EASTERN AND
SOUTHERN AFRICA

RWANDA

World Bank Group

COUNTRY CLIMATE AND DEVELOPMENT REPORT

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1818 H Street NW, Washington, DC 20433
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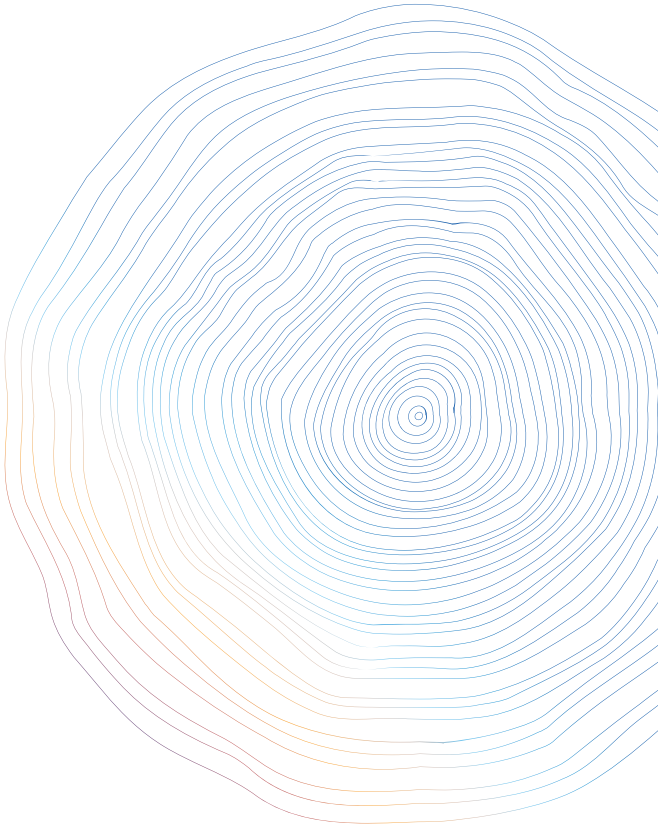

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COUNTRY CLIMATE AND DEVELOPMENT REPORT

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Acknowledgments

The Rwanda CCDR was prepared by a multisectoral World Bank Group team led by Pablo Cesar Benitez, Philip Schuler, and Ugo Amoretti, under the supervision of Iain Shuker, Vivek Suri, and Sebastien C. Dessus, and under the direction of Catherine Signe Tovey.

Core team members included Abebaw Alemayehu, Adam Stone Diehl, Akiko Kishiue, Alex Mulisa, Amparo Elena Gordill, Ana Karla Perea Blazquez, Andrey Shlyakhtenko, Arun Singh, Barry Patrick Maher, Belinda Mutesi, Brice Gakombe, Calvin Zebaze Djiofa, Chiara Odetta Rogate, Claire Davanne, Danielle Velez, Diji Chandrasekharan Behr, Elisée Gashugi, Emmanuel Taban, Erika L. Rhoades, Erin Elizabeth Baldwin, Esdras Byiringiro, Esther Bea, Esther Mutamba, Hasan Dudu, Hermione Louise Tara, Innocent Nzeyimana, James Blignaut, James Seward, John Kalisa, Joy Busolo, Juan Carlos Parra Osorio, Kei Tamaki, Kruskaia Sierra-Escalante, Lulit Mitik Beyene, Makoto Suwa, Makoto Suwa, Mark Dimmer, Michael John Hammond, Michelle Gomes Souto, Mikhail Matytsin, Natalia Romero, Nataliya Mylenko, Norah Kipwola, Nina Jansen, Oliver Jones, Onur Erdem, Pauline Deschryver, Peace Aimée Niyibizi, Peter Ngwa Taniform, Philippa Vivienne McLaren, Rogers Kayihura, Sveta Gaidashova, Shaun Mann, Shyam KC, Stephan Dreyhaupt, Vincent de Paul Kabalisa, Winston Dawes, Xingjun Ye, Yabei Zhang, Yosuke Kotsuji, and Weifeng Lu.

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Abbreviations and Acronyms

°C	Degrees Celsius
AFOLU	Agriculture, Forestry, and Other Land Use
AGRA	Alliance for a Green Revolution in Africa
AIF	Africa Improved Foods
BRD	Development Bank of Rwanda
BRT	Bus Rapid Transport
BUR1	First Biennial Update Report
CAPEX	Capital Expenditure
CDAT	Commercialization and De-risking for Agricultural Transformation
CFL	Compact Fluorescent Light
CGE	Computable General Equilibrium
CLT	Cross-laminated Timber
CMIP5	Coupled Model Intercomparison Project Phase 5
CMPs	Collaborative Management Partnerships
COVID-19	Coronavirus Disease of 2019
DFI	Development Finance Institution
DRRM	Disaster Risk Reduction and Management
DSA	Debt Sustainability Analysis
EDGE	Excellence in Design for Greater Efficiencies
EIA	Environmental Impact Assessment
EICV5	Fifth Integrated Household Living Conditions Survey
ENR-SSP	Environment and Natural Resources Sector Strategic Plan
EV	Electric Vehicle
FCS	Fragile and Conflict-affected States
FDI	Foreign Direct Investment
FOLU	Forestry and Other Land Use
FONERWA	National Fund for Climate and the Environment
GAFSP	Global Agriculture and Food Security Program
GCM	General Circulation Model
GDP	Gross Domestic Product
GGCRS	Green Growth and Climate Resilience Strategy
GHG	Greenhouse Gas
GIDD	Global Income Distribution Dynamics

GoR	Government of Rwanda
ha	hectare
HDI	Human Development Index
ICE	Internal Combustion Engine
ICT	information and communications technology
IDA	International Development Association
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IT	Information Technology
IWRM	Integrated Water Resources Management
km	kilometer
km²	square kilometers
kWh	kilowatt-hour
LCPDP	Least Cost Power Development Plan
LED	Light-emitting Diode
LPG	Liquefied Petroleum Gas
m	meter
m³	cubic meter
M&E	Monitoring and Evaluation
MANAGE	Mitigation, Adaptation, and New Technologies Applied General Equilibrium
MDA	Market Development Advisor
MFI	Microfinance Institution
MIDIMAR	Ministry of Disaster Management and Refugee Affairs
MIGA	Multilateral Investment Guarantee Agency
MINEMA	Ministry of Emergency Management
MININFRA	Ministry of Infrastructure
MoE	Ministry of Environment
mm	millimeter
MRV	Measurement, Reporting and Verification
MSP	Multi Stakeholder Partnership
$MtCO_2e$	million ton of CO_2-equivalent emissions
MW	megawatt
NAPA	National Adaptation Programme of Action
NBS	Nature-based Solutions

NCS	National Cooling Strategy
NDC	Nationally Determined Contribution
NECCP	National Environment and Climate Change Policy
NEP	National Electrification Plan
NGFS	Network for Greening the Financial System
NISR	National Institute of Statistics Rwanda
NLUDMP	National Land Use and Development Master Plan
NST	National Strategy for Transformation
NST1	First National Strategy for Transformation
NWCC	National Water and Climate Centre
ODA	Official Development Assistance
ODS	Ozone-depleting Substances
PAs	Protected Areas
PFM	Public Financial Management
PPP	Public-private Partnership
PrWS	Private Sector Window of the Global Agriculture and Food Security Program
PSTA-4	Strategic Plan for Agriculture Transformation 2018–2024 (Phase 4)
PSW	Private Sector Window
RCP	Representative Concentration Pathway (a GHG Concentration Trajectory)
REG	Rwanda Energy Group
REMA	Rwanda Environment Management Authority
RFL	Rwanda Finance Limited
RSSB	Rwanda Social Security Board
RTDA	Road Transport Development Agency
RWF	Rwandan Franc
SACCO	Savings and Credit Cooperative Organization
SAM	Social Accounting Matrix
SBN	Sustainable Banking Network
SDGs	Sustainable Development Goals
SMEs	Small and Medium Enterprises
SOEs	State-owned Enterprises
t/ha	ton per hectare
tCO_2e	ton of CO_2-equivalent emissions
TFP	Total Factor Productivity
Tmax	Maximum Temperature

UNFCCC	United Nations Framework Convention on Climate Change
US$	United States Dollar
VAT	Value-added Tax
WASH	Water, Sanitation and Hygiene
WB	World Bank
WBG	World Bank Group
WHO	World Health Organization
WtE	Waste-to-energy
WWTP	Wastewater Treatment Plant

Executive Summary

Executive Summary

Over the past two decades Rwanda has achieved remarkable social, political and economic progress. The Rwandan economy grew by 7.7% per year on average between 2004 and 2019, a pace exceeding those of its peers. Nevertheless, the Government of Rwanda recognizes that sustaining high growth rates will require building resilience to different shocks, including those stemming from climate change. While contributing only 0.003% to global greenhouse gas emissions, Rwanda is vulnerable to the consequences of climate change. The country has prepared ambitious measures to support a green, inclusive, responsible, and growth-orientated development pathway. These adaptation and mitigation measures are outlined its 2020 revised Nationally Determined Contribution (NDC) together with costed investments, programs, and policies. All measures are carefully designed to mutually reinforce adaptation and mitigation objectives, and contribute to meeting Rwanda's development objectives. For example, measures classified as mitigating emissions from livestock, agriculture, and land use (which together account for 74% of total emissions), include investments in conservation agriculture, animal husbandry, and soil and water conservation, which will also increase Rwanda's resilience to climate shocks.

