

CLIMATE RISK COUNTRY PROFILE

RWANDA



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This profile is part of a series of Climate Risk Country Profiles developed by the World Bank Group (WBG). The country profile synthesizes most relevant data and information on climate change, disaster risk reduction, and adaptation actions and policies at the country level. The country profile series are designed as a quick reference source for development practitioners to better integrate climate resilience in development planning and policy making. This effort is managed and led by Veronique Morin (Senior Climate Change Specialist, WBG) and Ana E. Bucher (Senior Climate Change Specialist, WBG).

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Climate and climate-related information is largely drawn from the [Climate Change Knowledge Portal \(CCKP\)](#), a WBG online platform with available global climate data and analysis based on the [latest Intergovernmental Panel on Climate Change \(IPCC\)](#) reports and datasets. The team is grateful for all comments and suggestions received from the sector, regional, and country development specialists, as well as climate research scientists and institutions for their advice and guidance on use of climate related datasets.

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FOREWORD

Climate change is a major risk to good development outcomes, and the World Bank Group is committed to playing an important role in helping countries integrate climate action into their core development agendas. The World Bank Group is committed to supporting client countries to invest in and build a low-carbon, climate-resilient future, helping them to be better prepared to adapt to current and future climate impacts.

The World Bank Group is investing in incorporating and systematically managing climate risks in development operations through its individual corporate commitments.

A key aspect of the World Bank Group's Action Plan on Adaptation and Resilience (2019) is to help countries shift from addressing adaptation as an incremental cost and isolated investment to systematically incorporating climate risks and opportunities at every phase of policy planning, investment design, implementation and evaluation of development outcomes. For all IDA and IBRD operations, climate and disaster risk screening is one of the mandatory corporate climate commitments. This is supported by the World Bank Group's Climate and Disaster Risk Screening Tool which enables all Bank staff to assess short- and long-term climate and disaster risks in operations and national or sectoral planning processes. This screening tool draws up-to-date and relevant information from the World Bank Group's Climate Change Knowledge Portal, a comprehensive online 'one-stop shop' for global, regional, and country data related to climate change and development.

Recognizing the value of consistent, easy-to-use technical resources for client countries as well as to support respective internal climate risk assessment and adaptation planning processes, the World Bank Group's Climate Change Group has developed this content. Standardizing and pooling expertise facilitates the World Bank Group in conducting initial assessments of climate risks and opportunities across sectors within a country, within institutional portfolios across regions, and acts as a global resource for development practitioners.

For developing countries, the climate risk profiles are intended to serve as public goods to facilitate upstream country diagnostics, policy dialogue, and strategic planning by providing comprehensive overviews of trends and projected changes in key climate parameters, sector-specific implications, relevant policies and programs, adaptation priorities and opportunities for further actions.

It is my hope that these efforts will spur deepening of long-term risk management in developing countries and our engagement in supporting climate change adaptation planning at operational levels.



Bernice Van Bronkhorst

Global Director

Climate Change Group (CCG)

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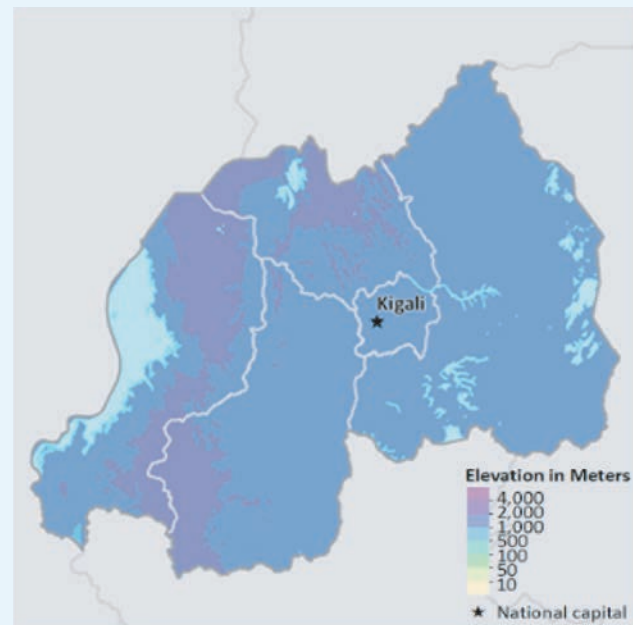
COUNTRY OVERVIEW

Rwanda is a small land locked country in Central Africa located between 1°4' and 2°51' south latitude and 28°45' and 31°15' east longitude. The country has a total land area of 26,338 km² and shares borders with Uganda to the north, Tanzania to the east, Burundi to the south, and the Democratic Republic of Congo to the west and northwest.¹ The country is divided into four main climatic regions: eastern plains, central plateau, highlands, and regions around Lake Kivu along the western border. Rwanda enjoys a tropical climate with hilly topography stretching from east to west. The Rwandan territory is covered with diverse ecosystems which includes mountain rainforests, gallery forests, savannah woodland, wetlands and aquatic forests and agro-ecosystems. Approximately 52% of the country's total land area is arable and the total cultivated area equates to 66% of the national territory, with over 93,000 hectares of marshland under

cultivation (**Figure 1**). With much small plot cultivation occurring on hills or mountain areas, increased runoff and landslides have been experienced, increasing the country's vulnerability to climate change impacts.²

Rwanda is a low-income country, but still ranks as one of the top 30 places in the world to do business (2019) and one of the fastest-growing economies in Africa.⁴ Rwanda has a population of 12.9 million people (2020) with an annual population growth rate of 2.5%. Approximately 17.4% of the population currently live in urban areas and this is projected to increase to 20% and 29.6% of the population by 2030 and 2050, respectively.⁵ The country has a Gross Domestic Product (GDP) of \$10.4 billion in 2019 and \$10.3 billion in 2020 and an annual growth rate of 9.5% in 2019 and -3.4% in 2020.⁶ Rwanda's strong economic growth has been accompanied by substantial improvements in living standards (**Table 1**), with a 2/3 drop in child mortality and near-universal primary school enrollment. A strong focus on development-orientated policies and initiatives has contributed to significant improvement in access to

FIGURE 1. Topography of Rwanda³



¹ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

² Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

³ World Bank (2019). Internal Climate Migration Profile – Rwanda

⁴ Ngohabonimana, D. (2019). What makes Rwanda one of Africa's fastest growing economies? TRTWorld [17 January 2019]. URL: <https://www.trtworld.com/magazine/what-makes-rwanda-one-of-africa-s-fastest-growing-economies-23410>

⁵ World Bank Data Bank (2021). Population estimates and projections, Rwanda. URL: <https://databank.worldbank.org/source/population-estimates-and-projections>

⁶ World Bank Data Bank (2021). World Development Indicators, Rwanda. [data accessed 13 September, 2021]. URL: <https://databank.worldbank.org/source/world-development-indicators>

services and human development indicators. Rwanda's poverty rate dropped from 39.1% in 2014 to 38.1% in 2017 and Rwanda experienced robust economic growth and social performance following the implementation of two, five-year Economic Development and Poverty Reduction Strategies—EDPRS (2008–12) and EDPRS-2 (2013–18). Over the last decade, growth averaged 7.2 % and per capita GDP grew at 5% annually.⁷ Rwanda's Vision 2050, a blueprint to transform Rwanda into an upper middle-income country by 2035 and a high-income country by 2050 requires an annual average GDP growth rate of at least 12% during 2018-2035 and 10% from 2035 to 2050.⁸ However, the lockdown and social distancing measures, which were critical to control the COVID-19 pandemic, sharply curtailed economic activities in 2020. The government expects GDP to drop by 0.2% in 2020, compared to a projected expansion of 8% before the COVID-19 outbreak.⁹

Despite the country's overall positive growth and development over the past 25 years, Rwanda is still highly vulnerable to impacts from climate change through its high dependence on rain-fed agriculture, as well as need to improve its road networks, health sector and water resource management.¹⁰ In Rwanda, the high levels of poverty and low-degree of development limits capacity of poor households and communities to manage climate risk, increasing their vulnerability to climate-related shocks.

TABLE 1. Data Snapshot: Key Development Indicators¹¹

Indicator	
Life Expectancy at Birth, Total (Years) (2019)	69.0
Population Density (People per sq. km Land Area) (2018)	498.7
% of Population with Access to Electricity (2019)	37.8%
GDP per Capita (Current US\$) (2020)	\$797.90

The ND-GAIN Index¹² ranks 182 countries using a score which calculates a country's vulnerability to climate change and other global challenges as well as their readiness to improve resilience. This Index aims to help businesses and the public sector better identify vulnerability and readiness in order to better prioritize investment for more efficient responses to global challenges. Due to a combination of political, geographic, and social factors, Rwanda is recognized as vulnerable to climate change impacts, ranked 124 out of 182 countries in the 2020 ND-GAIN Index. The more vulnerable a country is the lower their score, while the more ready a country is to improve its resilience the higher it will be. Norway has the highest score and is ranked 1st. **Figure 2** is a time-series plot of the ND-GAIN Index showing Rwanda's progress

⁷ World Bank (2021). Rwanda – Overview. URL: <https://www.worldbank.org/en/country/rwanda/overview>

⁸ Ministry of Finance and Economic Planning (2015). Vision 2050. Republic of Rwanda. URL: https://www.nirda.gov.rw/uploads/tx_dce/Vision_English_Version_2050_-31_Dec_2020.pdf

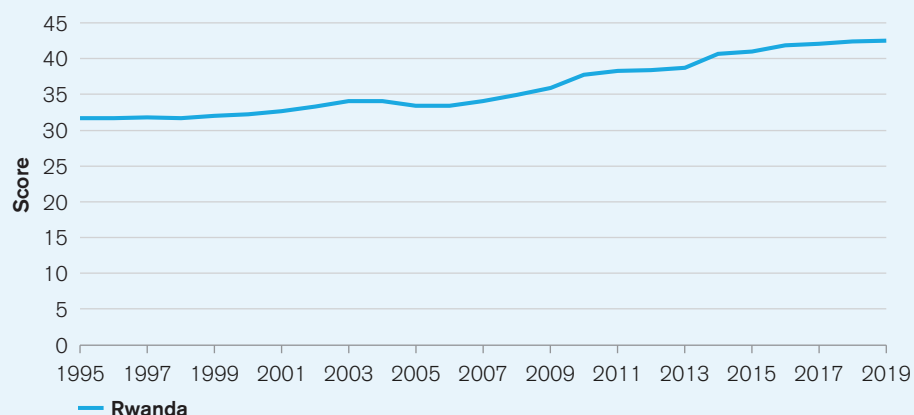
⁹ World Bank (2021). Rwanda – Overview. URL: <https://www.worldbank.org/en/country/rwanda/overview>

¹⁰ Netherlands Commission for Environmental Sustainability (2015). Climate Change Profile – Rwanda. URL: https://ees.kuleuven.be/klimos/toolkit/documents/687_CC_rwanda.pdf

¹¹ World Bank (2021). DataBank – World Development Indicators. URL: <https://databank.worldbank.org/source/world-development-indicators>

¹² University of Notre Dame (2021). Notre Dame Global Adaptation Initiative. URL: <https://gain.nd.edu/our-work/country-index/>

FIGURE 2. ND-GAIN Index for Rwanda



Rwanda submitted its [Updated Nationally-Determined Contribution \(NDC\)](#) to the UNFCCC in 2020, which outlines the country's vision and its commitment to developing a climate-resilient, low carbon economy. Commitments are also guided by Rwanda's [Green Growth and Climate Resilience Strategy \(2011\)](#) (GGCRS) and its [National Strategy for Transformation \(NST 1\) \(2017–2024\)](#). Rwanda is committed to ensuring its future stability and prosperity through mainstreaming climate change into all sectors of the economy and achieve climate resilience and low-carbon development.¹³ Through its NDC, Rwanda's adaptation efforts prioritize adaptation interventions, establish baselines, and develops sector-level performance indicators and targets. Priority adaptation interventions have been identified as the sustainable intensification of agriculture; agricultural diversity in local and export market; sustainable forestry, agroforestry and biomass energy; ecotourism conservation and payment of ecosystem services promotion in protected areas, integrated water resources management and planning; integrated approach to sustainable land use planning and management, disaster management; and climate data and projections.¹⁴ While climate change is being mainstreamed, adaptation efforts focus on the Water, Agriculture, Land and Forestry, Human Settlement, Health, Transport, and Mining sectors. Rwanda's NDC adaptation indicators will be embedded in its Environment and Natural Resources Management Results Based Monitoring and Evaluation framework (RBME) used to track and inform progress on NDC implementation towards the NST. This reporting framework is conducted biennially through Joint Sector Reviews. In addition, reporting on NDC adaptation indicators will be carried out in the context of a High-Level Policy Dialogue that tracks progress on the implementation of the GGCRS that circumscribes the broader context of NDC implementation.¹⁵

¹³ Republic of Rwanda (2011). *Green Growth and Climate Resilience – National Strategy for Climate Change and Low Carbon Development*. Kigali, October, 2011. URL: <https://cdkn.org/wp-content/uploads/2010/12/Rwanda-Green-Growth-Strategy-FINAL1.pdf>

¹⁴ World Bank (2020). *Revising Nationally Determined Contribution (NDC) mitigation and adaptation priorities for Rwanda*. NDC Support Facility. URL: <https://openknowledge.worldbank.org/handle/10986/35412>

¹⁵ Republic of Rwanda (2020). *Updated Nationally Determined Contribution*. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

Green, Inclusive and Resilient Recovery

The coronavirus disease (COVID-19) pandemic has led to unprecedented adverse social and economic impacts. Further, the pandemic has demonstrated the compounding impacts of adding yet another shock on top of the multiple challenges that vulnerable populations already face in day-to-day life, with the potential to create devastating health, social, economic and environmental crises that can leave a deep, long-lasting mark. However, as governments take urgent action and lay the foundations for their financial, economic, and social recovery, they have a unique opportunity to create economies that are more sustainable, inclusive and resilient. Short and long-term recovery efforts should prioritize investments that boost jobs and economic activity; have positive impacts on human, social and natural capital; protect biodiversity and ecosystems services; boost resilience; and advance the decarbonization of economies.

