continue to expand at rates of more than 2 percent per year. Agriculture will continue to be the main source of employment, with many workers considered to be underemployed. The demands on the economy will be greater as the current youthful population become adults. Food productivity will continue to be hampered by the high population density and the small and fragmented land holdings. The energy sector will transform slowly but remain dominated by biofuels.

In order to achieve its Vision 2050 aspirations, Rwanda will continuously review its policies and governance systems in order to steer the country towards meeting its Vision 2050 goals and targets. The country will not only need to amend its environmental agenda but will also work to improve and diversify the economy to reduce the demands and pressure on environmental resources, particularly land. The policy transformation in the country will result in more people settling in urban areas, and this will ensure the attainment of desired environmental outcomes, while society will benefit through greater prosperity and good health.

12.3 Scenario narratives and implications

Forests and biodiversity

Business as usual scenario

Rwanda's forests remain protected in national parks and forest reserves, while pockets continue to be scattered throughout the country. With the country having lost 50 percent of its protected areas in the last 40 years, efforts under the Bonn Challenge to restore 2 million hectares of forests, as well as efforts to enhance forest protection by privatising forest management and promoting value addition to some forest assets gain significant traction, but this is not enough to restore the country's forests to their state of 40 years ago. Major drawbacks to forest restoration are the growing population and the encroachment of farmland into forests. The situation is compounded by the huge demand on biofuels for energy, estimated at 85 percent of the current energy mix. While significant efforts are made to electrify the country, the demand for firewood remains high. Although the negative gap between supply and demand for firewood will continue to narrow slowly from the current 2 M tonnes per year, this is not expected to reach zero by 2050.

Rwanda continues to place its forest resources under private management, with the area of such privately managed forests increasing from 14.1 percent in 2017 to 80 percent by 2024 (RoR, 2017). Forests remain a key source of employment in both charcoal production and wood processing. The country's aim to reduce household dependency on the use of firewood for energy from as high as 79.9 percent in 2016/17 to 42 percent by 2024 (RoR, 2017) is fraught with lack of adequate alternative energy sources, especially electricity availability which is much lower than demand. As such the forest cover of 30.4 percent (MoE, 2018) is hard to maintain even though use of liquid petroleum gas is greatly increased.

Despite the failure to restore forests to their status of 40 years ago, Rwanda's policy direction may result in the country meeting its other targets for the forest sector under Vision 2050, including development of agro-forestry and fruits production, as well as forest conservation and community-based tourism.

A significant portion of Rwanda is under protection, including the four national parks, namely Volcanoes National Park, Nyungwe National Park, Akagera National Park and Gishwati-Mukura National Park, which collectively cover 234,393 hectares (RoR, 2020b), and are home to many species, including the iconic mountain gorillas which remains endangered. Given the high value tourism associated with the national parks, these prime sites continue to be protected through the country's laws as well as through the efforts of country investors.

There is a gradual increase in the area covered by agroforestry mainly to increase fodder for livestock, which largely depend on zero grazing. Expansion in agro-forestry is also one of the few solutions to household firewood needs as more and more forest areas are placed under private management, with limited communal access.

Policy options

The privatisation of management of parts of its forest sector, as well as the promotion of value addition in the forest industry, does not result in a comprehensive improvement of the country's forests, and neither will this result in better conservation as business interests take precedence over protection. Integrated land use planning, economic diversification, and a rapid roll out or rural electrification are needed if the country's forests and biodiversity are to be protected. Going into 2050, economic diversification results in fast paced urbanization, taking significant pressure off the land and rural areas. At the same time affordable electricity supply reduces the reliance on firewood for energy and this allows forests to be restored to their levels of 40 years ago, while other targets for forests, biodiversity and protected areas can be met, founded in inclusive land administration and tenure security.

Sustained (and enhanced) efforts are required to ensure that total value is obtained from forests, especially from nontimber forest products. An enabling policy environment is needed for public and private sector participation in the production and marketing of non-timber forest products, including honey, foods such as mushroom, and herbs and medicines.

Soil erosion and land degradation

Business as usual scenario

Rwanda's hilly topography makes it vulnerable to both soil erosion and landslides. The likelihood of landslides is further worsened by the country's exposure to flooding. Despite such vulnerability, the country's land assets are the most valued for food production and personal wealth. Household land ownership for agriculture is small at 0.76 ha and getting even smaller and fragmented.