The impact of risks of climate change could be consequential for Rwanda's growth given the reliance of the economy on climate sensitive sectors. Climate change is likely to increase variability in crop yields and agricultural production, cause severe flood damage to physical capital, reduce labor productivity, and impact demand for tourism. The CCDR estimates that if these risks materialize, Rwanda's GDP levels can drop by 5–7% below baseline in multiple years by 2050, with negative impact on private consumption, exports and government revenues. During year of severe floods (e.g., a 100-year flood), such extreme events are forecast to reduce GDP by an additional 4.4 percentage points below the baseline scenario during the flood year. Climate change is also expected to slow the pace of structural transformation in Rwanda, compromising future economic growth and poverty reduction.

By strengthening resilience to climate change, Rwanda can better prepare to manage the adverse impacts of climate change. Implementing the commitments articulated in the NDC is estimated to require new investments is US$11 billion, of which close to US$7 billion is conditional on new financing. This is equivalent to spending an average of 8.8% of GDP each year through 2030 — exceeding recorded and projected annual inflows of official development assistance (ODA) and foreign direct investment (FDI) between 2015 and 2030 and representing a large share of projected domestic revenue collection or public investment spending during the same period.

The Rwanda CCDR highlights key interventions that are needed in Rwanda to strengthen climate resilience in the context of country's development priorities and its commitments under the Paris Agreement. The CCDR finds that Rwanda's unconditional adaptation and mitigation commitments (i.e., the actions the country plans to implement through 2030 using existing and planned domestic and external financial resources) would substantially dampen the shocks to GDP resulting from increased weather variability. Unconditional NDC investments would boost industrial output and employment during project implementation compared to their baseline levels. The CCDR also finds that conditional actions boost the capital stock above the baseline by more than 4% on average in the late-2020s and by 1% towards mid-century. The additional climate investments in agriculture, energy, and infrastructure simulated in the CCDR could also accelerate the pace of structural transformation. Considering the current global and national fiscal context, finding the right balance between development and climate action will be instrumental for Rwanda to sustain its impressive growth rates and deliver its national development plan Vision 2050.

The CCDR offers recommendations organized by priority areas, where sector-specific interventions and projects are presented.

Priority Area #1: People and Resource-oriented Nature-Smart Development

Water infrastructure development and management

Sustaining growth in Rwanda will require greater private sector engagement and investment in the water sector. The private sector is a significant user of water resources. This necessitates the improvement in the water supply infrastructure and the implementation of water demand management practices. To co-ordinate this effort, the establishment of Multi Stakeholder Partnership and National Water Climate Centre that facilitates the collective action of both private and public sector with respect to water is recommended. It should further be recognized that while the expansion of water storage through infrastructure development is a critical component for achieving the economic growth aspired to for Vision 2050 and other supporting policies, additional measures will also be needed.

Demand-side interventions in the water sector are also required. These include, in addition to climate-smart agriculture, the reduction of non-revenue water though improved infrastructure and improved metering and institutional strengthening, the introduction of efficient domestic water use technologies, and economic incentives by applying block-rate tariffs. This will require an educational program as to the effect and impact of these demand side measures, and thereby also sensitizing all water users as to its value and importance.

The water resources sector will also benefit greatly from the measures indicated under other priority areas such as climate-smart urbanization, soil-conscious conservation agriculture and outward focused forestry and the development of the protected area network. The development of the water resources sector will also enhance social protection by improving water access and reducing poverty. As water is a cross-cutting catalyst for development and essential for quality of life and the development of human well-being, there is also an opportunity to develop a payments-for-ecosystem services system to enhance water security while promoting forestry, conservation agriculture and the development of protected areas.

Soil-conscious conservation agriculture

A program on soil-conscious conservation agriculture and payment for ecosystem services (PES) could be instrumental to combatting further soil loss caused by deforestation, land conversion, and land degradation. The reduction in natural vegetation has led to increased runoff and river flows, impacting water yield and increasing landslides and soil erosion, and decreasing infiltration and groundwater recharge. Programs to reverse this could enhance development and food and income security in the wake of climate change. The PES, if implemented with the emphasis on the expansion of the network of terraces (both radical and progressive), will increase soil carbon retention. The PES should be implemented with a strong emphasis also on crop rotation and intercropping such as the use of bananas in coffee plantations, which will furthermore result in increased biomass production, yield, and the quality of coffee.

Elimination of current subsidy on mineralized fertilizers while enhancing the support of the production of organic and locally produced compost could promote soil fertility benefits and reduce pollution of groundwater resources. There is a great opportunity and need for a country-wide educational program with respect to the principles and implementation of conservation agriculture, including no tillage. A PES that rewards landscape and ecosystem restoration, and is linked to other PES initiatives, would encourage private sector investment in land and water infrastructure.

Supporting actions should include the development and distribution of climate-resilient seed, the investment in affordable post-harvest and storage solutions and the improvement of crop and livestock management through climate responsive extension services. There is room for growth to extend agronomic information and training to farmers. This could be supported by innovation with respect to insurance to reduce the cost thereof and to link it to climate-smart response mechanisms.

Sustainable and productive forestry and collaborative management partnerships

The development of the protected areas (PA) network with an outward focus to maximize foreign exchange earnings will benefit people, and general ecosystem service delivery and biodiversity. In 2019, tourism generated foreign exchange earnings of US$498 million, which is about double the combined earnings from tea, coffee, and minerals. Maintaining or growing such earnings will require putting in place a PA network to mitigate the impacts of PAs being surrounded by areas with a high population density. Collaborative management partnerships (CMPs) could be used by the PA network to fast-track, among others, improving PA operational and management efficiency, the reviewing and adjustment of the entry fees, the application of concession fees and the introduction of traversing rights. This would put in place a system for awarding concessionaires the rights to operate routes in the PAs (such as Akagera National Park and the Gishwati Mukura Park) on the basis of a tender. To ensure the maximum benefits flow to the local communities, there should be a roll-out and expansion of revenue-sharing schemes to communities and local landowners for co-management and maintenance of PAs, for example, beyond the Virunga National Park. It is also important to introduce an investment-friendly environment, especially for foreign nationals with respect to new PAs, including in Gishwati Mukura.

The development of the PA network could be enhanced by the development of an outward focused, trade-orientated, professional, and productive forestry sector that also acts as a buffer zone to the PA network. To enhance the profitability and commercial nature of the forestry, the afforestation and reforestation in high-risk erosion zones would be required while improving forest resource harvesting and protection to reduce illegal activity. Improved forest land tenure and agglomeration of forested resources will also contribute to the improved management of the resource. These changes will pave the way for the involvement of private sector entities and a sustainable and productive forestry sector. Promotion of agroforestry could also support farmer resilience on small plots through more diversified incomes, social protection, and prevention of land degradation, among other benefits.

Priority Area #2: Low-carbon Energy and Transport Solutions for Climate-Smart Development

Rwanda could maintain a low-carbon growth trajectory by introducing low-carbon energy and transport solutions. From an energy sector perspective this involves, among others, switching from peat-based electricity generation to the expansion of lake methane and the increased use and adoption of both off-grid solar electrification and rooftop solar generation and solar water heaters, and the expanded use of the anaerobic digestion of organic waste, as well as landfill gas utilization.

Rwanda should also consider diversifying its power supply mix through regional power trade and the development of other renewables to reduce climate shocks. There are significant costs and technical challenges associated with large hydropower. Hydropower is also susceptible to variations in precipitation resulting from climate change. The CCDR recommends expanding other sources of supply to reduce hydropower's contribution to 20%. A coordination between the water and energy sectors is recommended to review the country's reliance on hydropower and expand small hydropower schemes. This would also align Rwanda's electricity expansion plan with the NDC.

Rwanda should also consider eliminating tax duties from all renewable or cleaner sources of energy. This is to be done in conjunction with the rapid implementation and national roll-out of clean cooking stoves, which will lead to a reduction in unsustainable firewood, charcoal and fossil energy consumption for cooking, and associated emissions and health costs.

Expansion of the program for national dissemination of compact fluorescent lighting and low emitting diode lamps and the enhancement of energy efficiency in industry will also be beneficial for Rwanda. The latter

should specifically include the phasing out of diesel gensets for on-site electricity consumption in mining, the phasing out of the use of clamp kilns and applying energy efficiency measures in the brick industry, and the use of waste heat recovery and rice husks as fuel within clinker production. The in-house improvement of both lighting and cooking solutions will greatly improve the quality of life of all Rwandans and improve the conditions for learning and productivity.

Equally important will be introducing fuel economy and emission standards in conjunction with an accelerated vehicle retirement program, or "scrappage" schemes. This can be used to incentivize the removal of the most polluting vehicles from the road, while improving the air quality in cities (and in turn labor productivity) and improving road safety.

Priority area #3: Climate-compatible urbanization

Land readjustments and parceling peripheral (yet well-linked) urban land into grids in advance of settlements, and in sites and services could reduce the vulnerability of the average urban household to climate hazards. The City of Kigali and the secondary cities have recently developed master plans that aim to incorporate climate change and environmental concerns. This is an important action given the expectation that urbanization is projected to occur rapidly in Rwanda. Such measures will enhance the inclusion and the economic participation of more people.