CLIMATOLOGY

Climate Baseline

Overview

Rwanda has a tropical climate characterized by its hilly landscape stretching from east to west. The country has four primary climatic regions: eastern plains, central plateau, highlands, and regions around Lake Kivu. The eastern plains receive an annual rainfall of between 700 mm and 1,100 mm, with mean annual temperature oscillating between 20°C and 22°C. The central plateau region enjoys rainfall of between 1,100 mm and 1,300 mm, with an annual mean temperature of between 18°C and 20°C. The highlands, including the Congo-Nile Ridge and volcanic chains of Birunga, benefit from an annual rainfall of between 1,300 mm and 1,600 mm and experience annual mean temperatures between 10°C and 18°C. Regions around Lake Kivu and Bugarama plains get annual rainfall of between 1,200 mm and 1,500 mm with annual mean temperatures between 18°C and 22°C.

Overall, the country's four climactic seasons are represented through the long rainy season: March to May, and short rainy season: September to November. These seasons alternate with the long dry season: June to August, and short dry season: December to February.¹⁶ Increased seasonal variability and longer-term climate change are likely to exacerbate the country's existing vulnerabilities from high poverty, food insecurity, as well as potential for internal displacement and conflict along its eastern and southern borders. Food security and progress of the agricultural sector is of primary concern as the majority of the country's agriculture is rain-fed and produced by small-holder farmers.¹⁷

¹⁶ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

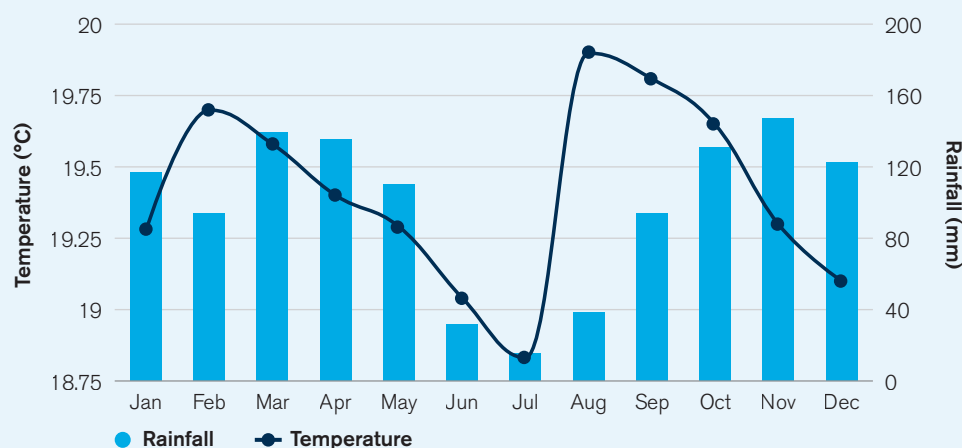
¹⁷ Nahayo, L. et al. (2019). Climate Change Vulnerability in Rwanda, East Africa. International Journal of Geography and Geology. 8(1). pp. 1-9. URL: <http://www.conscientiabeam.com/journal/10/abstract/5482>

Analysis of data from the World Bank Group’s [Climate Change Knowledge Portal](#) (CCKP) (**Table 2**) shows historical information for the latest climatology, 1991–2020. Mean annual temperature for Rwanda is 19.1°C, with average monthly temperatures ranging between 19.8°C (September) and 18.8°C (July). Mean annual precipitation is 1,177.6 mm. Rainfall is experienced throughout the year in Rwanda, with most significant rainfall occurring from September to May (**Figure 3**).¹⁸ **Figure 4** shows the geospatial variation of the observed average annual precipitation and temperature across Rwanda.

TABLE 2. Data Snapshot: Summary Statistics

Climate Variables	1991–2020
Mean Annual Temperature (°C)	19.4°C
Mean Annual Precipitation (mm)	1,177.7 mm
Mean Maximum Annual Temperature (°C)	25.5°C
Mean Minimum Annual Temperature (°C)	13.3°C

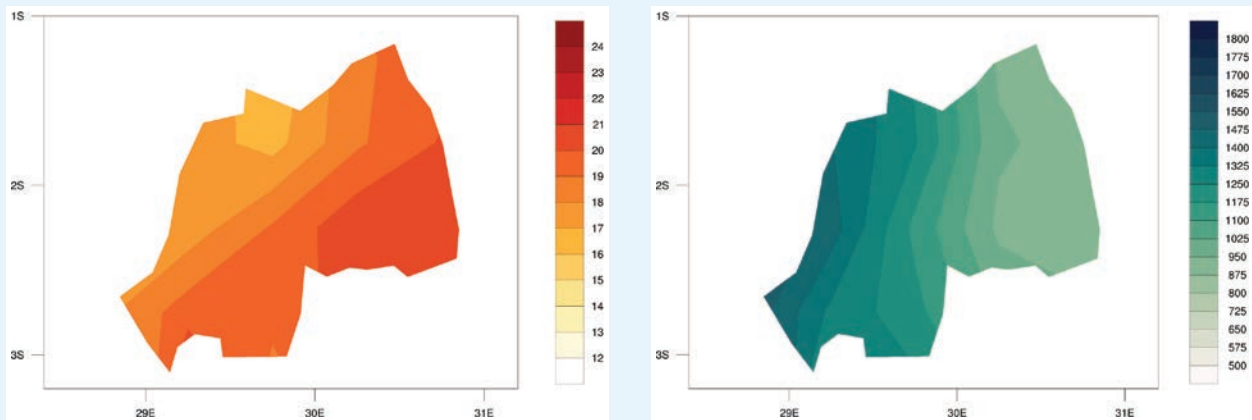
FIGURE 3. Average Monthly Temperature and Rainfall for Rwanda, 1991–2020¹⁹



¹⁸ WBG Climate Change Knowledge Portal (CCKP, 2021). Rwanda. URL: <https://climateknowledgeportal.worldbank.org/country/rwanda/climate-data-historical>

¹⁹ WBG Climate Change Knowledge Portal (CCKP, 2021). Rwanda. URL: <https://climateknowledgeportal.worldbank.org/country/rwanda/climate-data-historical>

FIGURE 4. Map of Average Annual Temperature(°C) (left); Annual Precipitation (mm) (right) of Rwanda,1991–2020²⁰

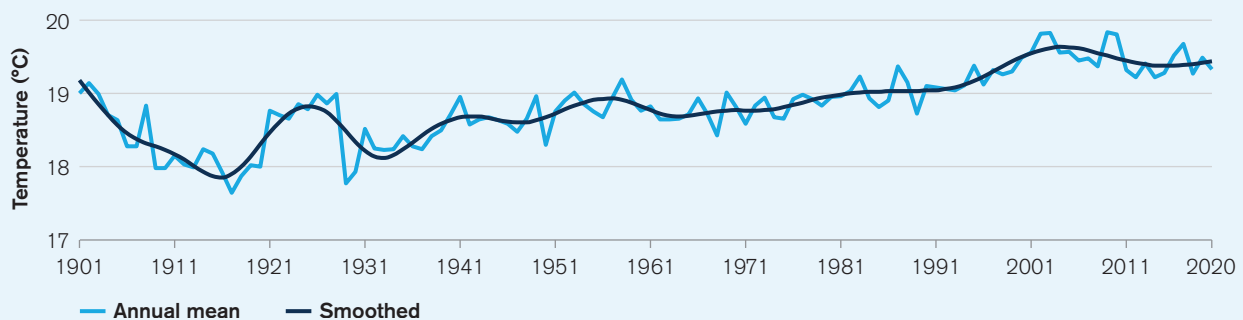


Key Trends

Temperature

In Rwanda, the high degree of interannual and interdecadal climate variability and lack of historical records has made climate trends in the country difficult to determine.²¹ Rwanda’s average annual temperature ranges between 15°C to 17°C in high altitude areas and up to 30°C in lowlands in the east and southwest (**Figure 5**).²² Regional temperatures for central-east Africa saw average increases of 0.29°C per decade from 1985 to 2015. Temperature increases have been experienced, 1971 to 2016 showing increase in mean temperature of between 1.4°C and 2.6°C in the south-west and eastern regions of Rwanda.²³ Additionally increased interannual variability in recent decades was also observed, for example average increased temperature from 2012 to 2014 increased by 0.79°C.²⁴

FIGURE 5. Observed Average Annual Temperature for Rwanda, 1901–2020



²⁰ WBG Climate Change Knowledge Portal (CCKP, 2021). Rwanda, Historical Climate. URL: <https://climateknowledgeportal.worldbank.org/country/rwanda/climate-data-historical>

²¹ GERICS (2015). Climate-Fact-Sheet, Burundi – Malawi – Rwanda – Tanzania.

²² Netherlands Commission for Environmental Sustainability (2015). Climate Change Profile – Rwanda. URL: https://ees.kuleuven.be/klimos/toolkit/documents/687_CC_rwanda.pdf

²³ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

²⁴ USAID (2019). Climate Change Risk Profile – Rwanda. URL: https://www.climatelinks.org/sites/default/files/asset/document/2019_USAID-ATLAS-Rwanda-Climate-Risk-Profile.pdf

Precipitation

In Rwanda, rainfall trends have shown an increasing occurrence of extremes since the 1960's across various regions of the country with the El Niño Southern Oscillation influences precipitation trends during El Niño years. The annual rainfalls in Rwanda exhibited high fluctuations since 1961 to 2016. Over this period, mean rainfall significantly decreased in January, February, May and June, but with a significant increase September to December across the country. Over this period, Rwanda's eastern region has experienced frequent dry episodes.²⁵ In the country's northern and western provinces, rainy seasons are becoming shorter and more intense, which has resulted in increased erosion risk in these mountainous areas of the country. Additionally, eastern regions have experienced serious rainfall deficits in a number of years, which has alternated with rainfall excesses.²⁶

Climate Future

Overview

The main data source for the World Bank Group's Climate Change Knowledge Portal (CCKP) is the CMIP5 (Coupled Model Inter-comparison Project, Phase 5) data ensemble, which builds the database for the global climate change projections presented in the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). Four Representative Concentration Pathways (i.e. RCP2.6, RCP4.5, RCP6.0, and RCP8.5) were selected and defined by their total radiative forcing (cumulative measure of GHG emissions from all sources) pathway and level by 2100. The RCP2.6 for example represents a very strong mitigation scenario, whereas the RCP8.5 assumes business-as-usual scenario. For more information, please refer to the [RCP Database](#). For simplification, these scenarios are referred to as a low (RCP2.6); a medium (RCP4.5) and a high (RCP8.5) emission scenario in this profile. **Table 3** provides CMIP5 projections for essential climate variables under high emission scenario (RCP8.5) over 4 different time horizons. **Figure 6** presents the multi-model (CMIP5) ensemble of 32 Global Circulation Models (GCMs) showing the projected changes in annual precipitation and temperature for the periods 2040–2059 and 2080–2099.