At current levels of food production per unit area and an expanding population, Rwanda needs land that is four times the country size to meet its food demands by 2050. As this option is not realistic, the other option is to increase food production by 15 times on the same piece of land (RoR, 2020a). Such intensive farming is not only impracticable, but also exposes the land to various forms of degradation, including soil erosion and soil acidification.

The current drive to agglomerate smallholder farms and to focus on a few selected crops could enable Rwanda to not only increase food production, but to also mechanise the sector, albeit initially on a small scale. This is important in view of the growing urbanisation trends that may see 70 percent of Rwanda's residents living in towns by 2050, thus removing manual labour from the land. Small levels of mechanization, while necessary, require training and experience for proper use and to avoid damaging the land given the rugged terrain, and the resultant exposure of the soil to erosion and to landslides. As such, the current extension services available through the Crop Intensification Production programme (CIP) needs to cover, not only agronomic and animal husbandry practices, but also appropriate mechanical and technology skills.

The Girinka Programme, which has already seen the number of donated cows increase to over 318,000 by 2018 (RoR, 2020a) (Figure 12-6), is set to trigger a huge expansion in the livestock population, causing not only high stocking numbers but also increasing the risk of exposure to soil erosion, as well as increasing the country's contribution to greenhouse gases in particular methane. Of particular concern is the zero grazing approach which sees more farmland devoted to growing fodder rather than food crops. However, there is more use of cattle manure, which is necessary for soil conditioning and fertility.

Policy options

The Crop Intensification Programme (CIP) is one of the flagship initiatives for ensuring Rwanda's food security, while protecting the country from both soil erosion and land degradation. While the CIP encourages both farm agglomeration and mono-cropping, there is need to refine the programme to suit the changing conditions. For example, it is necessary to provide for large-scale farm mechanization and for specialised farming. The country's generally high altitude and hilly conditions are suited to specialized tea and coffee farming, which can significantly increase export values from the current 30 percent of total exports (RoR, 2020c).

Through the refined CIP, Rwanda is geared towards smart farming through better use of knowledge of local agro-ecological conditions so that the most appropriate crops are grown in specific regions. The same will apply for livestock farming whereby the correct livestock units are adhered to for purposes of avoiding land degradation. Smart farming results in optimum farm production while the environment is protected.

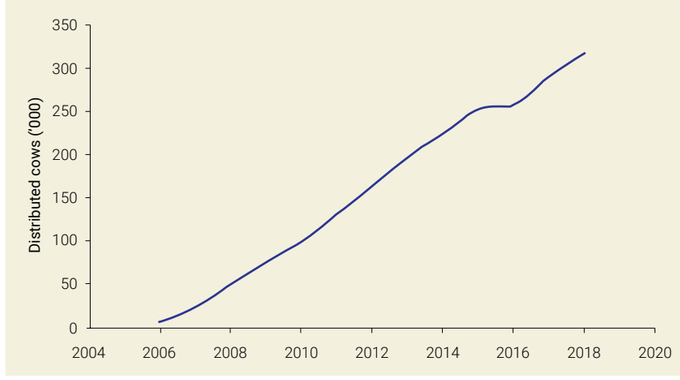


Figure 12-6: Rwanda´s Girinka Programme (RoR, 2020a)

Water and wetland resources

Business as usual scenario

Rwanda's water-scarcity situation, estimated at 670 cubic metres per capita (RoR, 2020c), is faced with additional challenges of water pollution, access to safe drinking water in urban areas, as well as incomplete coverage of sanitation services. The pollution from wastewater and agro-chemicals, among other sources, is greatly reduced by 2050. This is because of more organic farming methods, improved wastewater treatment, as well as restoration of watersheds to stop soil erosion and siltation of wetlands. The institutionalisation of water, sanitation, and hygiene (WASH) master plans at national, city and district levels, as well as the adoption of smart water supply approaches in green cities and industries, result in universal access to safe drinking water by 2050. Similarly, resilient faecal sludge management results in safely managed sanitation services for all by 2035.