The engagement of all key sectors in urban planning, zoning and building codes will help mitigate any unintended lock-in impacts in terms of the energy and the transport systems. The government and the stakeholders in the energy sector need to be involved early in the urban planning process, including reviewing and providing inputs in master plans from an energy efficiency perspective building on international experience. The government and the energy sector should also start developing building energy efficiency

and green building codes including integrating and incentivizing rooftop solar and net metering. From a transport perspective the introduction of electric vehicles and charging infrastructure (e-mobility), together with an enhancement of the public transport system could also enable the development of the country, especially when considering e-bicycles and low emissions motorcycles and the promotion of the modal shift from private to public and low-carbon transport modes through the increased use of public and non-motorized transport.

Implementation of the property tax levels mandated by the 2019 law and their fair and efficient enforcement will help mobilize municipal revenue and improve urban planning while maintaining a low-carbon footprint of cities. The challenges include limited urban planning capacity in the One-Stop Centers which create and enforce master planning zoning regulations and limited fiscal capacity at central and local government level, and iii) inadequate legal and regulatory framework. The current property tax regime is one of the lowest in the world even after reforms in 2019, and municipal revenues are greatly needed to implement measures to promote climate resilience at subnational level.

Restructuring of the construction permit fee from the current flat fee regime to a percentage of 0.1% or 0.2% of the value of the bill of quantities would also help generate much needed revenues. This has great potential to fund the One-Stop Centers, which are likely to improve their capacity to proactively generate local-level urban plans. This capacity is to entail, in part, the capability to conduct flood modelling and landslide susceptibility, which includes an analysis of the cost to assets and the broader economy that will be incurred in extreme flooding and precipitation events. In this context and from a disaster risk management perspective, the adoption and implementation of the New National Disaster Risk Reduction Management Policy is important. Protection should therefore be offered to critical infrastructure within floodplains which will require a detailed study delimiting the flood plain boundaries.

1

Climate and Development

1. Climate and Development

1.1. Context, Development Priorities and Objectives

1.1.1. The Rwandan Economy and its Vulnerability

Over the past two decades, Rwanda has achieved remarkable social, political, and economic progress. The Rwandan economy has grown well above average compared to its peers and rest of the world, achieving growth rates of more than 8% regularly, with 12.5% growth in 2019 (NISR 2021a).

However, the economy is extremely vulnerable to external shocks, including climate change. The vulnerability of the economy was clearly highlighted by the impact of the COVID-19 pandemic during 2020. Rwanda suffered its first economic recession since 1994, with the GDP contracting by 3.4%. The GDP per capita declined to $816, a year-on-year decline of $21 per capita from the 2019 level (NISR 2021a). The vulnerability is further highlighted by the low level of adjusted net savings[1], which fluctuated between -6% and +1% of gross national savings, from 2010 to 2019. The magnitude of the combined effect of the environmental damage and resource depletion is at least equal, but mostly more than, the gains made by the investment in financial and human capital.[2]

Rwanda is also highly vulnerable to adverse effects of climate change, as evidenced by the 2016 drought and the heavy rainfalls in 2018 and 2019. Rwanda's mean annual temperature increased by between 1.4°C (in the southwest) and 2.6°C (in the east) from 1971 to 2016 (GoR 2020a). The eastern regions also experienced serious rainfall deficits in several years, which has alternated with rainfall excesses (World Bank Group 2021a). The rainy seasons are becoming shorter and more intense in the northern and western provinces, which has resulted in increased erosion risk in these mountainous areas.

This compounded vulnerability stems from, among others, the fact that the Rwandan economy is dominated by nature-based tourism, rainfed agriculture, and other extractive industries. These two natural resource-based sectors dominate the economy, as can be seen in Figure 1A, with agriculture and trade, transport and the hospitality industry responsible for 65% of employment. From Figure 1B it is also clear that Rwanda's GDP is highly exposed to climate fluctuations, with the climate-sensitive economic sectors— agriculture, food and beverages, as well as trade, transport, and hospitality—accounting for 45% of the GDP. Goods and services derived from Rwanda's natural resource endowment accounted for 41% of export revenue between 2015 and 2021 (Figure 1C). The economic importance of the tourism industry is especially striking, as is its vulnerability to shocks. Travel services made up 21% of total exports between 2014 and 2019, and fell to only 6% in 2020 when the COVID-19 pandemic all but halted international air transport.

As noted, agriculture is a dominant sector in the economy, yet the scope for further expansion of agriculture-used land is limited. A growing rural population continues to put pressure on scarce land resources because nonfarm labor-intensive industries, and rural to urban migration, are still limited (World Bank 2020a). Thus, agriculture's contribution to the economy is disproportionately low, given that more than 80% of the population live in rural areas (World Bank 2019). This has given rise to an anticipated rapid rate of urbanization leading to a projection of an urban population of 15.4 million (or 70% of the total) by 2050 (GoR 2020b). Such rapid structural change could lead to unplanned land-use change which will threaten the state of the environment, leading to increased flood risks, land degradation, biodiversity loss, and an increase in the vulnerability of people in urban centers.

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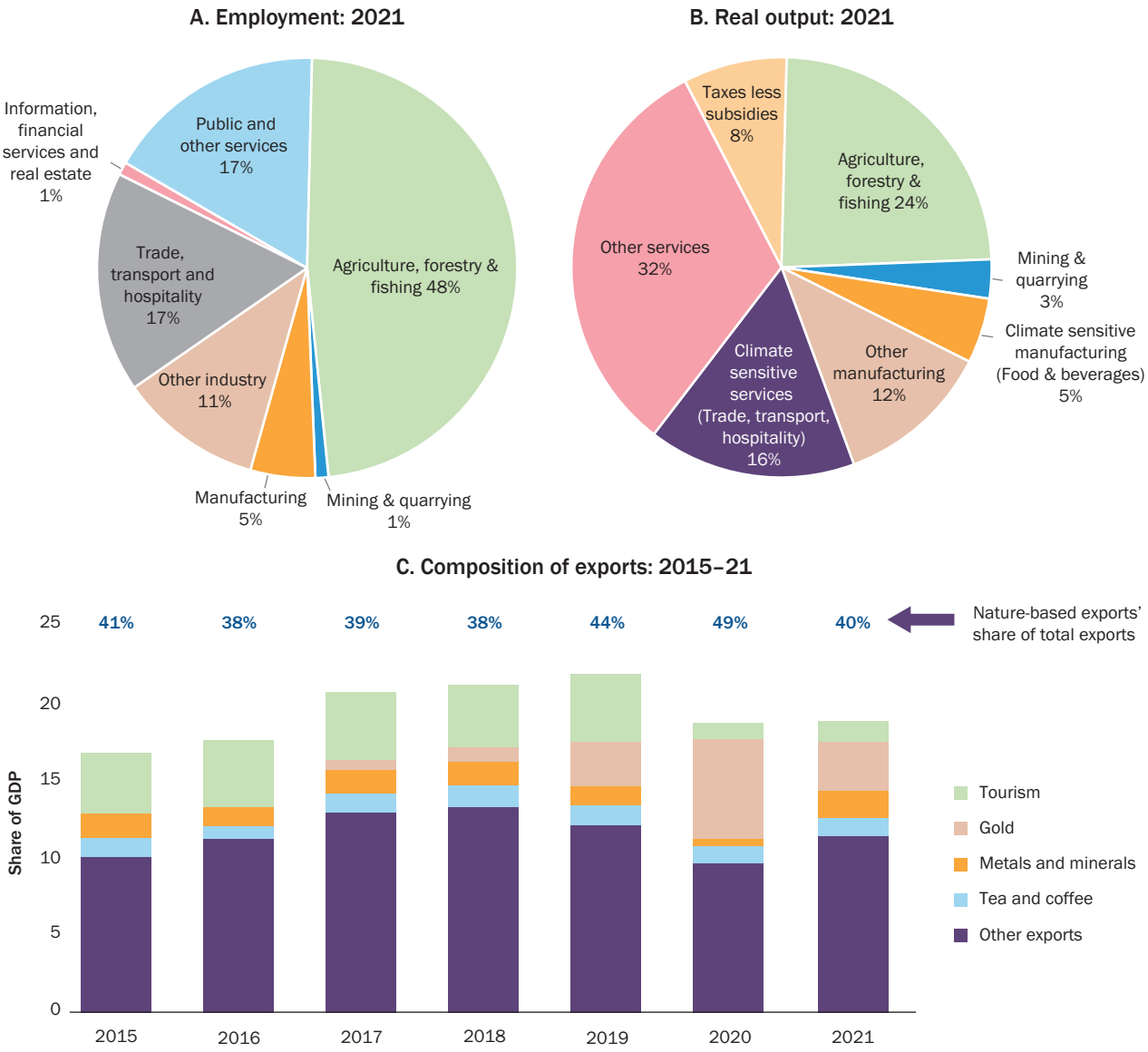
1 Adjusted net savings are equal to net national savings plus education expenditure, and minus energy depletion, mineral depletion, net forest depletion, carbon dioxide and particulate emissions damage.

2 https://data.worldbank.org/indicator/NY.ADJ.SVNG.GN.ZS?end=2019&locations=RW&start=2010
The four priorities are: 1) innovation and extension; 2) productivity and resilience; 3) inclusive markets and value addition; 4) enabling environment and responsive institutions (GoR 2019a; GoR 2018d).

Figure 1: Structural Representation of Rwanda's Economy: Employment, Output, and Exports



Sources: Staff calculations using data from NISR (2022a & 2022b); RDB (2022).