TABLE 3. Data Snapshot: CMIP5 Ensemble Projections

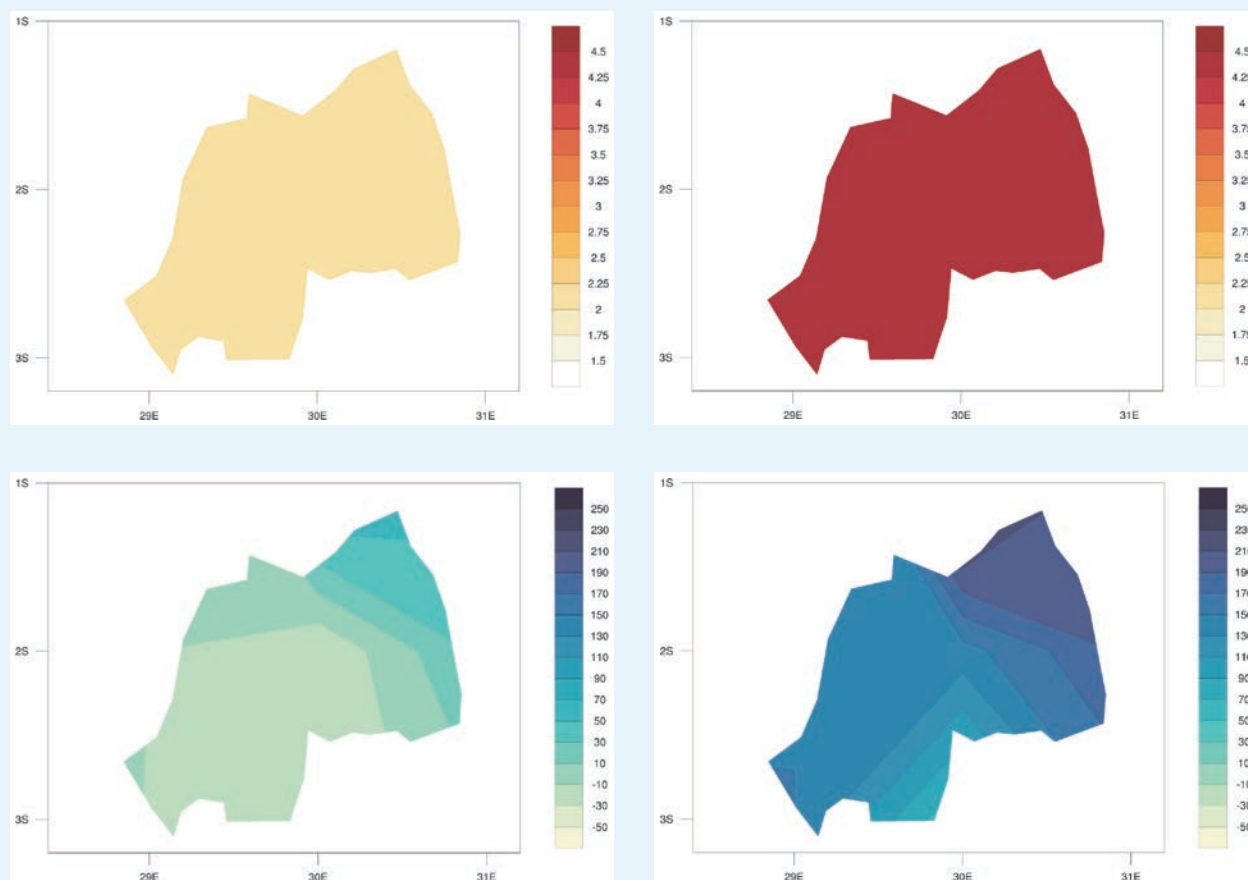
CMIP5 Ensemble Projection	2020–2039	2040–2059	2060–2079	2080–2099
Annual Mean Temperature Anomaly (°C)	+0.7 to +1.5 (+1.1°C)	+1.4 to +2.6 (+1.9°C)	+2.3 to +4.0 (+2.9°C)	+3.1 to +5.3 (+3.9°C)
Annual Precipitation Anomaly (mm)	-18.4 to +29.3 (3.3 mm)	-23.3 to +39.3 (5.1 mm)	-26.4 to +63.6 (9.5 mm)	-24.5 to +91.5 (18.2 mm)

Note: The table shows CMIP5 ensemble projection under RCP8.5. Bold value is the range (10th–90th Percentile) and values in parentheses show the median (or 50th Percentile).

²⁵ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

²⁶ Netherlands Commission for Environmental Sustainability (2015). Climate Change Profile – Rwanda. URL: https://ees.kuleuven.be/klimos/toolkit/documents/687_CC_rwanda.pdf

FIGURE 6. CMIP5 Ensemble Projected Change (32 GCMs) in Annual Temperature (top) and Precipitation (bottom) by 2040–2059 (left) and by 2080–2099 (right), Relative to 1986–2005 Baseline Under RCP8.5²⁷



Key Trends

Temperature

According to analysis from the German Climate Service Center (GERICS) of 32 Global Climate Models (GCMs), temperatures across Rwanda are expected to increase and projections show a change in annual mean temperature from 1.1°C to 3.9°C by end of the century. There is also the strong likelihood of increased duration of heat-waves by as much as 85 days through the end of the century; cold spells are also expected to reduce.²⁸ Increased temperatures are expected across all seasons.²⁹

²⁷ WBG Climate Change Knowledge Portal (CCKP, 2021). Rwanda Projected Future Climate. URL: <https://climateknowledgeportal.worldbank.org/country/rwanda/climate-data-projections>

²⁸ GERICS (2015). Climate-Fact-Sheet, Burundi – Malawi – Rwanda – Tanzania.

²⁹ Netherlands Commission for Environmental Sustainability (2015). Climate Change Profile – Rwanda. URL: https://ees.kuleuven.be/klimos/toolkit/documents/687_CC_rwanda.pdf

Across all emission scenarios, temperature increase for Rwanda are projected throughout the end of the century. As seen in the graph below, under a high-emission scenario, average temperatures are expected to increase rapidly by mid-century (**Figure 7**). An increase is also expected for the change in the number of summer days ($T_{max} > 25^{\circ}\text{C}$), and the change in number of days across the seasonal cycle is also seen in the graphs below. As shown below, the most significant increase in the number of days over 25°C are expected to occur from October to May, a time coinciding with rainfall and planting seasons for much of the country (**Figure 8**). Increased heat and extreme heat conditions will result in significant implications for human and animal health, agriculture, and ecosystems.

FIGURE 7. Projected Annual Mean Temperature for Rwanda (Reference Period, 1986–2005)³⁰

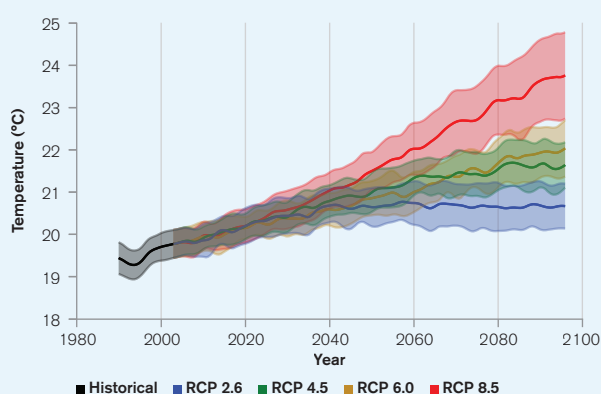
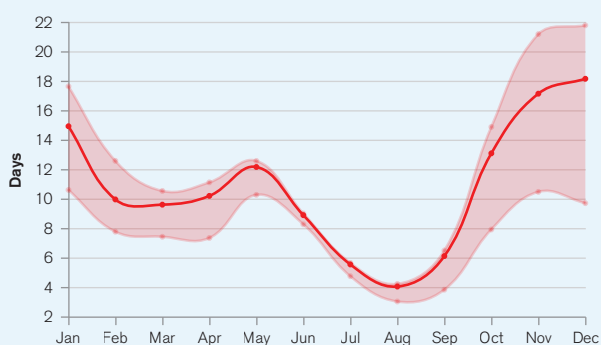


FIGURE 8. Projected Change in Summer Days ($T_{max} > 25^{\circ}\text{C}$) (RCP8.5, Reference Period, 1986–2005)³¹



Precipitation

Rainfall for the country is highly variable and GERICS analysis indicates a likely increase in annual rainfall, with the increase likely to occur during the main rainy season, December to April, with drier tendencies from July to September. The intensity of heavy rainfall is expected to increase from +3% to +17% and the frequency expected to increase from +9% to +60% by end of the century. An increase in the country's overall water balance is also expected. During periods of increased aridity, long-lasting dry spells are expected to increase by 0 to +8 days by end of the century.³² Frequent rainfall deficits are expected in parts of the eastern province (Bugesera, Nyagatare, Gatsibo, Kayonza, Ngoma, Kirehe) and the southern province (Nyanza, Gisagara), while increased rainfall is expected in parts of the western, northern and southern provinces.³³ This is expected to significantly impact agriculture, water, energy, forestry, and health sectors, as well as agricultural land and freshwater resources and ecosystems.³⁴

³⁰ WBG Climate Change Knowledge Portal (CCKP, 2021). Rwanda Agriculture Dashboard. URL: <https://climatedata.worldbank.org/CRMePortal/web/agriculture/crops-and-land-management?country=RWA&period=2080-2099>

³¹ WBG Climate Change Knowledge Portal (CCKP, 2021). Rwanda Climate Data – Projections. URL: <https://climatedata.worldbank.org/CRMePortal/web/agriculture/crops-and-land-management?country=RWA&period=2080-2099>

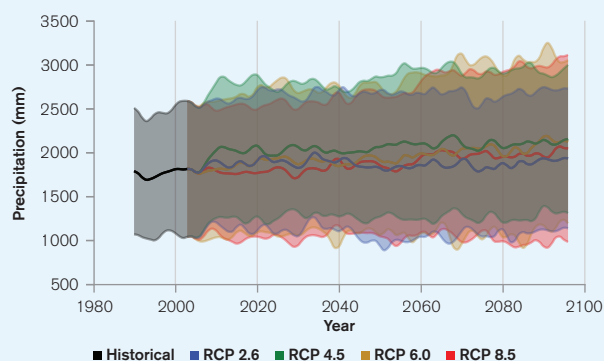
³² GERICS (2015). Climate-Fact-Sheet, Burundi – Malawi – Rwanda – Tanzania.

³³ Netherlands Commission for Environmental Sustainability (2015). Climate Change Profile – Rwanda. URL: https://ees.kuleuven.be/klimos/toolkit/documents/687_CC_rwanda.pdf

³⁴ Netherlands Commission for Environmental Sustainability (2015). Climate Change Profile – Rwanda. URL: https://ees.kuleuven.be/klimos/toolkit/documents/687_CC_rwanda.pdf

Heavy precipitation events are expected to coincide with an additional occurrence of extreme rainfall and extreme events with flooding events expected to impact rivers and surface water runoff during the summer rainy seasons. Natural disasters due to the increase in the frequency and intensity of floods and droughts are also expected to increase. **Figure 9** shows the projected trends for nationally aggregated annual precipitation for the different emission scenarios through the end of the century. Projections indicate a slight increase across each emission scenario. Water routing and storage and other management options, are often very different if the precipitation input comes as many weak or a series of heavy rainfall events.

FIGURE 9. Projected Annual Average Precipitation for Rwanda (Reference Period, 1986–2005)³⁵



CLIMATE RELATED NATURAL HAZARDS

Overview

Rwanda is at risk to numerous natural hazards and include droughts, floods, earthquakes, landslides, storms (windstorms, lightning, rainstorms and thunderstorms), wildfire, diseases, and epidemics. These events have had significant impacts on the lives and livelihoods of Rwandans. Since the early 2000s, the frequency and severity of disasters, particularly caused by floods, landslides and droughts, have significantly increased, with increasing impact of human casualties as well as economic and environmental losses.³⁶ In Rwanda, the effects of flood hazards have worsened as recent population growth and land scarcity have pushed people to settle in flood-prone areas. Heavy rainfall events and at times flash flooding, have become increasingly common. Heavy rainfall events are especially common in northern and western provinces, and cause flooding, flash flood events and can trigger landslides and mudslides, leading to infrastructure damage and death.³⁷ Additionally, nearly 70% of Rwanda's population is exposed to magnitude 6.0 earthquakes; 30% is exposed to magnitude 5.0 earthquakes. In 2008, two earthquakes occurred within hours of one another (magnitudes 6.1 and 5.0), killing nearly 40 people and destroying 1,201 homes in the hardest hit districts of Rusizi and Nyamasheke.³⁸

³⁵ WBG Climate Change Knowledge Portal (CCKP, 2021). Rwanda Water Dashboard. URL: <https://climateknowledgeportal.worldbank.org/country/rwanda/climate-sector-water>

³⁶ Ministry of Disaster Management and Refugee Affairs (2016). National Contingency Matrix Plan. URL: http://minema.gov.rw/uploads/tx_download/NATIONAL_DISASTER_CONTINGENCY_MATRIX_.pdf

³⁷ Flood List (2021). Rwanda. URL: <http://floodlist.com/tag/rwanda>

³⁸ GFDRR (2019). Rwanda. URL: <https://www.gfdr.org/en/rwanda>

Drought hazard are particularly of concern to the districts of Kayonza, Gatsibo, Kirehe, Nyagatare, Rwamagana, Ngoma and Bugesera in the eastern province. The highlands of the Congo-Nile Ridge in the Western, Southern and Northern provinces are prone to landslide due to their moderate to very high slope susceptibility and heavy rainfall in the area. While flooding is expected to occur across much of the country, areas which are particularly vulnerable to flooding are Nyabarongo, Sebeya, Nyabisindu, Mukungwa, and Kagitumba. Given the country's many hills, plateaus, and sloping areas Rwanda is also highly exposed to landslides. Approximately 40% of the population is exposed to landslides due to residing in highly vulnerable areas in the highlands of the western, southern and northern provinces.³⁹

Increased food insecurity is also of specific concern following disasters which result in land and infrastructure degradation due to erosion, direct crop failure due to floods and heavy rains, and possible nutrient leaching, and fungal growth due to increased humidity. Water availability will be affected by possible periods of drought in southern zones. This is expected to have significant consequences for the hardest hit regions due to poor crop and livestock performance.