Policy options

Rwanda will complement efforts to increase access to safe drinking water and improve sanitation services by increasing water supply through the construction of water capture infrastructure, including dams and weirs. Water harvesting techniques will also be employed while water conservation measures will be applied for agriculture. Integrated water resources management, as well as catchment-based water management will bring the management of water closer to the users, with significant benefits for water availability and access to all. Integrated land management will not only protect the land and forests, but also protect watersheds with additional benefits for water management.

Energy resources

Business as usual scenario

Biomass makes up 85 percent of energy supply, while electricity makes up only 2 percent. The huge demand for biofuels has meant an annual shortfall of 2 million metric tonnes in biomass fuel, a gap that is too wide to close by 2050. While there are significant efforts to generate more electricity from renewable sources such as hydropower and solar, much of the new generation is only enough to close the electricity importation gap, as well as to transition the electricity mix from non-renewable thermal sources to fully renewable, including hydro- and solar power.

With the growing participation of the private sector in the supply of electricity, Rwanda can meet its goal under the National Strategy for Transformation for universal access to electricity by 2024. Much of the electricity is generated though off-grid solar power for water heating and pumping, as well as for indoor lighting and refrigeration. Investment in efficient cooking stoves, increased use of LPG gas for cooking, as well as the prohibition of charcoal result in a significant reduction in the dependence on biofuels by 2050. With an expected investment outlay of US $3.3 billion in the energy sector, Rwanda's small installed capacity for electricity generation of 221.9 MW makes it hard for the country to meet its ambition to increase electricity output to 800 MW by 2040, while at the same time reducing electricity tariffs by 5 percent. However, significant progress is made to improve on energy efficiency, including efficient lighting and stabilization of the grid transmission.

The big investment in infrastructure, especially in the generation of electricity, results in positive downstream effects of job creation, as well as improved standards of living. However, as the investment is hindered by Rwanda's low energy potential, the country fails to meet its Vision 2050 energy targets. As a result, deforestation continues to be a challenge with attendant consequences such as land degradation and the risk of landslides.

Policy options

The energy sector is key to Rwanda's achievement of Vision 2050. With adequate supply of clean forms of energy, including electricity from renewable sources, the country can transform to a higher income country by 2050. Big investments in the generation of electricity, as well as in transmission lines and efficient use of electricity, result in not only the country achieving universal access to electricity and meeting its climate change goals, but also in the reduction of deforestation. The country's drive to attract both foreign and domestic investors continue to be high, and this benefits not just the energy sector but other sectors of the economy.

The multiple benefits that are accrued from clean energy, including good health as people are not exposed to indoor air pollution from the use of biofuels for cooking, result in the country prioritising the energy sector. The country remains challenged by the limited potential for electricity generation, which is not adequate for its needs. The only area where opportunities seem abundant is solar power, and the country´s policies must promote both small-scale and large-scale solar investments. For a stable grid supply, Rwanda will need to turn to the Eastern Africa Power Pool for excess power from countries such as Uganda and Ethiopia. This is despite the country's intention to invest in and depend on internally generated power.

Current efforts towards smart transport systems need to be enhanced through electrification of both road and rail transport systems. As one of the few countries assembling electric cars, Rwanda is a leading player in Africa in clean transportation. An enabling policy environment that promotes electric vehicles while discouraging fossil fuel powered vehicles is necessary. The policy environment must also allow for the development of the infrastructure for use of electric vehicles, including working with local authorities and power utility companies to facilitate the construction of electric car charging points.

Air and water quality

Business as usual scenario

Outdoor air quality across much of Rwanda is good, although dry seasons may have occasional dust storms. In urban areas, pockets of car fumes and dust are also common. Increased industrial activity and urban growth in Rwanda result in higher levels of outdoor air pollution levels. Urbanisation levels that are not matched with the development of infrastructure such as paved roads result in the country failing to reduce the outdoor pollution in towns and cities.

The high dependency on fossil fuels for cooking, and lighting across the country result in high incidences of indoor air pollution and cases of acute respiratory illnesses. As the country invests in off-grid solar energy, available solutions are only good for lighting while fossil fuels remain a much-needed energy source for cooking. As a result, indoor air pollution is slightly abated through the slowly increasing use of improved cooking stoves and LPG gas.