Poverty further exacerbates vulnerability—especially those in rural areas, youth, and those in female-headed households. Rwanda is a young nation with a median age of 19 years (World Bank Group and GoR 2020). This gives rise to a high population growth of 2.4% (World Bank 2019), which puts more pressure on the country's already high population density of approximate 4.5 people/ha. While the Gini coefficient improved from 0.522 to 0.429 from 2005 to 2016, the per adult equivalent expenditure in urban areas is still 2.6 times that of rural areas. Inequality manifests also in terms of gender, where a larger share of female-headed households is poor, at 39.5%, compared to 37.6% of male-headed households, and 62% of female-headed households engaged in independent farming, compared to 43% for male-headed households (GoR 2019a; World Bank 2019). The low level of education among adults is also hampering development, with more than 70% of household heads in the bottom 40th percentile having only incomplete primary, or no schooling at all (World Bank 2019).

The development challenges are, in part, also the result of a lack of access to basic services and technology. The percentage of households living in planned settlements is low at 61%, with the percentage of households having access to electricity at 71.9%, including 21.3% accessing through off-grid systems dominated by solar energy (REG 2022), and those with access to mobile-broadband internet at 28%. While 87% of households have access to an improved water source, not all that access is either in-house or at the stand (GoR 2017). In addition, only 25% of farms have access to any form of mechanized capability, and only 52% of farmers have access to high-quality seed — which is a matter of concern, given the agrarian nature of the country.

Poverty also highlights Rwanda's vulnerability to exogenous shocks and its development challenges when compared to its peers. When benchmarked against the top-performing low-income countries, poverty stands out as one of the measures in which it is the weakest. Nearly 60% of the Rwandan population lives below the international poverty line, while access to basic services is hampered by the fact that nearly 40% of the population live in informal settlements. There is a material risk that the number of people living in informal settlements in urban areas could increase as the degree of urbanization increases from the current 18.4% level to the targeted 70% level by 2050. The combined implication is that food security is well below the average for low-income countries, mainly due to challenges in food affordability and availability (rising food costs, high poverty rate, insufficient food supply and agricultural development) (World Bank Group 2021b).

The combined poverty-induced vulnerability and low degree of development limits the capacity of poor households and communities to manage climate risk, increasing their vulnerability to climate-related shocks, with respect to, among others, aspects related to health. While the country has made progress in tackling diseases such as tuberculosis and malaria, further progress is likely to be undermined by expected climate-change trends. Vector-borne diseases are expected to have an increasing impact on human health and are mainly due to malaria, tick bite fever, and schistosomiasis. The plausible increase in temperature and precipitation could open new habitats for the malaria-carrying mosquito and parasite species. Disasters are also likely to contribute to malnutrition and epidemics such as cholera, while water contamination from increased flooding is also expected to raise the risk of diarrheal disease, typhoid, cholera, and hepatitis A. Additionally, the magnitude and occurrence of existing impacts, such as heat stress, air pollution, and asthma are also expected to increase together with a reduction in labor productivity because of heat (Hallegatte *et al.* 2016; World Bank Group 2021b).

1.1.2. Recent Progress in Development

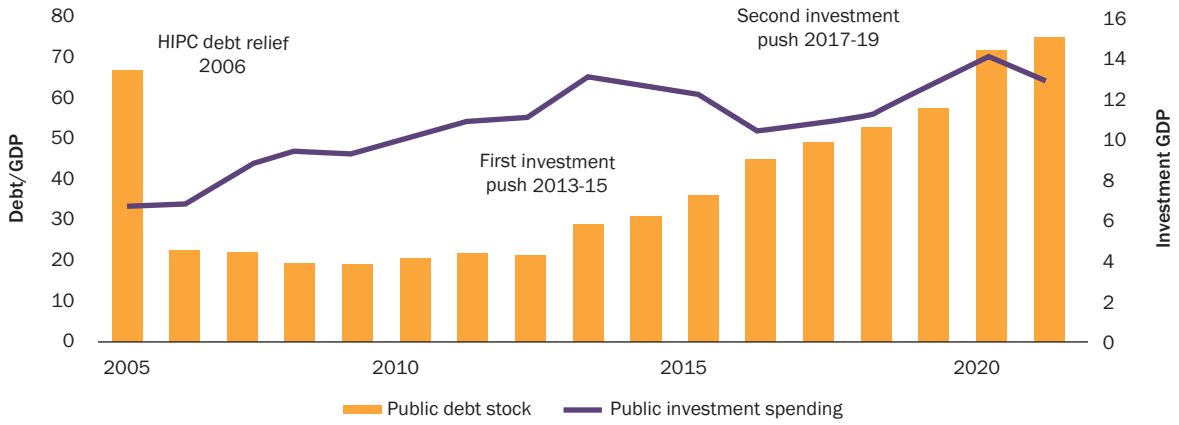
Despite the prevailing development challenges, Rwanda has made considerable progress on various fronts over the past two decades. The country's strong performance resulted in improving its position from the second-poorest country in the world in 1994 to transitioning ahead of 19 other countries in 2017, more than tripling the GDP per capita from $268 in 2000 to $837 in 2019. Rwanda also recorded a rapid increase in electricity access. Both on-grid and off-grid access increased over seven-fold from 10% (2010) to 71.9% (2022). In terms of the Sustainable Development Goals (SDGs), Rwanda has capitalized on visionary leadership, effective governance and accountability, and home-grown solutions that are resource efficient. The country plays a major role in enhancing ownership to accelerate development outcomes and integration of all SDGs in the national planning and monitoring framework for effective implementation (GoR 2019a).

The number of people living under the poverty line declined from 60.4% in 2001/01 to 38.2% in 2016/17 (SDG 1). The Human Development Index (HDI) improved by 106% from 0.25 to 0.524 from 1990 to 2017 (SDG 2). This is partly because of an improvement in nutrition with the prevalence of stunting in children under five years of age declining from 57% in 1992 to 38% in 2014/15. The infant mortality rate (SDG 3) declined from 86 deaths/1,000 live births in 2005 to 32 deaths/1,000 live births in 2014/15. Also, in terms of education and the access thereto, Rwanda has made good progress. The mean number of school years,

for example, increased by 2.3 years and the number of expected years of schooling increased by 5.5 years between 1990 and 2017 (SDG 4) (GoR 2019a).

Public investment helped drive Rwanda's impressive economic performance but has weakened fiscal sustainability. The first investment push of 2013–2015 more than doubled public debt from its level in the 2000s (after receiving debt relief). The second investment push of 2017–2019, followed by increased spending to respond to the global pandemic, pushed debt up to around 75% of GDP (see Figure 2), triggering a downgrade in Rwanda's debt sustainability risk rating (IMF and World Bank 2022).

Figure 2: Public Investment and Debt, 2005–2021



Source: MINECOFIN and World Bank staff.

The scope for maintaining high levels of public investment is now much more limited. The government is committed to fiscal consolidation over the medium term. The need to invest in human development as the pandemic subsides creates new spending pressures (World Bank 2021a). Strengthening public investment management systems to increase the efficiency and effectiveness of the public investment program can potentially create fiscal space. Ultimately, future economic growth depends on unlocking international and domestic private investment (World Bank Group 2019). As a result of the progress made over the past number of years, there are specific areas which show much promise for future growth. Based on four drivers for growth—namely innovation, integration, agglomeration and competition—six high-priority areas have been identified (World Bank Group and GoR 2020). They are depicted in Figure 3 and are specified below:

- Human capital development;
- Export dynamism and regional integration;
- Well-managed urbanization;
- Competitive domestic enterprises;
- Agricultural modernization; and
- Capable and accountable public institutions.

Given the development challenges highlighted above as well as the opportunities for growth and development, the Government of Rwanda (GoR) has identified key development objectives as formulated through its development plans. Two of these national development plans are GoR's medium-term National Strategy for Transformation (NST) (GoR 2017) and the country's long-term Vision 2050 (GoR 2020c).

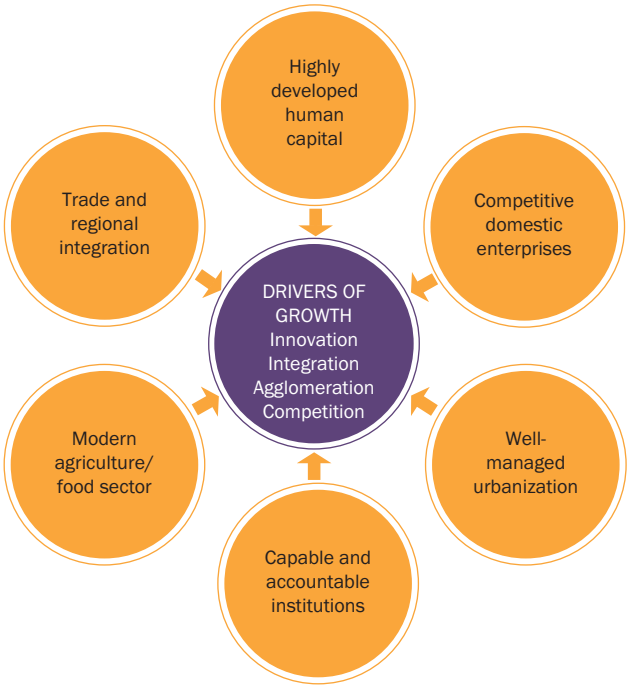
It is Rwanda's vision to become a low-impact, resilient, and developed economy by 2050. This vision (GoR 2020c) is to be achieved by, among others, its Economic Transformation pillar whose objective is to "accelerate inclusive economic growth and development founded on the private sector, knowledge and

Rwanda's Natural Resources." The following is a selection of its objectives: i) increased agriculture and livestock quality, productivity, and production, ii) accelerated urbanization to facilitate economic growth, iii) transport, iv) energy, and v) manufacturing, as well as the promotion of industrial development, export, and the expansion of trade-related infrastructure. These development objectives will be discussed briefly.