Data from the Emergency Event Database: EM-Dat,⁴⁰ presented in **Table 4**, shows the country has endured various natural hazards, including droughts, floods, landslides, epidemics, and storms.

TABLE 4. Natural Disasters in Rwanda, 1900–2020

Natural Hazard 1900–2020	Subtype	Events Count	Total Deaths	Total Affected	Total Damage ('000 USD)
Drought	Drought	6	237	415,6545	00
Epidemic	Bacterial Disease	11	317	7,259	0
Earthquake	Ground Movement	2	81	2,286	0
Flood	Flash Flood	4	34	26,051	0
	Riverine Flood	10	170	85,739	9
Storm	Convective Storm	2	3	6,553	0
Landslide	Landslide	5	117	11,949	28,000

Key Trends

Climate change trends in Rwanda are expected to increase the risk and intensity of flooding through increased frequency and intensity of heavy rainfall events. Additionally, the country's eastern and central areas are expected to experience increased aridity and drought, with significant impact on livelihoods. Droughts have already resulted in famine, population displacement, conflicts, and biodiversity loss. Seasonal droughts are expected to be prolonged, which will cause problems especially in the east and southeast of the country (Bugesera, Mayaga, and Umutara). The country has experienced major floods over consecutive years (2006–2009), which has resulted in serious health problems, displacement, large scale erosion, and damage to infrastructure. Changes in rainfall with increased temperature and increases in floods and droughts will impact food security and water availability. Increased incidence

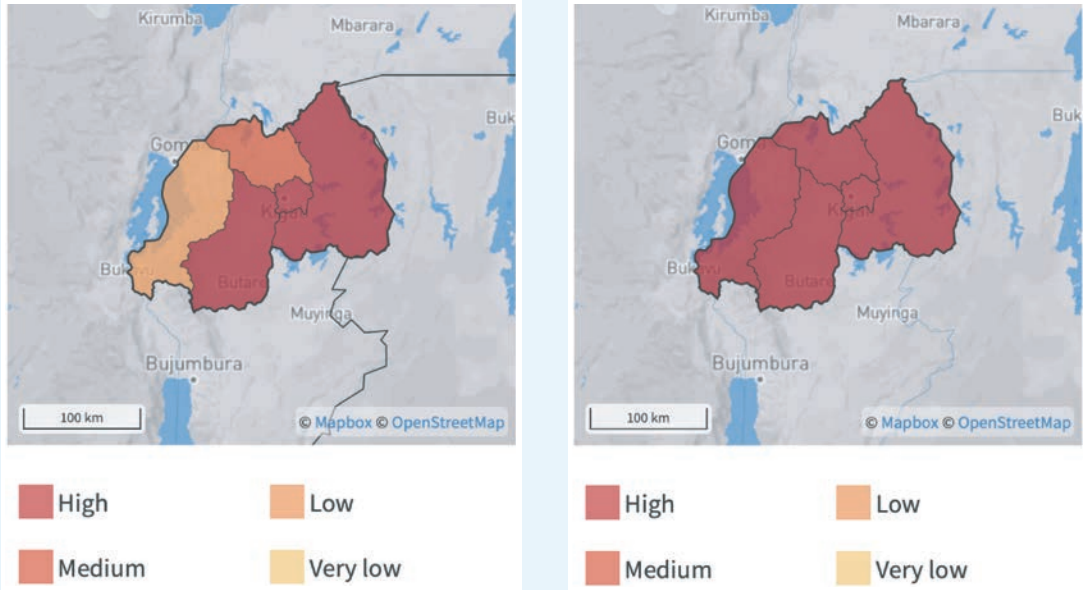
³⁹ Ministry of Disaster Management and Refugee Affairs (2015). National Risk Atlas of Rwanda. URL: https://www.gfdr.org/sites/default/files/publication/National_Risk_Atlas_of_Rwanda_electronic_version_0.pdf

⁴⁰ EM-DAT: The Emergency Events Database – Université catholique de Louvain (UCL) – CRED, D. Guha-Sapir, Brussels, Belgium. URL: http://emdat.be/emdat_db/

of extreme rainfall may also result in soil erosion and water logging of crops, thus decreasing yields and increasing food insecurity. Given projected climate change trends, Rwanda and the surrounding region is expected to be a hotspot of food insecurity in the future, which limits opportunities for import. This may result in significant economic losses, damage to agricultural lands and infrastructure as well as human casualties. Land degradation and soil erosion, exacerbated by recurrent flood adversely impacts agricultural production, disproportionately affecting the livelihoods of the rural poor. Food security will be influenced because of the vulnerability of some crops to increasing temperatures and/or water stress. In Rwanda, the most food insecure regions of the country are the west and central south.⁴¹

Climate change, deforestation, watershed degradation, land use, urbanization and widespread settlements into flood and landslide-prone areas have already exacerbated issues and impacts from flooding and droughts and have also increased the risk of wildfires. Heavy rainfall can also trigger riverine and flash floods. Heavy rainfall and flash floods are common in the country's hill areas and can also trigger landslides and mudslides. Additionally, water stress during the traditional dry periods (June to August) may be further exacerbated with competing demands from household consumption and agriculture. Infrastructure projects are being developed to enable the construction of dams and irrigation networks. Increased heat will further strain existing water resources and impacts from changing rainfall patterns.⁴² **Figure 10** shows different risks from river flooding, water scarcity, extreme heat, and wildfires.

FIGURE 10. Risk of River Flood (left)⁴³; Risk of Wildfire (right)⁴⁴



⁴¹ Netherlands Commission for Environmental Sustainability (2015): Climate Change Profile – Rwanda. URL: https://ees.kuleuven.be/klimos/toolkit/documents/687_CC_rwanda.pdf
⁴² Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf
⁴³ ThinkHazard! (2021). Rwanda River Flood. URL: <http://thinkhazard.org/en/report/205-rwanda/FL>
⁴⁴ ThinkHazard! (2021). Rwanda Wildfire. URL: <http://thinkhazard.org/en/report/205-rwanda/WF>

Implications for DRM

The government has scaled up efforts to integrate disaster risk management (DRM) into its national policies and long-term development plans. In 2010, the Ministry of Disaster Management and Refugee Affairs was established to manage both natural and man-made disasters. The country formulated a National Disaster Management Policy (2012), which is guided by the country's National Disaster Contingency Matrix (2016). These strategies serve as the country's legal and institutional framework for DRM and ensures that activities are coordinated and partnerships are fostered between the government and stakeholders. Climate change has been integrated as a critical pillar within the country's disaster management agenda. The 2011 National Strategy for Climate Change and Low Carbon Development provides a mechanism to mobilize funding to finance climate change resilience programs.⁴⁵ Currently, efforts are focused on strengthening institutional capacity and coordinating DRM mechanisms across sectors and enhancing disaster preparedness and ensuring alignment with local and national disaster management plans. Public warning and disaster-related information systems are also being developed and promoted.⁴⁶ Rwanda is committed to improving its disaster management and will conduct risk assessments and vulnerability mapping to improve planning and related adaptation efforts; risk assessments will be conducted and completed countrywide by 2030. The country is also establishing an integrated early-warning system and disaster response plan to reduce impacts from natural disasters, especially those occurring near populated areas. This will improve preparedness and mobilizations capacities and help agencies and affected areas to more effectively target disaster areas.⁴⁷

CLIMATE CHANGE IMPACTS TO KEY SECTORS

Rwanda is highly vulnerable to seasonal variability and long-term climate change. Increasing vulnerability is expected to result in cumulative impacts across the country's social, economic, and environmental structures. Heavy rainfall and floods in particular are likely to have significant consequences on the environment, society, food security situation, and wider economy. Significant impacts are also expected for the country's water resources, agriculture, and health sectors. Increased temperatures, flooding, increased aridity, and soil erosion puts both urban and rural communities at risk, particularly for poor and vulnerable groups. Environmental degradation, impacted water resources, and loss of biodiversity and ecosystem services constitute serious obstacles to the country's continued development and responsible management of its natural resources, which is also likely to impact the country's tourism sector. Projected trends of climate variability and longer-term change are likely to exacerbate these concerns, as the majority of agricultural and livestock production is rainfed, and provides livelihoods for the majority of the population. Increased temperatures and variable rainfall will also impact the country's forests, also critical to livelihoods and ecosystem services, which are already under threat from land use change and growing demand for charcoal and tropical forest products. More extreme weather events such as intense rainfall after prolonged dry spells can lead to erosion and flash flooding, damaging roads and infrastructure, wiping out crops and put additional lives at risk.⁴⁸

⁴⁵ GFDRR (2019): Rwanda. URL: <https://www.gfdr.org/en/rwanda>

⁴⁶ Ministry of Disaster Management and Refugee Affairs (2016): National Contingency Matrix Plan. URL: http://minema.gov.rw/uploads/tx_download/NATIONAL_DISASTER_CONTINGENCY_MATRIX_.pdf

⁴⁷ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

⁴⁸ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

Gender

An increasing body of research has shown that climate-related disasters have impacted human populations in many areas including agricultural production, food security, water management and public health. The level of impacts and coping strategies of populations depends heavily on their socio-economic status, socio-cultural norms, access to resources, poverty as well as gender. Research has also provided more evidence that the effects are not gender neutral, as women and children are among the highest risk groups. Key factors that account for the differences between women's and men's vulnerability to climate change risks include: gender-based differences in time use; access to assets and credit, treatment by formal institutions, which can constrain women's opportunities, limited access to policy discussions and decision making, and a lack of sex-disaggregated data for policy change.⁴⁹

Agriculture

Overview

The agricultural sector is critical to Rwanda's economy and food security. Nearly all agricultural activities in the country are rain-fed and its strong dependency on natural resources further increases vulnerability to climate change. The agriculture sector employs over 70% of the working population and is generally characterized by low-productivity, with nearly 90% of households practicing traditional subsistence agriculture methods.⁵⁰ Approximately 51% of Rwanda's land area is agricultural, and approximately 73% of which is used to grow crops (food crops, cash crops, and forages). The remaining 27% is kept fallow or used for pastures and afforestation. The Eastern Province has the most agricultural land (439,000 ha) and the Northern Province has the least (212,000 ha). Subsistence farming dominates Rwandan agriculture and farm size is extremely small and farms are fragmented; the average area per agricultural household is 0.76 ha and 80% of agricultural land holdings are less than 1 ha. Due to Rwanda's hilly topography, 70% of the land is either on hillsides or on the top of hills. Only 30% of farms in Rwanda are located on flatland or at the bottom of hills. This contributes to a series of challenges and risks as the hilly land is subject to drought, soil erosion, and landslides, and marshland is subject to floods during heavy rains. Additionally, the country's hilly topography also makes it very difficult to use modern farm equipment or irrigation. This not only reduces agricultural productivity but also adds to agricultural risks in the event of adverse weather conditions.⁵¹ Rwanda also has one of the highest rates of population density in the world: 416⁵² persons per square kilometer, which further increases demand for food security and increase pressure on the country's agriculture sector and natural resource base.⁵³

Under Rwanda's Vision 2050, the sector is aiming to increase the number of professional farmers and commercialized value chains. It is expected that less than 30% of the population will be working as farmers, a decrease from the current 70% employment. The sector aims to be market-driven, linked to urbanization and trade. With a goal of being nearly 15 times more productive than it is today. To achieve this, the agriculture value added per worker will need to

⁴⁹ World Bank Group (2016). Gender Equality, Poverty Reduction, and Inclusive Growth. URL: <http://documents1.worldbank.org/curated/en/820851467992505410/pdf/102114-REVISED-PUBLIC-WBG-Gender-Strategy.pdf>

⁵⁰ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

⁵¹ World Bank (2015). Rwanda – Agricultural Sector Risk Assessment. URL: <http://documents.worldbank.org/curated/en/525111468180254519/pdf/96290-WP-P148140-Box393232B-PUBLIC-TAP-Rwanda-ASRA-WEB-10062015.pdf>

⁵² World Bank (2015). Determinants of participation and transaction costs in Rwanda's land markets. URL: <http://documents.worldbank.org/curated/en/802811468000931425/pdf/99426-BRI-PUBLIC-Box391490B-ADD-SERIES-TITLE-See-73154.pdf>

⁵³ Netherlands Commission for Environmental Sustainability (2015). Climate Change Profile – Rwanda. URL: https://ees.kuleuven.be/klimos/toolkit/documents/687_CC_rwanda.pdf

increase to more than eight-fold by 2035 and more than triple by 2050. This transformation will also be reflected in Rwanda's landscape by 2050, with farmers taking up less area in countryside while producing more using modern farming and land efficient techniques, such as urban farming and greenhouses. As specified under Vision 2050, the agricultural sector is aiming to meet all domestic dietary needs of the population by 2050 and traditional cultural exports, such as coffee and tea, are projected to double in volume and quadruple in value.⁵⁴ However, this sector transformation will require significant increase in available of electricity and water, in which climate change poses an increasing threat.