Wastewater and agro-chemicals are major sources of surface water pollution. With a growing and urbanising population, as well as through the unintended consequences of large-scale use of inorganic fertilizers under the Crop Intensification Programme, the risk of water pollution is elevated. Water weeds such as the Water hyacinth thrive in some of the country's water bodies, and the costs of treatment of drinking water is also high.

Policy options

The drive to improve Rwanda's air quality should include an improved design in the rural homestead for better ventilation, while use of clean cooking stoves should be encouraged. In urban areas, roads need to be paved to limit the amount of dust pollution. Together, with the universal access to electricity and a public transport system that runs on electricity, the country should be able to meet its Vision 2050 targets for modern housing and settlements with environmentally friendly and climate resilient surroundings.

Continuous improvement is needed in urban planning, including proper channeling of storm water and wastewater treatment, as well as farming methods that do not result in the erosion of agro-chemicals into water bodies, so that there are less levels of water pollution.

Waste management

Business as usual scenario

The infrastructure for waste management in Rwanda is still developing. The rapid urban growth brings to the fore the need for clear waste management laws and well-functioning institutions. All towns in the country are equipped with and serviced by infrastructure for solid waste management, initially to close the 35 percent gap in waste collection coverage, and later to cover the increased waste generation of 14 percent by 2035 (REMA, 2019). Significant effort is placed in waste collection, landfilling and composting, resulting in all urban centres maintaining cleanliness. While households are well guided to minimize and sort their waste, they are not penalised for mishandling waste. As such households have no incentive and neither do they feel deterred from improper waste management practices. In towns and cities, management of wastewater remains a challenge with the available wastewater treatment plants failing to cope with the growing urban population. Low density residential areas rely more on septic tanks for their wastewater management.

Going into 2050, the country steps up its waste management approaches to include recycling and reuse of economically valuable waste products. Composted organic waste and treated wastewater are used in agriculture, while investments are also made to generate energy from some organic waste products. The infrastructure for waste management is continuously modernised, while laws are updated to match the new realities of increased waste generation and new waste streams.

Despite significant progress in waste management, the country struggles to cope with non-traditional forms of waste such as medical waste, electronic waste products and plastic. The drive to decarbonise the transport sector results in the increasing use of more electric public and private vehicles. This is further encouraged as Rwanda is one of the few countries in Africa assembling electric cars. New types of car batteries are added to the electronic waste stream, and the country is challenged by how best to manage such waste.

Although the country has a ban on single-use plastics in place, the usage of plastics in packaging is still widespread, a situation that remains into 2050.

Policy options

Rwanda's future policy options and approaches to waste management need to be centred around the household and business levels. This will result in local level cleanliness, which then gets reflected across much of the country. Continuous raising of awareness results in waste separation at household level, which makes it possible for one to make choices for composting, reusing, or recycling. With high levels of awareness, significant success can be scored in the reduction of waste generation. The infrastructure for wastewater management needs continuous modernisation and upgrading to meet the needs of growing urban populations.

Incentives and new laws are needed to encourage industry to be active players in waste management, including the adoption of biodegradable packaging materials, and the extended producer responsibility as a way of getting industry to invest in their value chains and ensure that waste leakages into the environment at every stage of the value chain are reduced.

While new laws are enacted and old ones modernised, much of Rwanda's success in waste management will continue to arise from proper enforcement, including the current ban and control on the use of non-biodegradable single-use plastic products.

Climate change and natural disasters

Business as usual scenario

Rwanda's efforts remain focused on adaptation to the impacts of climate variability and change, with the goal being on mitigation through green economic growth approaches.

Affordable, reliable and clean energy, a key part of Rwanda's Vision 2050 aspiration is achieved through sustained investment in renewable electricity while phasing out thermal and biofuel sources of energy. At a local scale, off-grid solar power solutions result in improved food and nutrition security through water pumping for small to medium sized irrigated farming, which allows for year-round food production. As the country's rural economy expands, significant migration into towns is also witnessed, causing a big demand for employment, including green jobs. While significant positive changes are experienced in employment, the country's youthful population is too large for the country to meet its goals for job creation resulting in both unemployment and under-employment.