Vision 2050: Agriculture, Forestry, and Land Use

According to Vision 2050 (GoR 2020c), agriculture's contribution to the GDP must decline from its current high of 28% to 21% by 2035, and 16% in 2050. To achieve this target, an economic transformation away from agriculture towards the other economic sectors is necessary. However, the agriculture sector must simultaneously improve its efficiency and its ability to provide for a rapidly urbanizing society. To achieve this modernization, the government aims to transform the sector to be market-driven, linked to urbanization and trade, and nearly 15 times more productive than today. Agriculture value added per worker will need to increase more than eight-fold by 2035, and more than triple again by 2050 to achieve comparative levels of high-income countries. Development targets in the agriculture sector will be achieved only through a big increase in productivity and the development of professional agriculture services. This includes strong downstream and upstream linkages throughout the agriculture sector.

Figure 3: Rwanda's Drivers for Growth and Key Priority Areas



Source: World Bank Group and GoR (2020).

National development priorities in the agriculture sector have a strong focus on reducing the losses from extreme weather events and climate change. It has been established that the successful implementation of the four priorities of Rwanda's Strategic Plan for Agriculture Transformation (PSTA 4) is required to reduce losses because of climate change.[3] It is therefore envisaged that the Rwandan farmers will have access to tools that will help them to reduce losses from the effects of weather and climate change through the following measures: (i) better insurance and financial services and other risk management and transfer tools, (ii) increased diversification at the household level, (iii) improved market information and strengthened contract farming models, and (iv) decentralized managed grain reserves to mitigate large hikes in local food prices. Rwanda is making good progress towards achieving food security through crop intensification, erosion control, irrigation, as well as early childhood development, and a multisectoral intervention to address malnutrition (GoR 2019a). The following are some of the specific plans of action:

- Strengthen the commercialization of crop and animal resource value chains;
- Work with the private sector to increase the surface of consolidated and irrigated land and promote agricultural mechanization;
- Promote new models of irrigation scheme management;
- Improve management of the distribution of inputs working with the private sector;

3 The four priorities are: 1) innovation and extension; 2) productivity and resilience; 3) inclusive markets and value addition; 4) enabling environment and responsive institutions (GoR 2019a; GoR 2018d).

- Improve seed varieties through research and development;
- Improve the post-harvest handling and storage facilities in conjunction with the private sector;
- Attract private sector and farmers to invest in flagship projects in the livestock subsector; and
- Establish a comprehensive agricultural ecosystem financing program including lease financing and insurance with a focus on priority value chains.

The government initiatives are supported by the World Bank and the International Finance Corporation (IFC). This is done through the support for essential goods, works, and services, which will facilitate the generation and dissemination of technology along the selected value chains, targeting increase in productivity and commercialization. The IFC partnership with GoR seeks to promote investments in improving low-quality inputs, inefficient production techniques, and lowering high transportation costs. Private sector actors, such as agro-processors, will be supported through private investments in high-potential sectors that include sugar, horticulture, and tea (World Bank 2020a).

Forestry and land use are important priorities to achieve Rwanda's vision of transitioning toward a green economy. A steady depletion of Rwanda's forest and water resources has heightened the country's sensitivity to climate change. Since 1990, there has been a steady decline in total forest cover, and an increase in cropland (NISR 2019). Demand for biomass for energy use is a major driver of deforestation and forest degradation. The Economic Transformation pillar prioritizes the sustainable management of natural resources and the environment. It seeks objectives that will increase the sustainability and profitability of forestry management, increase and sustain the area covered by forests to 30% by 2024 (from 29.6% in 2017) through forest landscape restoration, manage and protect water catchments to mitigate disasters, and strengthen land administration and management.

In addition to, and because of, deforestation and land degradation, critical watersheds and water catchments have been converted to agricultural land. The resulting reduced vegetation cover has led to increased runoff and river flows, increasing the water yield (NISR 2019). Reduced vegetation has caused a decrease in infiltration, and groundwater reserves have been depleted. Increased runoff linked to greater soil erosion and soil loss has increasingly posed significant problems that threaten food security. Watershed destruction, inappropriate settlements, inappropriate agricultural practices, and inadequate sanitation have led to more siltation, sedimentation, pollution, and the risk of invasive aquatic weeds. This deterioration in water assets has been exacerbated by climate-related impacts on water resources (World Bank 2020a).

Limited access to land also remains a constraint for Rwanda's private sector. Access to serviced land for commercial operations and on-site value addition is a major constraint for firms and is often raised as the biggest challenge by foreign investors looking to set up operations. Access to agricultural land is a serious constraint for investors seeking to undertake large-scale farming, and land consolidation for private investors is challenging (World Bank 2020a).

Vision 2050: Urbanization, Transport, and Energy

Urbanization plays a major role in Rwanda's strategy to facilitate the transformation of the national economy to become a developed country. It is thus the objective of the government that urbanization should increase from the current level of below 20% of the population to 53% by 2035, and 70% by 2050 (GoR 2021a). This is to be accommodated with the following sub aims: i) the proportion of urban population living in slums, informal settlements or inadequate housing will decrease from 63% to 44% in 2035 and 20% in 2050, and ii) the proportion of rural households settled in integrated planned settlements will increase from 67% to 100% by 2035 and beyond. Rwanda has envisioned urbanization as a strategic driver of economic development to deal with demographic pressures, employment, and sustainable land use. The aim is to reinforce the administrative and urban governance of urban areas and the human settlements system to promote local economic development, based on local potentialities and interlinkages (GoR 2018a).

Despite major strides in urbanization in urban areas, and in Kigali, in particular, there is still scope for major improvement. Urbanization challenges are reflected in housing constraints with more than 60% of urban households (79% of Kigali residents) living in unplanned settlements. The current supply of formal housing remains unaffordable for most of Rwanda's population. This reduces the agglomeration economies of urbanization. However, the shortages create significant opportunities for private sector-led provision of affordable housing. Larger markets will only be reached by moving down the "housing pyramid" (World Bank 2020a).

National urbanization objectives are accompanied by ambitious development objectives in the energy and transport sectors. The rapid rate of urbanization sought by GoR, combined with the aim to decrease the number of inadequate housing apartments, must coincide with improved service delivery and infrastructure development. Electricity provisioning is key here, with the aim to improve access to electricity from 56% in 2020 to 100% by 2024 and beyond, with the per capita energy consumption level increasing from 50 kilowatt-hours (kWh) in 2019 to 1,026 kWh in 2035, and 3,080 kWh in 2050 (GoR 2020c). In addition, Rwanda has set an ambitious target under the 2018 Energy Sector Strategic Plan to halve the number of households relying on traditional cooking technologies from 83 % (2017) to 42% (2024) through promotion of the most energy-efficient technologies (MININFRA 2018). In keeping with the overall objective of having a low impact, it is envisioned that the share of renewable energy in the power generation mix will increase from 54% to, at least, 60% by 2035 and beyond. Given the added economic activity, there will be the need to transport more people from a domestic perspective. This is to be achieved through the development of a modern and efficient transport system where the median time taken to commute to work is 45 minutes by 2035 and 25 minutes by 2050. The percentage of the population using public transportation will be at 90% or more, and convenient public transport will be accessible at least within 500 meters (m) radius or less.

Rwanda's infrastructure needs remain vast. Connectivity and logistics remain major challenges for the country (World Bank 2021b). The high cost of power is another major challenge for Rwanda's enterprise sector. The cost of electricity at $0.23 per kWh is amongst the highest in the region and well above the average end-user tariff of $0.18 per kWh. The Rwanda Energy Group (REG) is relying on significant subsidies, although declining from 1.1% in 2020/21 to 0.8% in 2021/22 of GDP. Power outages— particularly for manufacturing firms—also hurt competitive advantage. One-third of firms report that access to reliable electricity is a challenge to their operations (World Bank 2020a).

From a commercial perspective Rwanda needs an efficient transport system to address the constraints arising from being landlocked. Rwanda's vision is to gain modern infrastructure, cost-effective and quality services, while ensuring sustainable economic growth and developing an eco-friendly, safe, and seamless integrated multimodal transport system for passenger and goods, both at the national and regional levels (GoR 2019b). Currently, the transport system is not connected to the regional railway networks, and thus, trade is entirely dependent on air and road transport. Efficient transport systems and services would enhance competitiveness by reducing the cost and improving the speed of procuring imported inputs and moving exports. Logistics costs remain high (approximately $3,633 per container from Mombasa to Kigali), making Rwanda one of the most expensive places for a container to reach. Rwanda's transport costs account for 40% of the imports/exports value, compared to 12% for Kenya and 36% for Uganda (World Bank 2021).