Climate Change Impacts

Projected climate variability and change trends for Rwanda such as rising temperatures, an increase in frequency and intensity of heavy rain events and increased duration of dry spells threaten Rwandan agriculture. The sector is already challenged by seasonal changes and increasingly variable rainfall, limited infrastructure, substantial post-harvest losses, and lack of access to inputs and finance. Rising temperatures threaten to compromise the quality and productivity of highly lucrative, temperature-sensitive crops such as tea and coffee (which account for more than 20% of export earnings) as agro-ecological zones shift to higher elevations with less arable land.⁵⁵ Warming temperatures are also likely to expand the range of crop pests, such as the coffee berry borer beetle, and livestock diseases, such as Rift Valley fever. Projections of longer dry spells are particularly concerning in the east and south, where approximately 44,000 households suffered crop and livestock losses in the 2016 drought. Furthermore, 90% of crops are grown on hills and steep slopes and heavy rainfall events may lead to landslides and further exacerbate soil erosion and degrade cultivated lands.⁵⁶

Climate change trends in the country are anticipated to impact crop production. Bean production (22–30% of cultivated land) is expected to significantly decrease because they require cooler temperatures (14–18°C) and low soil moisture will further decrease yields. Sorghum is expected to become suitable for some areas in the northwest which are currently too cold. Potato yields are expected to increase (25–90% by mid-century), which will help the country meet domestic demands. Changes in precipitation is also expected to negatively impact rice production.⁵⁷ In contrast, temperature increases are likely to expand production potential through mid-century for maize, Irish potato, cassava, and sorghum. Bean yields are projected to decrease under warming temperatures, especially in the lower elevations of the east and far southwest. Coffee and tea are the most important cash crops of the country. Coffee especially is very sensitive to climatic factors as temperatures above 25°C as well as atypical rainfall patterns have adverse effects on production quantity and quality. Higher temperatures will force coffee producers to cultivate higher lands that are more prone to erosion, simultaneously leading to possible conflicts with residing small-scale farmers. Increased temperatures are expected to lead to an overall decrease in coffee and tea

⁵⁴ Ministry of Finance and Economic Planning (2015). Vision 2050. Republic of Rwanda. URL: https://www.nirda.gov.rw/uploads/tx_dce/Vision_English_Version_2050_-31_Dec_2020.pdf

⁵⁵ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

⁵⁶ USAID (2019). Climate Change Risk Profile – Rwanda. URL: https://www.climatelinks.org/sites/default/files/asset/document/2019_USAID-ATLAS-Rwanda-Climate-Risk-Profile.pdf

⁵⁷ World Bank (2015). Rwanda – Agricultural Sector Risk Assessment. URL: <http://documents.worldbank.org/curated/en/525111468180254519/pdf/96290-WP-P148140-Box393232B-PUBLIC-TAP-Rwanda-ASRA-WEB-10062015.pdf>

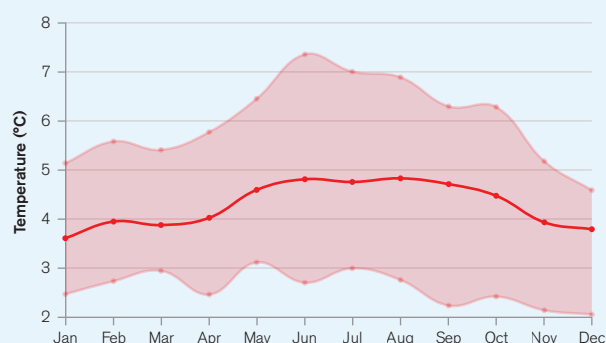
production and a significant reduction of cereal crops. Rwanda's persistent lack of economic diversification' beyond these key crops makes it more vulnerable to climate change.⁵⁸

As temperatures rise, local trends in daily maximum temperatures may offer insights on these upper thresholds for specific crops, translating these potentially into changing yields (**Figure 11**).

Adaptation Options

Both the sensitivity of the agricultural sector to the climate and the high reliance of this sector on rainfall and water resources have important implications for Rwanda's farmers and wider economy. Rwanda is implementing multiple adaptation and mitigation strategies and actions to strengthen the sector's resilience. The country is in the process of mainstreaming agro-ecology technologies in its current agriculture intensification program and natural resource-based livelihood programs. Scaled agriculture production will include the implementation of agro forestry sustainable food production by 2030. Rwanda is promoting both the recovery and reuse of both organic waste and wastewater in order to restore and maintain soil fertility. Rwanda can expand its soil conservation and land husbandry programs through the installation of land protection structures such as radical and/or progressive terraces. Increased investment in irrigated agriculture will increase production, harness fresh water resources and ensure food security to the population. District irrigation master plans will be designed and small-scale schemes will be developed where possible based on water catchments, and farmer organizations trained in their development.⁶⁰ Adaptation goals also include the mainstreaming of agro-ecology techniques in farms to improve productivity, soil health and water conservation. The reuse of organic waste composting and wastewater irrigation is also being promoted given the soil's fertility decline and high population density. The country is currently promoting the use of organic fertilizer and enriched compost to maximize productivity and curb the country's use of inorganic fertilizers, which have adverse environmental consequences. In order to more sustainably manage water resource and protect steep production zones, districts are currently developing irrigation plans for small-scale agricultural use where possible, based on available water catchments. Finally, the country is working to diversity its local and export markets to meet growing demand and maximize its agricultural trade.⁶¹

FIGURE 11. Projected Change in Average Max Temperature for Rwanda (RCP8.5, Reference Period 1986–2005)⁵⁹



⁵⁸ World Bank (2015). Climate-Smart Agriculture in Rwanda. URL: <https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA%20RWANDA%20NOV%2018%202015.pdf>

⁵⁹ WBG Climate Change Knowledge Portal (CCKP, 2021). Rwanda Agriculture Dashboard. URL: <https://climateknowledgeportal.worldbank.org/country/rwanda/climate-sector-agriculture>

⁶⁰ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

⁶¹ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

Water

Overview

Rwanda's hydrological system is split into two basins which are divided by the Congo-Nile ridge, with water systems to the west of the ridge flowing into the Congo basin and the east flowing into the Nile basin. The country's hydrologic network covers 8% of the national area, equivalent to about 21 43 km²; the country has 101 lakes. The Congo basin drains approximately one-third of the national territory equating to approximately 10% of the country's water. Rwanda has abundant lakes, rivers, and wetlands, and groundwater is an important water source in rural areas. The wetlands of Rwanda are composed of marshlands, lakes, rivers and streams and represent nearly 15% of the national territory of which 6.3% are marshlands and 8.6% are lakes or streams that are either permanent or seasonal. Total wetlands cover 276,477 ha with 20% of the total wetlands are currently fully protected. These are dominated by papyruses especially in Kamiranzovu, Gishoma, Rugezi marshlands and around lakes such as Muhazi, Burera and Ruhondo.⁶² Rwanda is endowed with substantial freshwater resources.⁶³ So far, regular rainfall patterns and minimal consumption has, thus far, largely not necessitated water storage, water monitoring or irrigation infrastructure. However, the challenges of rapid population growth, increased urbanization and industry expansion, environmental degradation and pollution are leading to accelerated depletion and degradation of available water resources.⁶⁴ In addition, under the Vision 2050, access to water is expected to be scaled up from 87% to 100% of the population by 2024 with the increasing additional need of water to support the agriculture sector transformation.⁶⁵

Climate Change Impacts

So far, Rwanda has not experienced serious water scarcity problems due to its relatively high precipitation rates, however, this is despite the lowering level of lakes and waterways. Rapid population growth, urbanization, environmental degradation and pollution, with projected changes in precipitation patterns, raise new challenges for the country. More attention to water management and options for water storage, irrigation infrastructure and water monitoring is needed to cope with future water demands in all regions of the country.⁶⁶

While Rwanda is endowed with relatively abundant water resources, the country is facing increased pressure from its changing climate. Warming temperatures and longer dry spells are likely to diminish surface flows, leading to water shortages (particularly in the east and around Kigali) and reduce groundwater recharge. Dry season flows in the Nyabarongo River, which supports Kigali's primary water supply, are expected to decrease in coming decades, exacerbating shortages already occurring in the capital city.⁶⁷ Additionally, the increase in the proportion of annual precipitation falling in heavy rainfall events as leads to rapid runoff and flooding, which reduces groundwater recharge

⁶² Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

⁶³ Rwanda (2011). Green Growth and Climate Resilience – National Strategy for Climate change and Low Carbon Development. URL: <https://cdkn.org/wp-content/uploads/2010/12/Rwanda-Green-Growth-Strategy-FINAL1.pdf>

⁶⁴ Aboniyo, J. et al. (2017). National Water Resources Management Authority for A Sustainable Water Use in Rwanda. Sustainable Resources Management Journal. 2(3). DOI: <http://doi.org/10.5281/zenodo.000000>

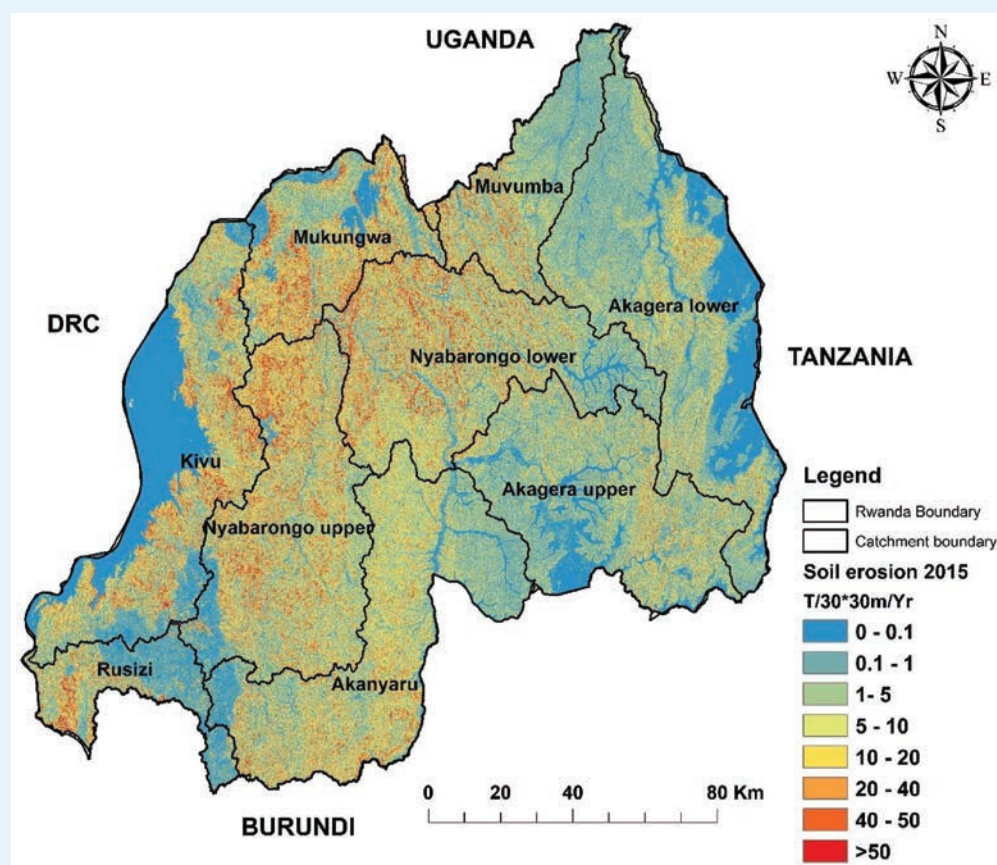
⁶⁵ Ministry of Finance and Economic Planning (2015). Vision 2050. Republic of Rwanda. URL: https://www.nirda.gov.rw/uploads/tx_dce/Vision_English_Version_2050_-_31_Dec_2020.pdf

⁶⁶ Netherlands Commission for Environmental Sustainability (2015). Climate Change Profile – Rwanda. URL: https://ees.kuleuven.be/klimos/toolkit/documents/687_CC_rwanda.pdf

⁶⁷ Rwanda (2011). Green Growth and Climate Resilience – National Strategy for Climate change and Low Carbon Development. URL: <https://cdkn.org/wp-content/uploads/2010/12/Rwanda-Green-Growth-Strategy-FINAL1.pdf>

because too much rain at one time can exceed soil absorption capacity. Heavy rainfall also increases siltation of rivers, lakes, and reservoirs, and contaminates industrial, agricultural, and domestic sources. Increasing demand from the country's growing population, agricultural needs, industrial pollution, and years of persistent environmental degradation is increasing pressure on water resources. The rising temperatures and increased duration of dry spells are resulting in warmer surface temperatures, accelerating bacteria growth and reducing water quality. Projected longer dry-spells for the east of the country is likely to lead to water shortages, reduced river flows and increased contamination.⁶⁸ Increased aridity and drought is also expected to result in land degradation, a loss in biodiversity, and surface water, as well as adverse impacts to crop production (including yield and quality) and increase the likelihood of wildfires. Heavy rainfall events are will likely result in increased erosion and to lead to increased flooding and water logging in agricultural areas, impacting crop production, especially for tuber crops.⁶⁹ **Figure 12** shows the intensity of soil erosion across the country.