Given the global nature of climate change, some solutions are crafted at the global stage. Rwanda continues to be a significant global player. The country follows suit in decarbonising the transport sector, but the huge demands on clean electricity that come with such transformation result in the country failing to catch up with the developed world.

Rwanda experiences landslides owing to its terrain and deforestation. The migration to universal access to electricity results in significant reduction in levels of deforestation, which together with forest restoration efforts and terracing, result in reduced levels of exposure to landslides. The restoration of forests and protection of wetlands also results in reduced frequencies of flooding.

Policy options

Climate smart solutions need upscaling in Rwanda, including mass public transport systems driven by clean energy from renewable sources. The smart public transport system will be favoured by the public if it is efficient and on time. Huge tariffs on the use of personal fossil fuel driven cars may deter the public from owning and using fossil fuel driven cars. The incremental investment in clean forms of energy will make Rwanda a low-carbon economy by 2050 if the current efforts are sustained.

While forest restoration efforts will result in a significant reduction in the frequency and severity of disasters such as floods and landslides, the country will also need to invest in early warning capacity so that there is little to no loss of human and animal life due to these disasters.

Impacts of climate change through the widespread fires in the United States of America, Turkey and France, as well as widespread flooding in Europe and Asia, make Rwanda understand too well that it is also vulnerable to both wildfires and flooding due to its extensive forests and rugged terrain. Going into 2050, the country will need to invest in not only firefighting equipment, but also strengthens its policies for local level firefighting, including the establishment of fireguards. Current terracing efforts need to be sustained if landslides are to be avoided.

12.4 Conclusion and recommendations

The above scenario analyses discussed the Business as Usual and suggested some policy options. While the Business-as-Usual scenario painted some gaps in policy implantation of Rwanda´s Green Growth and Climate Resilient Strategy, it also noted that the country´s strategy places Rwanda on the right footing to be a future high-income state that is built around environmental sustainability. A notable policy gap under the Business-as-Usual scenario is the need to focus on developing internal electricity generation capacity as the country's energy potential is not big enough to meet demand. In addition, there is need for continuous improvement in some of the flagship initiatives like the Crop Intensification Programme as they may be too rigid to meet the continuously changing conditions.

The suggested policy options noted the adjustments needed if Rwanda is to meet its targeted aspirations. Most of the adjustments are centered on smart and green growth. Of note, is the need for Rwanda to benefit from excess electricity from the Eastern Africa Power Pool if the country is to fully meet its green growth targets.

The scenarios acknowledge the strong governance systems and institutions in Rwanda, although some need transformation and modernization if Vision 2050 targets are to be achieved. A notable challenge to Rwanda´s success and environmental sustainability is the high population density and the impact thereof on food production. Agriculture, which is key to both food production and the national economy, is challenged by small and fragmented farm holdings, as well as a rugged terrain that induces land degradation.

While the aspirations under the country´s Green Growth and Climate Resilient Strategy are generally ambitious, Rwanda has the potential to successfully achieve most of the goals under the Business-as-Usual scenario. Much more will be achieved if the suggested policy options are implemented, but this is also only possible in the absence of sideswipes as is the current case with COVID-19.

References

Bagstad, K., Ingram, J., Lange, G., Masozera, M., Ancona, Z., Bana, M., . . . Uwer, C. (2019). Towards ecosystem accounts for Rwanda: Tracking 25 years of change in flows and potential supply of ecosystem services. People and Nature, 2(1), 163-188. https://besjournals.onlinelibrary.wiley.com/doi/10.1002/pan3.10062

Cantore, N. (2011). The Crop Intensification Program in Rwanda: A sustainability analysis. Kigali: UNDP, UNEP and ODI. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/viewer.html?pdfurl=https%3A%2F%2Fwww.files.ethz.ch%2Fisn%2F128618%2F5712.pdf&clen=242539&chunk=true

Chemouni, B. (2017, February 06). Retrieved from Taking Stock of Rwanda's Decentralisation: Changing Local Governance in a Post-Conflict Environment: http://eprints.lse.ac.uk/71988/1/Chemouni_Taking%20stock%20of%20Rwanda%27s%20decentralisation_author_2017.pdf

EAC. (2021, June 25). Environment and Natural Resources. Retrieved from East African Community: https://www.eac.int/environment

FAO. (2021, July 13). FAOSTAT. Retrieved from http://www.fao.org/faostat/en/#country/202

GoR. (2019). Sustainable Development Goals - Rwanda Voluntary National Review. Kigali: Government of Rwanda. https://sustainabledevelopment.un.org/content/documents/23432Rwanda_2019_VNR_Final_Draft___17_06_2019.pdf

GoR. (2020). Concise Sector Working Paper: Energy. Kigali: Government of Rwanda.