Vision 2050: Manufacturing, Trade, and Sustainable Growth

Part of the structural transformation of the economy is to advance its level of development, including its GDP/capita growth, from $816 (2020) to $4,036 (2035), and $12,476 (2050). This must be achieved by focusing on sectors with high productivity that can also assist in achieving an increase in Gross National Savings, as a percentage of the GDP from 13% to 22.4% (2035) and to 27.7% (2050). The sectors that have been identified as the growth sectors are information and communications technology (ICT), finance, light

manufacturing (for example, textile, apparel, and leather sectors), and agro-processing. The focus will be on home-grown solutions. Rwanda envisions a structural transformation that will have the following positive results: i) increase the financial sector's contribution to the GDP from 2% to 5.2% by 2035, and to 11.8% by 2050; ii) result in the local and international recognition of the brand "Made in Rwanda"; and iii) solidify the country's position as the regional trading hub (logistic services, aviation hub, and innovation hub, and others), and the gateway to East and Central Africa. As part of the latter objective, Rwanda anticipates a Kigali-based logistics platform that will monitor and optimize logistic systems across Rwanda with real-time online technology, massively reducing the cost of transport. This is to be supported by state-of-the-art industrial parks, infrastructure, dedicated power lines, modern water and drainage systems, and high-speed internet connectivity.

Rwanda's structural features—its small market size, hilly terrain, lack of direct access to the sea, and low human capital—are all barriers to job-intensive growth, which is a critical factor in sustainable growth. Although the business environment for attracting private investment has been a priority for the government, there are still many barriers to overcome if the private sector is to drive jobs. Cross-cutting constraints across sectors (for example, ICT, transport, and finance) persist, making it difficult for firms to compete and take advantage of market opportunities. An overwhelming majority of firms are small, lacking the economies critical for competitiveness. There is a significant misallocation by businesses of factors of production that is slowing structural transformation and inhibiting total factor productivity growth. Strengthening the enabling environment for domestic and international private firms and corporate governance regime for state-owned enterprises (SOEs) along with sustaining government commitments is essential for sustaining a high growth rate (World Bank 2020a).

1.2. Risks and Development Opportunities from Climate Change and Natural Hazards

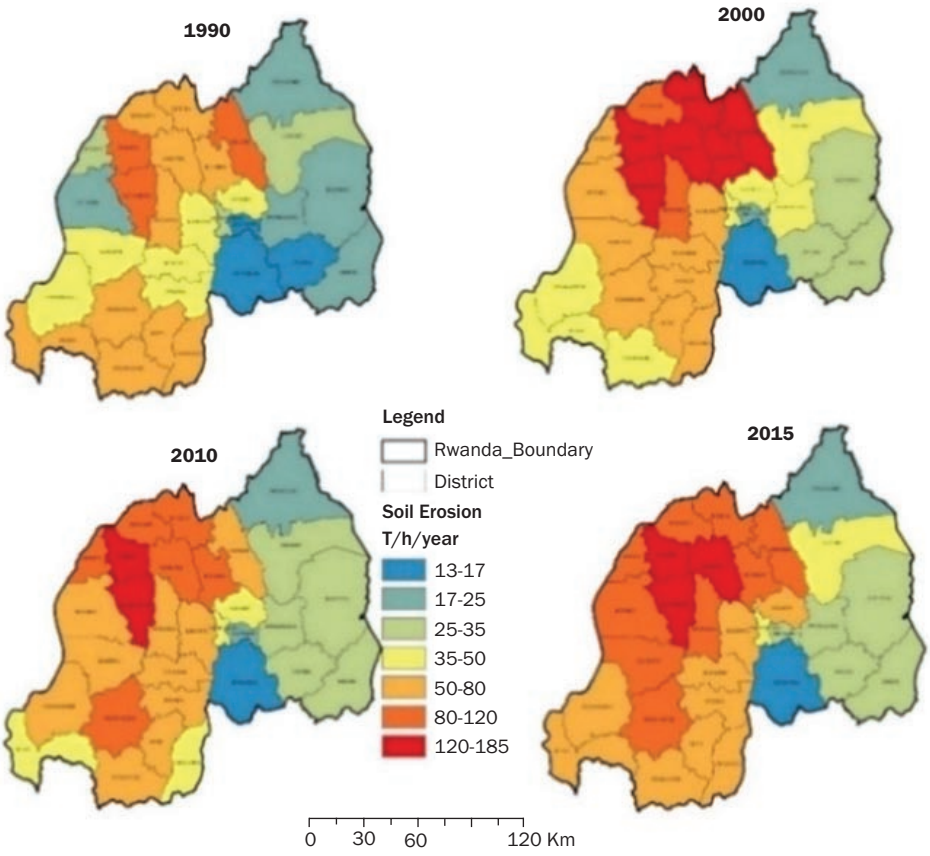
1.2.1. Rwanda's Topographic and Climatological Context

Rwanda, although small (26,338 square kilometers [km^2]) and landlocked, has a range of climate and topographical zones. The country lies in the tropical zone between 1- and 3-degrees latitude south of the equator. It has four primary climatic regions, namely the eastern plains, the central plateau, the highlands, and the regions around Lake Kivu in the far west. The country has a largely tropical climate and is characterized by its very hilly landscape, stretching from east to west. Most of the country is more than 2000 m above mean sea level, especially in the west where it breaches 3000 m. While this elevation moderates its climate, the west is highly susceptible to soil erosion. In 2015 approximately 158 million tons of topsoil were eroded, with an annual average of 62 tons per hectare; see Figure 4 for national soil erosion distribution. Soil erosion has increased by 54% since 1990 (NISR 2019).

Variances in precipitation across Rwanda occur in terms of both season and climatic region. Rwanda traditionally has four temporal climactic seasons. These is a long rainy season from March to May, a short rainy season from September to November, alternating with a long dry season running from June to August, and a short dry season from December to February (GoR 2018b). The mean annual temperature over the period 1991–2020 was 19.1°C with average monthly temperatures ranging between 19.8°C (August) and 18.8°C (July) (See Figure 5).[4] The distribution of its monthly precipitation varies between approximately 10 millimeters (mm) in July, and 150 mm in November, with the mean annual precipitation over the period of 1,178 mm.

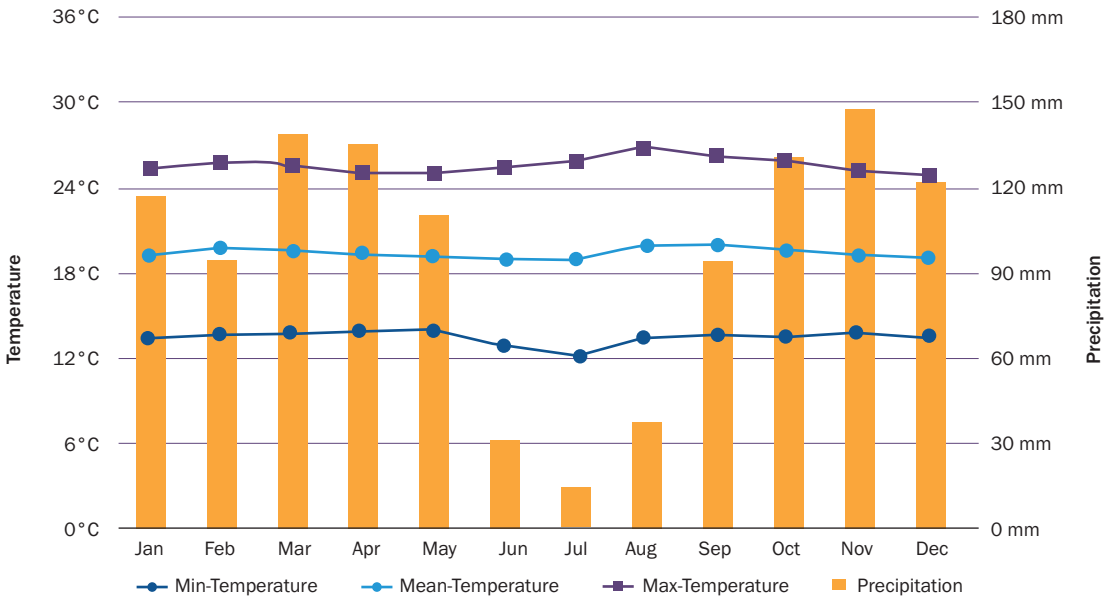
4 Data sources are from observed, historical data produced by the Climate Research Unit of University of East Anglia (https://www.uea.ac.uk/groups-and-centres/climatic-research-unit).
Data (https://crudata.uea.ac.uk/cru/data/hrg/) are presented at a 0.5° x 0.5° (50 km x 50 km) resolution.

Figure 4: Soil Erosion in Rwanda



Source: NISR (2019).