FIGURE 12. Intensity of Soil Erosion in Rwanda, 2015 (per 30M × 30M pixel)⁷⁰



⁶⁸ USAID (2019). Climate Change Risk Profile – Rwanda. URL: https://www.climatelinks.org/sites/default/files/asset/document/2019_USAID-ATLAS-Rwanda-Climate-Risk-Profile.pdf

⁶⁹ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

⁷⁰ World Bank (2019). Rwanda Natural Capital Accounts – Ecosystems. WAVES. p. 9. URL: https://www.wavespartnership.org/sites/waves/files/kc/Rwanda%20NCA%20Ecosystem%20Accounts%20_Published%20on%203-12-2019.pdf

Changes in precipitation patterns will impact river flow, irrigation, water management and flooding. This can be seen through both the supply as well as the demand. Increases in heavy rainfall and flooding come with equally greater periods of enhanced drought, which get exacerbated by higher temperatures, and thus stronger evapotranspiration. Projected climate change trends for Rwanda are therefore expected to enhance the contrast between wet and dry and thus might change the dynamics around the balance between availability and use of water. Higher intensity rain and enhanced droughts pose significant challenges to water supply infrastructure and water quality. This is also an important understanding for the water sector (as well as energy) as it provides insight into increasing or decreasing pressure on water resources.

Adaptation Options

To address the concerns of the country's water resources sector, Rwanda's Water Resources Board (RWVB) was established by the law N°71/2019, January 2020 to address the country's water concerns. Rwanda also established a national framework for Integrated Water Resource Management (IWRM) which establishes clear roles, responsibilities, and decision-making processes for all water-related activities across the relevant sectors for improved coordination.⁷¹ The national framework is coordinated by the Integrated Water Resources Management Department under the Rwanda Natural Resources Authority. An Inter-Ministerial Council facilitates participatory mainstreaming processes in water use sectors. The national framework for IWRM will be implemented down to district and catchment levels. It will include compliance and enforcement, information access policies and custodial arrangements.⁷² As part of this strategy, Rwanda has integrated management of water resources at the district and community levels, defined catchment wide responsibilities, clustered catchment partner-districts according to sub-catchment regions, and is working to improve understanding of water users within districts and catchments. Additional research is also needed to better understand the country's water balance and the impacts from changed precipitation trends and increasing population and industry demand. As part of its wider adaptation agenda, Rwanda is also developing a National Water Security Plan to improve water harvesting and storage techniques and improve irrigation efficiencies. Water resources management strategies will be supported through the mandating of rainwater harvesting, building codes and construction of dams by 2030. Adaptation infrastructure should be developed, which is capable of supporting the projected hydrological variations and river flows. Improved infrastructure can also reduce flooding disasters and improve transport networks. Improved water management and usage will benefit agriculture, water quality and availability and help to ensure adequate food security and water access. Improved efficiency in water management practices, currently considered to be low, will benefit households and communities.⁷³

Forestry

Overview

Forests are of significant importance to Rwanda and the country is working to reverse its legacy of deforestation as currently nearly 30% of the country is covered by forests. Natural forests, which cover 10.8% of the country, are comprised of an association of forested belts in National Parks, forest reserves, natural and gallery forests and

⁷¹ Rwanda Water Resource Board (2021). RWB Overview. URL: <https://www.rwb.rw>

⁷² Rwanda (2011). Green Growth and Climate Resilience – National Strategy for Climate change and Low Carbon Development. URL: <https://cdkn.org/wp-content/uploads/2010/12/Rwanda-Green-Growth-Strategy-FINAL1.pdf>

⁷³ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

other remnant forests. Afforestation projects and timber plantations from human made forests consist primarily of eucalyptus and pine, woodlots and agro-forestry plantations cover 18.4% and represent nearly 63% of all forest cover. Planted forests supply almost all fuelwood, with charcoal accounting for about 15.2% of households' primary energy sources. Rwanda is actively promoting agro-forestry to provide wood for fuel during the transition to available and affordable electricity for all.⁷⁴

Climate Change Impacts

Rwanda's forests are critical to its environmental sustainability and wider ecosystem health. 64% of the country's total forest was deforested from 1960 to 2007, however reforestation efforts are reversing these trends. The forestry sector is at risk from increasing temperatures, heavy rainfall, and longer dry periods which are likely to exacerbate soil erosion and land degradation, increase wildfire risk, shift distributions of native species (such as the giant senecio trees), and expand the range of invasive species.⁷⁵ Rwanda already experiences high rates of soil erosion that is depleting top soil in forests and riparian corridors, with the mountainous Gishwati ecosystem (which contains high numbers of threatened reptiles and amphibians) being particularly vulnerable. Rising temperatures also threaten plants and wildlife through increased physiological stress and disruption of pollination and predator-prey relationships. An estimated 107 mammal, 199 bird, 31 fish, 34 amphibian, and 79 plant species in the Albertine Rift region are highly vulnerable due to thermal sensitivity and/or changes in habitat suitability induced by climate change. Among the animals most notably affected are the hippo, African wild dog, western rift puddle frog, grey-crowned crane, and the critically endangered mountain gorilla.⁷⁶ Decrease in rainfall will likely increase water stress of trees particularly in semi-arid areas in Eastern and Southern regions, reducing their productivity and leading to dieback. Additionally, more frequent droughts in the region will upsurge anthropogenic stress and increase deforestation and forest degradation, frequent and severe forest fires and reduce capacity of water catchments. Increased precipitation may increase forest productivity due to increased rainfall availability. However, increased extreme weather events such as strong winds, violent storms, violent floods and landslides will affect negatively forest resources particularly in fragile areas such as on steep slopes and valleys. These threats to biodiversity are likely to decrease tourism, a key source of foreign earnings and economic diversification.⁷⁷

Adaptation Options

Within Rwanda, strategic options for adapting forests and biodiversity to change climate change is focused on improved spatial planning, strengthening the country's sustainable forest management, establishing seed banks for reforestation activities, extending the network of protected areas on land and in the wetlands and strategic investment to restore the country's degraded ecosystems. In 2011, Rwanda's National Forest Policy, which aims to make the forestry sector a key pillar of the country's economy.⁷⁸ The policy won the World Future Council's Future Policy Award as the world's most inspiring and innovative forest policy, and through the global Bonn Challenge; since Rwanda has

⁷⁴ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

⁷⁵ Tsanga, R. et al. (2019). Wood Supply Chain in Rwanda. A market analysis. GIZ. URL: https://www.cifor.org/publications/pdf_files/Reports/GIZ-CIFOR_RwandaReport.pdf

⁷⁶ USAID (2019). Climate Change Risk Profile – Rwanda. URL: https://www.climatelinks.org/sites/default/files/asset/document/2019_USAID-ATLAS-Rwanda-Climate-Risk-Profile.pdf

⁷⁷ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

⁷⁸ Tsanga, R. et al. (2019). Wood Supply Chain in Rwanda. A market analysis. GIZ. URL: https://www.cifor.org/publications/pdf_files/Reports/GIZ-CIFOR_RwandaReport.pdf

pledged to restore 2 million hectares of deforested and degraded lands.⁷⁹ In support of its wider forestry protection and reforestation efforts, Rwanda has committed to ensuring the use of mixed-species approaches which contributes to the achievement of both mitigation objectives and adaptation benefits of ecosystem resilience and enhanced biodiversity. Through this strategic action, the country's target is to achieve an overall 30% sustained forest cover of the total national land surface by 2030 from 28.8% in 2013. Additionally, by 2030, Rwanda will implement public private partnerships to sustainably manage all forestry plantations through multi-year contracts with forests operators (via cooperatives) who will plant and maintain young plantations until they reach their commercial size.⁸⁰

Energy

Overview

Rwanda has one of the lowest electricity consumption rates per capita in the central-east African region, and generation capacity remains low. Primary energy use is dominated by biomass and accounts for over 86% of the total usage. Over 83% of Rwandan households use wood for their cooking fuel, followed by charcoal (15.2%), crop waste (0.8%) and gas or biogas (0.2%). The average household uses around 1.8 tons of firewood each year to satisfy its cooking needs with a traditional stove. At a national level, the use of electricity for lighting changed from 11% in 2010 to 20% in 2014. In Rwanda, households are the dominant consumers of electricity (51%), the bulk of which demand is primarily used for lighting. The industrial sector (42%) is the second largest consumer of energy, which mainly comes from motor-drivers and lighting. Public sector consumption of electricity (6%) is primarily used for powering public buildings, street lighting and water pumping.⁸¹ In Rwanda, the electrical power generation has shown significant increase and from late 2017, 42% of households had access to electricity including 31% connected to the national grid and 11% accessing electricity through off-grid facilities.⁸² Under the Vision 2050, per capita consumption of energy is expected to increase from 50 kWh in 2019 to 3,080 kWh in 2050, with an aim of at least 60% of the total electricity generated from renewable energy sources.⁸³

Climate Change Impacts

Rwanda's energy sector is heavily dependent on environmental resources with around half of its electricity coming from hydropower and more than 80% of the population depending on wood fuel for their energy needs. This makes the country highly vulnerable to climate change and natural disasters. Additional strain from population growth and economic expansion further increases demands on the energy sector. Due to high reliance on biomass for energy generation, stresses on forestry resources in various parts of the country, including Bugesera district, which is considered

⁷⁹ Rwanda (2011). Green Growth and Climate Resilience – National Strategy for Climate change and Low Carbon Development. URL: <https://cdkn.org/wp-content/uploads/2010/12/Rwanda-Green-Growth-Strategy-FINAL1.pdf>

⁸⁰ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

⁸¹ Munyanega, J., Wakeel, M. and Chen, B. (2016). Overview of Rwanda energy sector: From energy shortage to sufficiency. CUE2016- Applied Energy Symposium and Forum 2016: Low carbon cities & urban. *Energy Procedia*. 104. pp. 215–220. DOI: <https://doi.org/10.1016/j.egypro.2016.12.037>

⁸² Ministry of Environment (2018): Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

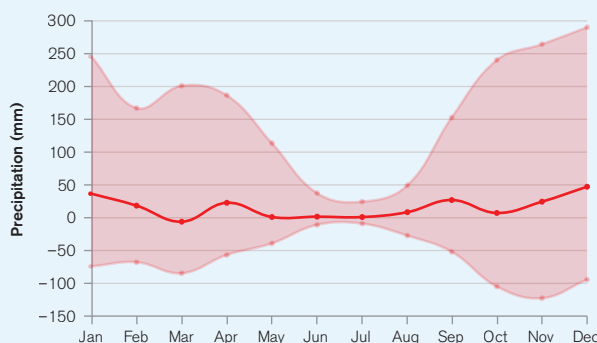
⁸³ Ministry of Finance and Economic Planning (2015). Vision 2050. Republic of Rwanda. URL: https://www.nirda.gov.rw/uploads/tx_dce/Vision_English_Version_2050_-_31_Dec_2020.pdf

as a hotspot for potential climate change impacts. The expected decreasing trends in mean rainfall and number of rainy days during the rainy seasons for the southeastern lowlands and central plateau, which already have a limited water supply, are likely to cause a decline in water storage. This may result in shortening the crop-growing period and the biomass supply; also disrupting potential for hydropower generation. Rainfall quantity (amount and timing) can also affect the moisture content of the soil (affecting yields) or feedstock quality (resulting in low energy feedstock inputs at the generating plant).⁸⁴

Rwanda has variety of potential energy resources from biomass, hydro, solar, petroleum, methane gas, wind and geothermal. Rwanda's potential for renewable energy, micro-hydro, geothermal and solar, is considered to be significant.⁸⁵ Hydropower is the foremost energy resource in Rwanda for power generation. Future domestic generation developments for the main grid are expected to continue from both hydropower sources and thermal (heavy fuel oil and methane-based production from Lake Kivu). Geothermal and wind power resources are also being investigated with initial geothermal estimates suggesting that further investigation of geothermal potential is warranted.⁸⁶ Rwanda is continuing to expand its electricity generation capacity to achieve universal access by 2024. However, this goal depends heavily on expansion of hydropower, which currently accounts for more than half of Rwanda's electricity generation capacity. Production is at risk from increased flood damage to dams and turbines, reservoir siltation, and river flow variability during longer dry spells. Additionally, increased siltation following heavy river flow and/or heavy rainfall and flooding events will reduce hydropower production capacity and potentially damage turbines.⁸⁷

Hydro and micro-hydropower facilities present promising opportunities for needed electricity generation across the region and given the abundance of surface water resources and the likely increase in precipitation. However, the changing characteristics of annual and seasonal precipitation as well as the increase in heavy rainfall events is increasingly likely to disrupt river flow, increase investment and construction costs, and increase challenges to sustained energy generation. Extreme weather events such as heavy rains can damage infrastructure, roads, communication networks and disrupt supply lines. An increase in the frequency and intensity of heavy rains and flooding is also likely to impact fragile infrastructure systems which can also impact hydro-power generation. **Figure 13** shows the average annual precipitation across the seasonal cycle; increases are expectations from November to February.