GoR. (2021). Revised Green Growth and Climate Resilience Strategy. Kigali: Government of Rwanda. https://www.greengrowthknowledge.org/national-documents/rwanda-green-growth-and-climate-resilience-national-strategy-climate-change-and low-carbon.

IPCC. (2019). IPCC-data. (Intergovernmental Panel on Climate Change (IPCC)) Retrieved July 27, 2021, from https://www.ipcc-data.org/guidelines/pages/glossary/glossary_b.html

IRDP (2018) Crop Intensification Program (CIP) Citizen's Satisfaction Survey – 2018. Institute of Research and Dialogue for Peace (IRDP) http://www.irdp.rw/wp-content/uploads/2019/02/Final-printed-CIP-report.pdf

Kok, K., Biggs, R., & Zurek, M. (2007). Methods for Developing Multi-scale Participatory Scenarios: Insights from southern Africa and Europe. Ecology and Society, 13(1), 8. https://www.semanticscholar.org/paper/Methods-for-Developing-Multiscale-Participatory-and-Kok-Biggs/595aa1c4c7eb2b1242cf3075ae94a19d4e439804

MINAGRI. (2011). The Strategies for Sustainable Crop Intensification in Rwanda. Kigali: MINAGRI. http://197.243.22.137/ngoma/fileadmin/_migrated/content_uploads/CIP_Strategies_2011.pdf

MININFRA (2018). Rwandan Energy Sector Strategic Plan (ESSP). Kigali: Ministry of Infrastructure. https://www.reg.rw/fileadmin/user_upload/Final_ESSP.pdf

MoE. (2018). Rwanda National Forestry Policy 2018. Kigali: Republic of Rwanda. https://www.environment.gov.rw/fileadmin/user_upload/Moe/Publications/Policies/Rwanda_National_Forestry_Policy_2018__1_.pdf

NISR. (2014). Fourth Population and Housing Census, Rwanda, 2012: Thematic Report - Population size, structure and distribution. Kigali: National Institute of Statistics of Rwanda. https://statistics.gov.rw/publication/rphc4-thematic-report-population-size-structure-and-distribution

NISR. (2015). Rwanda Poverty Profile Report 2013/2014. Kigali: National Institute of Statistics Rwanda. https://www.statistics.gov.rw/file/4135/download?token=cylGgLRl#:~:text=The%202013%2F14%20EICV%20is,and%202010%2F11%20EICV%20surveys.&text=The%20survey%20shows%20that%20poverty,Generally%20the%20progress%20is%20impressive.

NISR. (2016). EICV4 - Economic Activity Thematic Report. Kigali: Republic of Rwanda. http://catalog.ihsn.org/index.php/catalog/5975/download/80767

NISR. (2017a). 2012 PHC Population Projections. UN Department of Economic and Social Affairs. https://www.statistics.gov.rw/publication/rphc4-final-report-publication-tables

NISR. (2017b). GDP National Accounts 2016; Rebased estimates of GDP - an explanatory note. Kigali: National Institute of Statistics of Rwanda. http://statistics.gov.rw/publication/eicv-5-rwanda-poverty-profile-report-201617

NISR. (2018). The Fifth Integrated Household Living Conditions 2016/17: Rwanda Poverty Profile Report. Kigali: National Institute of Statistics of Rwanda. http://statistics.gov.rw/publication/eicv-5-rwanda-poverty-profile-report-201617

Olson, J., & Berry, L. (2004). Land Degradation in Rwanda: Its Extent and Impact. In L. Berry, J. Olson, & D. Campbell, Assessing the Extent, Cost and Impact of Land Degradation at the National Level: Findings and Lessons Learnt from Seven Pilot Case Studies. Bonn: UNCCD. https://rmportal.net/library/content/frame/land-degradation-case-studies-06-rwanda/at_download/file