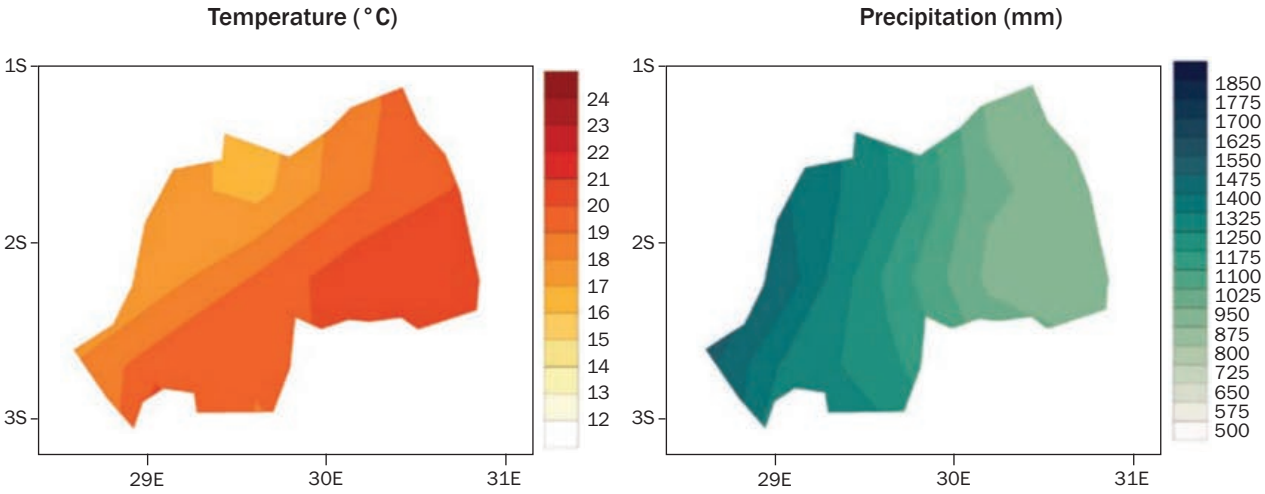
Figure 5: Rwanda's Average Observed, Monthly Mean, Maximum, and Minimum Temperatures and Precipitation, 1991–2020



Source: World Bank Group (2021a).

The temporal variances in Rwanda's climate are mirrored spatially as well, with significant differences between the low-laying east—with a mean precipitation between 700 and 1,100 mm, and a mean annual temperature of 20–22°C, and the west—with a mean precipitation between 1,200 and 1,600 mm, and a mean annual temperature of 10–18°C (World Bank Group 2021a). This steep gradient is indicated in Figure 6.

Figure 6: Geospatial Distribution Average Annual Temperature and Precipitation, 1991–2020



Sources: World Bank Group (2021a), based on World Bank Group (2021c).

1.2.2. Rwanda's Susceptibility to Impacts Because of Climate Change: Historic Evidence

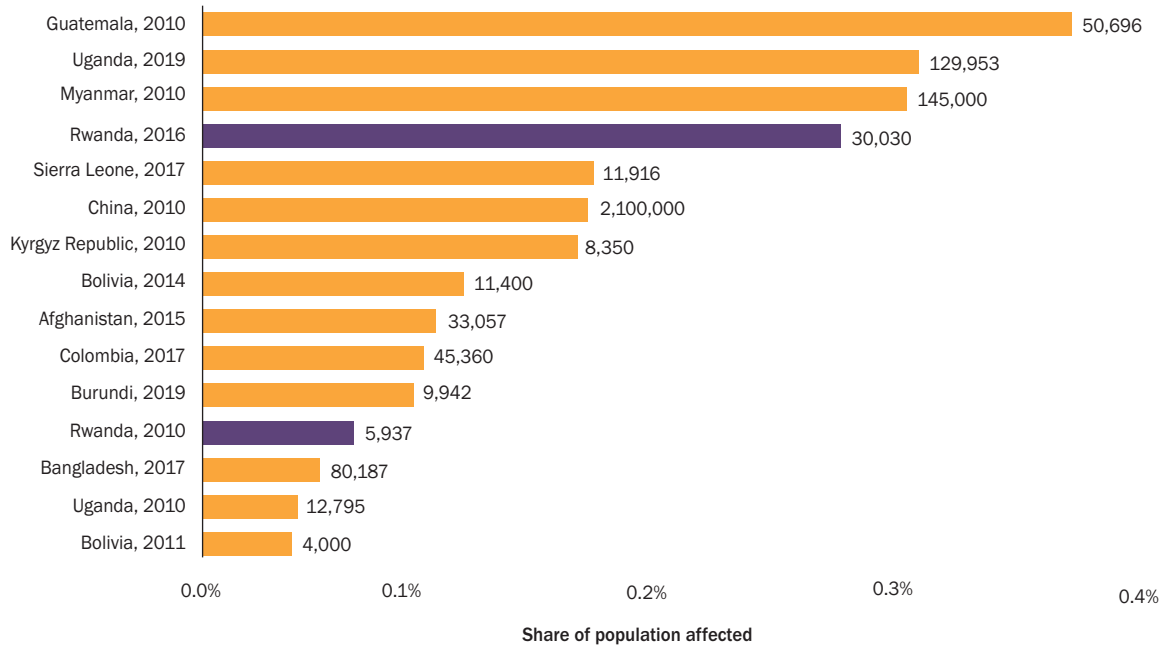
Rwanda has suffered widespread damages and losses from a range of climate-related events, notably from droughts, landslides, and flooding. Droughts have historically had the widest reach; the 1996 event affected 12% of the population (Table 1). During the past decade, Rwandans have been among the world's most affected by landslides, with two events in the top 15 (Figure 7). In 2020, landslides caused 125 deaths and, together with floods and rainstorms, damaged up to 7,769 houses (Table 2). The 2018 floods caused damage to physical assets valued at RWF 201 billion and economic losses of RWF 21 billion (2.4% and 0.3% of GDP, respectively) (GoR 2019c).

Table 1: Most Severe Natural Hazards-related Disasters, Share of People Affected: 1990–2021

Type of disaster	Share of population affected in most severe event	Year of most severe event
Drought	11.93%	1996
Landslide	0.26%	2016
Flood	0.24%	2002
Storm	0.05%	2017
Epidemic	0.04%	1998
Earthquake	0.02%	2002

Sources: EMDAT, WDI.

Figure 7: Top 15 Landslide Events, Share and Number of People Affected, 2010–2021



Sources: EMDAT, WDI.

Table 2: National Damages by Climate-related Event and Type: 2020

Event	Landslide	Flood	Lightning	Rainstorm	Fire	Windstorm	Hailstorm	Total
Deaths	125	62	46	45	1	0	0	**298**
Injured	63	5	182	144	9	2	0	**414**
Houses damaged	1,643	178	11	5,948	84	234	0	**8,098**
Damaged crops (ha)	180	2,993	0	1,265	0	0	215	**4,662**
Lost cattle	14	1	99	14	4	0	0	**132**
Other livestock	156	3,021	37	140	3	0	8	**3,365**
Classrooms	4	0	0	82	0	10	0	**96**
Health centers	1	1	0	2	0	0	0	**4**
Roads	71	23	0	60	0	0	0	**154**
Churches	0	0	0	16	0	6	0	**22**
Bridges	43	23	0	37	0	0	0	**103**
Admin Offices	1	0	0	9	0	7	0	**17**
Water supply	16	0	0	10	0	0	0	**26**
Trans-mission lines	3	1	11	80	0	3	0	**98**
Markets	0	0	0	5	1	0	0	**6**
Factory	0	0	0	1	0	0	0	1

Source: Ministry of Emergency Management Disaster Damages (2020).

Heavy rainfall, flooding, and landslides are the most damaging and costly climate risks for Kigali and all other secondary cities, except Nyagatare, which faces the worst threat from drought. Flooding has worsened since 2000 and the flood hazard has increased as urban populations have increased and people have settled in flood-prone areas. The Government of Rwanda is committed to sustainable urbanization. In 2013, the City of Kigali adopted its first master plan, which was revised in 2020 and projected to 2050, to stop and address unplanned settlements and developments in disaster risk areas. While droughts tend to take a serious toll on production in rural areas, they also contribute to food price inflation and reduced consumption in urban areas. For example, prices of basic foods rose significantly during a particularly long drought in 2016, affecting all major cities. The more agriculturally dependent and drought-prone secondary city of Nyagatare is already suffering from drought, via loss of crop and livestock and decreased production in the agro-processing sector located there.[5] Given the historic evidence of changes in climate, the question is: What are the potential future trends concerning Rwanda's climate?

Rainfall trends have shown an increased occurrence of extremes, with the El Niño Southern Oscillation influencing precipitation trends during El Niño years. Rwanda's eastern region has experienced frequent dry episodes from September to December. While the precipitation regime has not changed significantly in overall volumes, changing rainfall dynamics are being observed. For example, rainfall events in Rwanda are becoming more intense, but with extended periods of aridity. Given Rwanda's hilly topography, intense rainfall events result in greater and more severe landslides and mudslides. In the 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, the country's primary dry season, June–August, not only overlaps with the hottest time of year, but the number of consecutive dry days (days <1 mm of precipitation) is also projected to extend through mid-century.

1.2.3. Rwanda's Potential Climate Futures

Rwanda is increasingly experiencing the impacts of climate change, notably with respect to temperature. According to Rwanda's updated nationally determined contributions (NDCs), temperature increases have been observed from 1971 to 2016, showing rises in the mean temperature between 1.4°C and 2.6°C in Rwanda's southwest and eastern regions (World Bank Group 2021c). To assess plausible climate, future scenarios are used as examples of possible climate trajectories over the 21st century. For this, a greenhouse gas (GHG) concentration trajectory is used—the so-called Representative Concentration Pathway (RCP)—but many more scenarios would be required to include anthropogenic trends and natural variability. The climate scenarios discussed below, and their respective impacts, are thus illustrative and do not cover the full range of possible climates and impacts.