FIGURE 13. Projected Change in Precipitation (RCP8.5, Reference Period 1986–2005)⁸⁸



⁸⁴ Ministry of Environment (2018): Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

⁸⁵ de Dieu Niyontege, J. et al. (2019). Solar-powered mini-grids and smart metering systems, the solution to Rwanda energy crisis. Journal of Physics: Conference Series. 1311, 2nd International Conference on Clean Energy and Electrical Systems 27–29 June 2019, Nanjing, China. URL: <https://iopscience.iop.org/article/10.1088/1742-6596/1311/1/012002/meta>

⁸⁶ Rwanda (2011). Green Growth and Climate Resilience – National Strategy for Climate change and Low Carbon Development. URL: <https://cdkn.org/wp-content/uploads/2010/12/Rwanda-Green-Growth-Strategy-FINAL1.pdf>

⁸⁷ USAID (2019). Climate Change Risk Profile – Rwanda. URL: https://www.climatelinks.org/sites/default/files/asset/document/2019_USAID-ATLAS-Rwanda-Climate-Risk-Profile.pdf

⁸⁸ WBG Climate Change Knowledge Portal (CCKP, 2020). Rwanda Energy Sector. URL: <https://climateknowledgeportal.worldbank.org/country/rwanda/climate-sector-energy>

Adaptation Options

Rwanda is committed to increasing the share of renewable energy in its power generation through construction of hydro, solar power plants and methane-based electricity power plants in order to shift from using fossil fuels for its electricity needs. This will be supported through regional interconnectivity through construction of new transmission lines and sub-stations and the improvements of existing supply networks. This will allow the import of electricity that would be otherwise generated from fossil fuel power plants (diesel or peat power plant) to meet the future supply and demand for energy.⁸⁹ Rwanda has also committed to establish up to 100 solar PV mini-grids communities, with total capacity of up to 9.4 MWp and will establish rural productive zones using electricity for increasing the income generating potential of rural communities. To more effectively manage demand during peak periods, Rwanda will establish dedicated energy efficiency and demand side management unit to oversee the design and implementation of relevant efficiency programs to clip electrical peak demand. To reduce the consumption of biomass, Rwanda intends to increase the diffusion of improved cook stoves to reach 100% of all households by 2030.⁹⁰

Health

Overview

Rwanda is highly vulnerable to the adverse health impacts of increasing temperatures, increased aridity in some areas and risks of extreme rainfall events and flooding. While the country has made progress tackling communicable diseases such as tuberculosis and malaria, progress in social, economic and public health progress is likely to be undermined by expected climate change trends. In Rwanda, vector-borne diseases expected to increasingly impact human health due to climate change are malaria, tick bite fever and schistosomiasis. Human health would also be negatively impacted by natural disasters which can contribute to malnutrition and epidemics of diseases such as cholera. Impacts from increased food security and reduced water quality are also concerns for increased adverse health implications for the country.⁹¹ Under Vision 2050, Rwanda aims to eliminate chronic malnutrition by 2035, which may be challenged due to increasing risks of climate change.⁹²

Climate Change Impacts

Rwanda is vulnerable to adverse health impacts due to increasing temperatures and altered precipitation trends. Projected trends are expected to impact bacteria, disease and virus trends in the country, with a concern of an increase in epidemics due to transference into new areas. Given the implications for increased temperature and precipitation on the lifecycle and habitat of malaria-carrying mosquito and parasite species, warmer temperatures may open up new locations suitable for transmission.⁹³

⁸⁹ de Dieu Niyonteze, J. et al. (2019). Solar-powered mini-grids and smart metering systems, the solution to Rwanda energy crisis. *Journal of Physics: Conference Series*. 1311, 2nd International Conference on Clean Energy and Electrical Systems 27–29 June 2019, Nanjing, China. URL: <https://iopscience.iop.org/article/10.1088/1742-6596/1311/1/012002/meta>

⁹⁰ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

⁹¹ Sayinzoga, F. and Bijlmakers, L. (2016). Drivers of improved health sector performance in Rwanda: a qualitative view from within. *BMC Health Services Research*. 16(123). URL: <http://www.bioline.org.br/pdf?rw20018>

⁹² Ministry of Finance and Economic Planning (2015). Vision 2050. Republic of Rwanda. URL: https://www.nirda.gov.rw/uploads/tx_dce/Vision_English_Version_2050_-31_Dec_2020.pdf

⁹³ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

While Rwanda has made impressive progress reducing the risk of malaria in recent years, however a warmer and wetter climate (in central, northern, and western areas) is expected to expand areas of malaria transmission farther into the highlands, possibly increasing incidence by up to 150% by 2050. Water contamination from increased flooding is also expected to raise the risk of diarrheal disease, typhoid, cholera, and hepatitis A. Warming surface water temperatures are also expected to increase the risk of schistosomiasis. Longer dry periods in the east (e.g., Bugesera, Mayaga, and Umutara regions) and increased heavy rainfall damage around the country are likely to exacerbate local food shortages and malnutrition rates. Regular flooding and landslides (such as the March and April 2018 floods in the west and northeast) were responsible for death, displacement, and damaged homes and health centers. Additionally, the magnitude and occurrence of existing impacts, such as heat stress, air pollution, asthma, food-borne diseases, and diarrheal diseases are also expected to increase.⁹⁴

In Rwanda, the annual distribution of days with a high-heat index provides insight into the health hazard of heat. Increased night temperatures can result in decreased opportunity for natural cooling. Increased health threats can be projected and monitored through the frequency of tropical nights (>20°C). Tropical Nights (**Figure 14**) represents the projected increase in tropical nights across different emission scenarios (CMIP5 ensemble). As seen, increased nighttime temperatures are projected to be minimally increased, except for the sharp increase expected under the high emission scenario. The Warm Spell Duration Index (**Figure 15**) shows the cumulative nature of a sequence of multiple days with high temperatures, which can raise the impact on the human body and lead to health issues in broad segments of the population. As seen, the warm spells are projected to rapidly increase across all emission scenarios by mid-century.

FIGURE 14. Projected Number of Tropical Nights (Tmin >20°C) (Reference Period, 1986–2005)⁹⁵

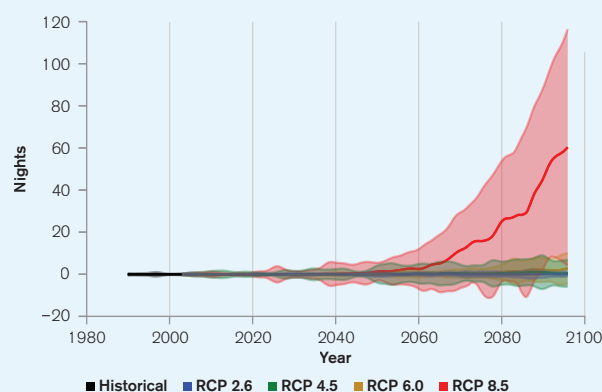
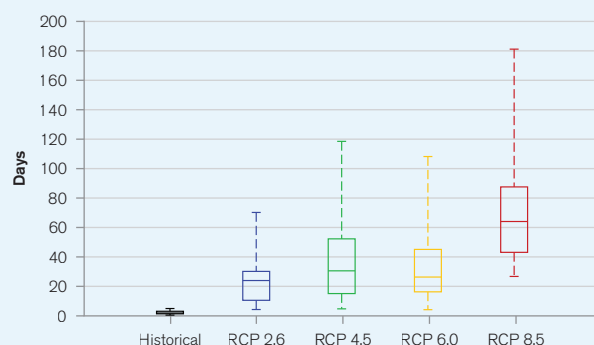


FIGURE 15. Projected Warm Spell Duration Index in Rwanda for the Period 1986 to 2059 (Reference Period, 1986–2005)⁹⁶



⁹⁴ USAID (2019). Climate Change Risk Profile – Rwanda. URL: https://www.climatelinks.org/sites/default/files/asset/document/2019_USAID-ATLAS-Rwanda-Climate-Risk-Profile.pdf

⁹⁵ WBG Climate Change Knowledge Portal (CCKP, 2021). Rwanda Health Sector. URL: <https://climateknowledgeportal.worldbank.org/country/rwanda/climate-sector-health>

⁹⁶ WBG Climate Change Knowledge Portal (CCKP, 2021). Rwanda Health Sector. URL: <https://climateknowledgeportal.worldbank.org/country/rwanda/climate-sector-health>

Adaptation Options

Rwanda is committed to improving its healthcare system, service delivery and resilience to climate change. The resilience of the country's health system is beginning to be incorporated into the country's wider adaptive management strategies and efforts. To that extent, Rwanda's national health policies and programs are designed to increase the sectors adaptive capacity and increase cross-cutting information sharing and risk assessments. To achieve this, institutional structures, systems and tools used in the health sector need to be adapted to the risks associated with extreme weather conditions, disrupted seasonal trends and accelerating climate variability.⁹⁷ The ability to respond adequately, quickly and effectively to potential climate-related hazards is of critical importance to sector success and resilience; failure to adapt will result in huge costs.⁹⁸ The health sector is also collaborating on strengthening protection mechanisms for preservation and conservation in order to promote environmental health and mitigate adverse effects of climate change on the population, including contributing to increased sensitization to reduce the air pollution in households.⁹⁹ Promoting access to water, sanitation and hygiene especially in the health facilities, in the public places and in the communities is critical. This will be enforced through the regulation and implementation of policy and laws for air quality and indoor pollution and other environmental factors related to non-communicable diseases.¹⁰⁰ Additionally, health care system personnel may not be fully aware of the relationship between climate change, seasonal variability and health impacts. Increases in training and capacity can improve the level of knowledge and skills to prevent diseases connected with climatic factors, however this knowledge remains relatively limited among the general population.

Biodiversity and Tourism

Overview and Climate Change Impacts

Rwanda has diverse ecosystems, which include mountain rainforests, gallery forests, savannah woodland, wetlands and aquatic forests, and agro-ecosystems.¹⁰¹ These ecosystems host a great diversity of flora and fauna. In Rwanda, there are four national parks: (i) Volcanoes National Park, which is well known for presence of mountain gorillas and a wide variety of plants and animal species; (ii) Nyungwe National Park, which has more than 1,200 species of flora and 275 species of birds; (iii) Akagera National Park, which covers 108,500 ha and has more than 900 species of plants and 90 mammals; and (iv) Gishwati-Mukura National Park, which covers an area of 4,520 ha.¹⁰² These parks play a critical role in protecting the natural ecosystems and biodiversity of the country. The country's socio-economic development is highly dependent on its biodiversity as a majority of its population is directly dependent on biological

⁹⁷ Sayingoga, F. and Bijlmakers, L. (2016). Drivers of improved health sector performance in Rwanda: a qualitative view from within. *BMC Health Services Research*. 16(123). URL: <https://doi.org/10.1186/s12913-016-1123-1>. URL: <http://www.bioline.org.br/pdf?rw20018>

⁹⁸ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

⁹⁹ Ministry of Health (2017). Fourth Health Sector Strategic Plan, July 2018–June 2024. URL: http://moh.gov.rw/fileadmin/templates/Docs/FINALH_2-1.pdf

¹⁰⁰ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

¹⁰¹ Republic of Rwanda (2011). Rwanda Biodiversity Policy. URL: https://www.rema.gov.rw/abs/content/read_file/5e54b9ef5b116#:~:text=Rwanda%20is%20well%20known%20for,Akagera%20region%20in%20the%20East.

¹⁰² Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

resources for food, medicine, shelter, fuel, building materials, and trade. However, this has resulted in overreliance of these resources, resulting in loss of approximately 50% of original surface area over the last 40 years.¹⁰³ Changes in land use, particularly agriculture and rural and urban development, have negatively affected biodiversity in Rwanda. The tourism sector is directly related to the biodiversity sector as the development of the sector has concentrated in and around protected areas, particularly its national parks.¹⁰⁴ The tourism sector is one of the fastest growing and priority sectors under Rwanda's Vision 2050 and the largest contributor of foreign exchange.

The biodiversity sector is considered as one of the most vulnerable sectors to climate change, indirectly impacting the tourism sector. Climate change is affecting both physical habitats and species from prolonged droughts, landslides, floods, and windstorms. Projected changes are likely to result in direct physiological impacts on individual species, changes in abiotic factors, and ultimately alter the interactions among species.¹⁰⁵ The terrestrial and aquatic ecosystem diversity will be impacted by heavy rains that are expected to increase temperatures in Rwanda.