Peterson, G., Cumming, G., & Carpenter, S. (2003). Scenario Planning: A tool for conservation in an uncertain world. Conservation Biology, 17(2), 1-10. https://training.fws.gov/courses/alc/alc3194/resources/publications/scenario-planning/Peterson_et_al_2003.pdf

REG. (2019). Rwanda Least Cost Power Development Plan (LCPDP) 2019-2040. Kigali: Rwanda Energy Group. http://www.reg.rw/fileadmin/user_upload/LCPDP_REPORT_June_2019.pdf

REMA. (2015). Rwanda: State of Environment and Outlook 2015. Kigali: Rwanda Environment Management Authority. https://www.researchgate.net/publication/304039495_Rwanda_-_State_of_Environment_and_Outlook_Report_2015

REMA. (2019). Rwanda Compendium of Environment Statistics, 2018. Kigali: Rwanda Environment Management Authority. https://unstats.un.org/unsd/environment/Compendia/Compendium%20of%20Environment%20Statistics%20of%20Rwanda%202018.pdf

RoR. (2017). Seven Year Government Programme: National Strategy for Transformation (NST1) - 2012-2024. Kigali: Republic of Rwanda. https://www.minaloc.gov.rw/fileadmin/user_upload/Minaloc/Publications/Useful_Documents/National_Strategy_For_Trsansformation_-NST1.pdf

RoR. (2018). Energy Sector Strategic Plan (ESSP) for 2018/19 - 2023/24. Kigali: Republic of Rwanda. http://www.reg.rw/fileadmin/user_upload/Final_ESSP.pdf

RoR. (2020a). Concise Sector Working Paper: Revising Rwanda's Green Growth and Climate Resilience Strategy. Kigali: Republic of Rwanda.

RoR. (2020b). National Land Use and Development Master Plan (NLUDMP): 2020 - 2050. Kigali: Republic of Rwanda. https://www.environment.gov.rw/fileadmin/user_upload/Moe/Publications/Policies/National_Land-Use_and_Development_Master_Plan_2020-2050.pdf

RoR. (2020c). Vision 2050. Kigali: Republic of Rwanda. https://kigalicity.gov.rw/fileadmin/templates/Documents/policies/Rwanda_Vision_2020__revised_2012_.pdf

RoR; UNFPA. (2017). Unlocking Rwanda's Potential to Reap the Demographic Dividend. Rwanda: UNFPA Rwanda. https://www.afidep.org/publication/unlocking-rwandas-potential-to-reap-the-demographic-dividend/

Rukundo, E., Liu, S., Dong, Y., Rutebuka, E., Asamoah, E., Xu, J., & Wu, X. (2018). Spatio-temporal dynamics of critical ecosystem services in response to agricultural expansion in Rwanda, East Africa. Ecological Indicators, 89, 696-705. https://www.sciencedirect.com/science/article/pii/S1470160X18301171

Uhorakeye, T., & Möller, B. (2018). Assessment of a climate-resilient and low-carbon power supply scenario for Rwanda. International Journal of Sustainable Energy Planning and Management, 17, 45-60. https://core.ac.uk/display/229011507

UNEP. (2002). Africa Environment Outlook. Nairobi: UNEP. https://booksonline.link/get/loading.php?id=k_1LwgEACAAJ&item=Africa%20Environment%20Outlook

WFP. (2018, December). Rwanda: Comprehensive Food Security Analysis 2018. Retrieved from https://reliefweb.int/sites/reliefweb.int/files/resources/WFP-0000103863.pdf.

World Bank. (2021a). GDP per capita (current US $) - Rwanda. Retrieved from The World Bank Data: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=RW

World Bank. (2021b). The World Bank: Where we Work. Retrieved from The World Bank in Rwanda: https://www.worldbank.org/en/country/rwanda/overview

Rwanda Environment Management Authority
P.O. Box 7436 Kigali, Rwanda
Tel +250252580101
Fax +250252580017
E-mail: info@rema.gov.rw
Twitter: @REMA_Rwanda
Website: www.rema.gov.rw