Adaptation Options

Rwanda has identified a number of adaptation strategies for the conservation of biodiversity, including: (i) effective conservation of the existing biodiversity, especially, in the protected areas; (ii) reduce the source of harm not directly linked to climate change; (iii) effective conservation of natural and planted forest ecosystems; and (iv) mainstreaming climate change into biodiversity policies.¹⁰⁶ For the tourism sector, Rwanda introduced a new strategy in 2014 to develop Rwanda into a center for meetings, incentives, conferences, and events as an alternative to nature-visiting tourism.¹⁰⁷

Infrastructure

Overview

The infrastructure sector is fundamental for the economic transformation envisioned under Rwanda's Vision 2050. By 2050, Rwanda aims to have a formal housing sector that is available and accessible to all segments of the population. Rwanda also aims to develop a modern and efficient transport system with more efficient commute times by 2035 and continued improvements by 2050.¹⁰⁸ Public transportation is expected to serve more than 90% of the population. To realize this vision, the sector has been identified as a key priority sector in the recent years.

¹⁰³ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

¹⁰⁴ Republic of Rwanda (2016). National Biodiversity Strategy and Action Plan (NBSAP). URL: <https://www.cbd.int/doc/world/rw/rw-nbsap-v2-en.pdf>

¹⁰⁵ Republic of Rwanda (2011). Rwanda Biodiversity Policy. URL: https://www.rema.gov.rw/abs/content/read_file/5e54b9ef5b116#:~:text=Rwanda%20is%20well%2D%20known%20for,Akagera%20region%20in%20the%20East

¹⁰⁶ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

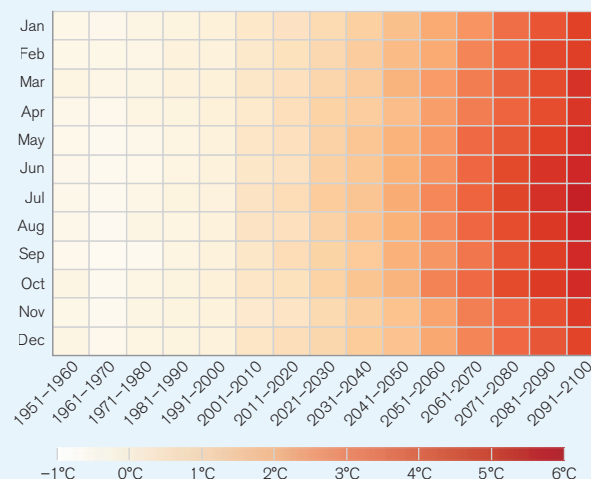
¹⁰⁷ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

¹⁰⁸ Ministry of Finance and Economic Planning (2015). Vision 2050. Republic of Rwanda. URL: https://www.nirda.gov.rw/uploads/tx_dce/Vision_English_Version_2050_-31_Dec_2020.pdf

Climate Change Impacts

Rwanda is expected to experience an increasing trend in annual mean temperature up to 2050 and a decreasing trend in annual mean rainfall and number of rainy days. This suggests that more dry spells are expected as well as an increase in the number of days reaching high temperature. These projected changes will affect the infrastructure assets in Rwanda. While the vulnerability will vary based on the area and type of infrastructure, impacts from climate change are expected to significantly pose a threat on the sector's ability to meet its Vision 2050 targets. Natural disasters resulting in flooding, soil erosion, and landslides can impact existing infrastructure and contribute to the deterioration of older infrastructure. These changes will also increase the cost to build and maintain roads and housing infrastructure. A non-exhaustive estimate calculated by the Government of Rwanda suggested that over \$80 million, which represent 22.8% of the 2015/2016 national budget allocated to the sector, could be lost due to vulnerability to climate change.¹⁰⁹ **Figure 16** shows the projected seasonal changes for maximum temperatures in Rwanda, revealing an increase in maximum temperatures of 2°C to 5°C, throughout the year from mid-century, under RCP8.5.

FIGURE 16. Projected Changes in Maximum Temperatures for Rwanda (RCP8.5, Reference Period, 1986–2005)¹¹⁰



Adaptation Options

Rwanda has identified a number of priority adaptation measures for the transport and housing sector to promote safe, suitable and well-kept building infrastructures up to 2050. In the transport sector, these measures include, (i) integration of climate information in transport infrastructure planning and design; (ii) catchment management; (iii) institutional capacity development on adaptation mechanisms; (iv) application of climate adapted material and technologies; (v) regular maintenance and upgrading of road and drainage infrastructures (improved transport infrastructure); and (vi) real time awareness and intervention during transport failure.

In the housing sector, adaptation measures identified include, (i) mapping of vulnerability areas before construction; (ii) preventing construction on unsuitable sites, such as flood plains and steep slopes; (iii) developing green city models; (iv) establish climate-resilient infrastructure; (v) establishment of early warning system for disaster response plans; (vi) relocate households from high-risk zones; and (vii) erection of the foundation of buildings used for housing.

¹⁰⁹ Ministry of Environment (2018). Third National Communication under the United Nations Framework Convention on Climate Change. URL: https://unfccc.int/sites/default/files/resource/nc3_Republic_of_Rwanda.pdf

¹¹⁰ WBG Climate Change Knowledge Portal (CCKP, 2021). Rwanda Mean Projections. URL: <https://climateknowledgeportal.worldbank.org/country/rwanda/climate-data-projections>

Institutional Framework for Adaptation

Rwanda's long-term vision is to become a climate resilient economy. As such the country has outlined strategic objectives and commitments to achieve its energy security and a low-carbon energy supply, which supports the development of green industry and services, sustainable land use and water resource management that result in food security, appropriate urban development and preservation of biodiversity and ecosystem services, and ensures social protection, improved health and disaster risk reduction that reduces vulnerability to climate change impacts.¹¹¹ In order to achieve these goals, the Ministry of Environment is responsible for designing and monitoring national climate policies. The Rwanda Environment Management Authority (REMA), which operates within this ministry is responsible for climate policy implementation through its Department of Climate Change and International Obligations. The Fund for Environment and Climate Change (FONERWA), known as Rwanda's Green Fund¹¹² was established in October 2014 and also operates within the Ministry of Environment. FONERWA aims to mobilize domestic and international financing to environment and climate change projects. This is expected to be the engine of green growth, mobilizing and channeling domestic and international financing to public and private environment and climate change projects. The green fund will support projects that align with the country's commitment to a strong and prosperous green economy. The Ministry of Environment has been accredited as an implementing entity for the Adaptation Fund and are also accredited to the Green Climate Fund.¹¹³

Policy Framework for Adaptation

Rwanda submitted its Third National Communication to the UNFCCC in 2018 and its Updated Nationally-Determined Contributions in 2020. Its National Adaptation Plan of Action was finalized in 2006. To reach its adaptation goals, Rwanda is working towards an integrated to support cross-cutting national policies and strategies to mainstream environmental sustainability and climate change adaptation efforts. Improvements to legislative and regulatory frameworks, and capacity development and transfer of technology in certain priority areas will further support these efforts. Continued adaptation efforts are focused on the country's most vulnerable sectors: agriculture, forestry, water resources, and health, and on increasing the country's resilience capabilities, and strengthen the country's social and economic structures against vulnerability.¹¹⁴

National Frameworks and Plans

- [Updated Nationally Determined Contribution \(2020\)](#)
- [Third National Communication \(2018\)](#)
- [Fourth Health Sector Strategic Plan \(2017\)](#)
- [National Strategy for Transformation \(NST 1\) 2017–2024 \(2017\)](#)

¹¹¹ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

¹¹² FONERWA (2019). Overview. URL: <http://www.fonerwa.org>

¹¹³ LSE (2019). Grantham Research Institute on Climate Change and the Environment – Rwanda. URL: <http://www.lse.ac.uk/GranthamInstitute/country-profiles/rwanda/>

¹¹⁴ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

- [Nationally Determined Contributions \(2016\)](#)
- [National Contingency Matrix Plan \(2016\)](#)
- [National Biodiversity Strategy and Action Plan \(NBSAP\) \(2016\)](#)
- [Vision 2050 \(2015\)](#)
- [National Urbanization Policy \(2015\)](#)
- [5-Year Strategic Plan for the Environment and Natural Resources Sector–2014–2018 \(2013\)](#)
- [Economic Development and Poverty Reduction Strategy II \(2013\)](#)
- [National Disaster Management Policy \(2013\)](#)
- [Strategic Transport Master Plan for Rwanda \(2012\)](#)
- [Public Transport Policy and Strategy for Rwanda \(2012\)](#)
- [Vision 2020 \(revised version 2012\)](#)
- [Second National Communication \(2012\)](#)
- [Green Growth and Climate Resilience Strategy \(2011\)](#)
- [Rwanda Biodiversity Policy \(2011\)](#)
- [Rwanda Tourism Policy \(2009\)](#)
- [National Adaptation Program of Action \(2006\)](#)
- [First National Communication \(2005\)](#)

Recommendations

Research Gaps

- Improve, support and reinforce the teaching of meteorology, climate science and hydrology in the higher education and university channels of natural sciences and build capacity of staff
- Enhance capabilities for handling climate change data at the national, regional and local levels
- Develop a system for monitoring, preventing and effectively responding to the human diseases associated with climate change¹¹⁵
- Implement regular measuring and reporting of energy use across sectors to develop a GHG emissions profile and future energy requirements, to better support short- and long-term planning of energy resource management¹¹⁶
- Develop an MRV framework for tracking the progress of project implementation and Rwanda’s pathway towards achieving its NDC, whilst meeting its international obligations under the Paris Agreement. Such a framework will include developing a set of performance indicators and supporting metrics for monitoring and reporting the progress towards meeting the NDC for the identified prioritized sectors/mitigation actions within each sector and approach to tracking climate finance¹¹⁷
- Evaluate needs and develop a national strategy for technology transfer to support NDC adaptation measures

¹¹⁵ Ministry of Health (2017). Fourth Health Sector Strategic Plan, July 2018–June 2024. URL: http://moh.gov.rw/fileadmin/templates/Docs/FINALH_2-1.pdf

¹¹⁶ Rwanda (2011). Green Growth and Climate Resilience – National Strategy for Climate change and Low Carbon Development. URL: <https://cdkn.org/wp-content/uploads/2010/12/Rwanda-Green-Growth-Strategy-FINAL1.pdf>

¹¹⁷ World Bank (2020). Revising Nationally Determined Contribution (NDC) mitigation and adaptation priorities for Rwanda. NDC Support Facility. URL: <https://openknowledge.worldbank.org/handle/10986/35412>

Data and Information Gaps

- Improve technical capacity to analyze hydro-met data and project impacts across sectors; specifically, regarding health and natural disaster events
- Complete an updated Technology Needs Assessment to speed up technology transfer for key sectors, particularly energy, water and agriculture¹¹⁸
- Establish institutional capacity for providing timely early warning systems to farmers for improved decision making and understanding seasonal variability for key agricultural zones¹¹⁹
- Increase understanding of water resource threats and groundwater risks to improve long term management and improve water use efficiency in agriculture and urban management
- Improve regulation and enforcement to protect forests, rainforests and protected areas
- Strengthen information exchange by enhancing technologies transfer and capacities necessary from national to local levels to promote environment and climate change mitigation and adaptation through education and public awareness development
- Build capacity of media, theatre groups, and entertainment and advertising industries to mobilize their experience in shaping public awareness and increase the active public participation in the climate change adaptation and mitigation debate
- Design strategic ways to provide capacity building to sectors, including sector experts, to facilitate planning and continuous NDC monitoring in general and in particular on climate adaptation¹²⁰

Institutional Gaps

- Establish a National Environment and Climate Change Research Center for climate data archived and available for research.
- Expand Rwanda's Technical and Vocational Educational and Training to develop skills for effective climate change impact translation and improved adaptation planning across sectors.
- Establish land-use plans by type of use (road infrastructure, mines/petroleum, agriculture, animal husbandry, forests, protected areas or wildlife reserves, urban spaces etc.).
- Integrate climate change concerns into relevant policies and planning processes at the state and national levels¹²¹
- Finalize and adopt the framework bill on the environment as well as outstanding nature conservation bills
- Provide national level adaptation reporting , which aligns and responds to data and information demands at strategic levels including NST and sector strategic plans to guide policy reforms and support effective integration of climate adaptation efforts¹²²
- Finalize regulations to fund and implement impact studies regarding climate change impacts for the country and key sectors¹²³

¹¹⁸ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

¹¹⁹ Rwanda (2011). Green Growth and Climate Resilience – National Strategy for Climate change and Low Carbon Development. URL: <https://cdkn.org/wp-content/uploads/2010/12/Rwanda-Green-Growth-Strategy-FINAL1.pdf>

¹²⁰ World Bank (2020). Revising Nationally Determined Contribution (NDC) mitigation and adaptation priorities for Rwanda. NDC Support Facility. URL: <https://openknowledge.worldbank.org/handle/10986/35412>

¹²¹ Republic of Rwanda (2020). Updated Nationally Determined Contribution. URL: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

¹²² World Bank (2020). Revising Nationally Determined Contribution (NDC) mitigation and adaptation priorities for Rwanda. NDC Support Facility. URL: <https://openknowledge.worldbank.org/handle/10986/35412>

¹²³ Rwanda (2011). Green Growth and Climate Resilience – National Strategy for Climate change and Low Carbon Development. URL: <https://cdkn.org/wp-content/uploads/2010/12/Rwanda-Green-Growth-Strategy-FINAL1.pdf>

CLIMATE RISK COUNTRY PROFILE

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