According to the optimistic RCP2.6[6] scenario, Rwanda's mean annual temperature could be 20.64°C, with a range between 20.08°C to 21.11°C by 2050. Under RCP4.5[7], the middle-of-the-road scenario, the mean annual temperature could reach 20.92°C by 2050, with a range between 20.16°C to 21.47°C as can be seen in Figure 8. Under the RCP8.5[8], the pessimistic scenario, it is estimated that the mean annual temperature could be 21.51°C, with a range between 20.65°C to 22.06°C by 2050 (see Figure 8). The anticipated maximum temperatures are set to increase from about 26.01°C to between 27.38°C (RCP2.6) and from 25.89°C to 27.54°C (RCP4.5), and from 26.62°C to 28.25°C (RCP8.5) by 2050 (see Figure 9).

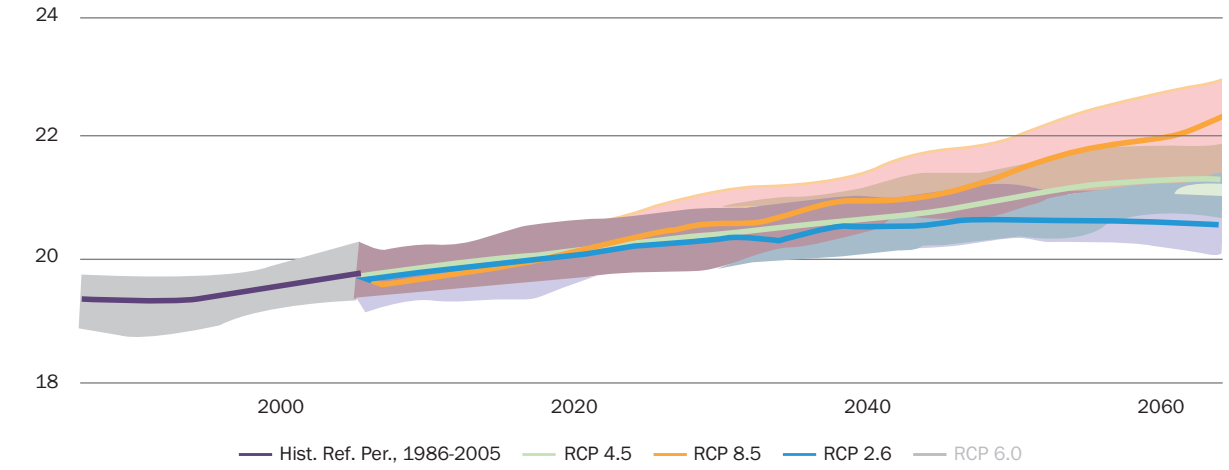
5 Chapter 3 estimates the net impact of these rural-urban and input-output effects at the macroeconomic level.

6 The most optimistic yet stringent climate scenario. This requires a successful global effort to limit temperature rise, or for global CO_2 emissions to decline to around zero, by 2080.

7 The intermediate scenario. This assumes countries' climate actions to be less ambitious or successful and that emissions peak between 2040 and 2050 and then decline.

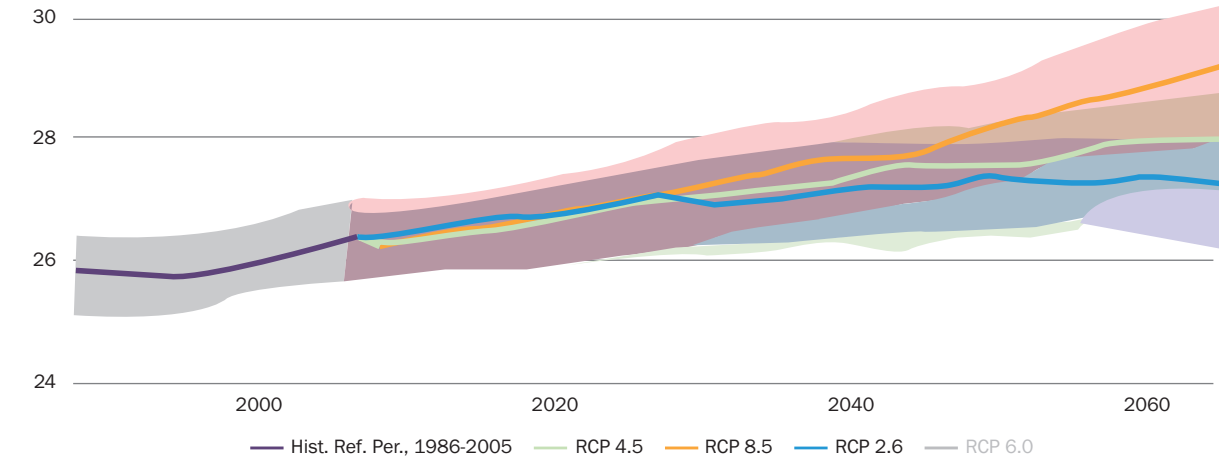
8 Although long-term GHG emissions in the RCP8.5 are considered overly pessimistic, the CMIP5 climate change scenarios with RCP8.5 provide a useful (and not implausible) high-warming scenario, which would be consistent with continued GHG emissions and high climate change sensitivity, or positive feedback from the carbon cycle.

Figure 8: Projected Changes in Rwanda's Mean Annual Temperature, by RCP (CMIP5)



Source: World Bank Group (2021c).

Figure 9: Rwanda's Projected Maximum Temperatures, by RCP



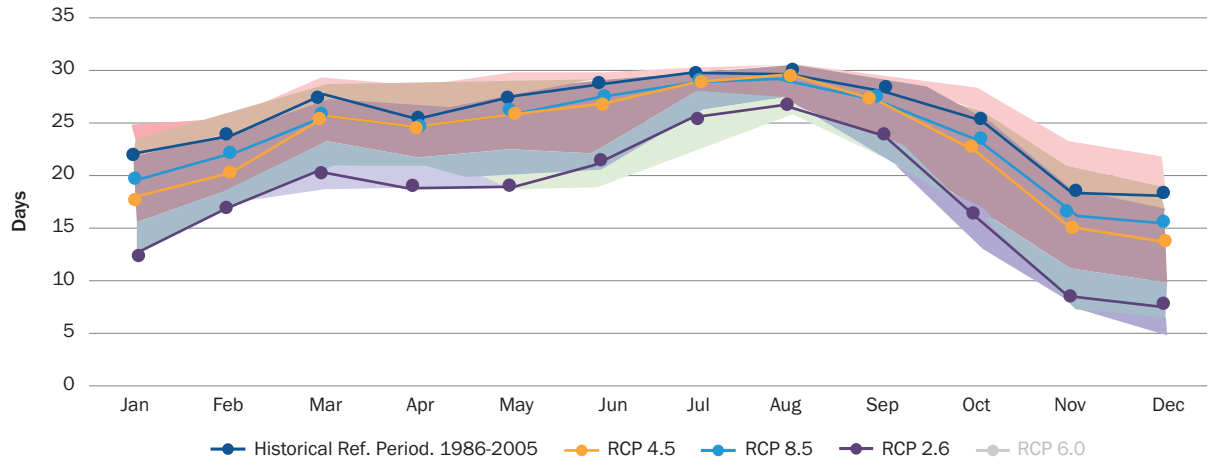
Source: World Bank Group (2021c).

Additionally, the projected number of days with a maximum temperature exceeding 25°C is projected to increase from approximately 220 days per annum (p/a) for the historical reference period, 1986–2005, to approximately 279 days p/a under RCP2.6, and approximately 289 days p/a under RCP4.5, and to 307 days p/a under RCP8.5, by 2050. Furthermore, as can be seen in Figure 10, the number of days surpassing 25°C (for RCP8.5) will increase throughout the year, most notably during March to October, by mid-century.

The maximum of daily maximum temperatures is also expected to increase, with ensemble median increases of approximately 2°C expected throughout the year, by the 2040–2059 period, under RCP8.5. This is likely to result in not only warmer and extended summer seasons, but higher temperatures during the hottest time of the day. While the projected increases in temperatures for Rwanda through mid-century are not projected to surpass critical biophysical or extreme heat thresholds, Rwanda's broader climate is warming.

Climate change is expected to increase the frequency of extreme weather events affecting Rwanda. The rate of occurrence of the largest precipitation event was calculated for the return period of 1, 5, 10, 20, 50 and 100 years, under RCP4.5 and RCP8.5 for 50th and 66th percentiles for the period 2010–2039 and

Figure 10: Rwanda's Projected Seasonal Cycle of the Number of Summer Days (Tmax >25°C) for the Period 2040–2059, Under RCP2.6, RCP4.5 and RCP8.5



Source: World Bank Group (2021c).

2020–2049, as compared to the 'present day' reference period: 1986–2015 (World Bank Group 2021c).[9] Across the five provinces of Rwanda, the return period of extreme precipitation events is expected to increase under RCP8.5 over time. This implies a higher frequency of occurrence towards the middle and end of the century. For example, the largest 1-in-50-year precipitation event is expected to occur approximately every 45 and 37 years under RCP4.5 and RCP8.5, respectively, for the period 2020–2049, using the 66th percentile (see Table 3). In general, for both climate change scenarios, the frequency increase of the largest precipitation in the northern part of Rwanda is expected to be greater than the rest of the country.

Table 3: Extreme Frequency in Precipitation for Rwanda, 10-year and 50-year Return Periods

Province	Probability of occurring in years (66th percentile)				Return periods
	RCP4.5		RCP8.5		
	2010–2039	2020–2049	2010–2039	2020–2049	
East	9.3	8.7	9.0	7.9	10-year event
Kigali City	9.2	8.6	8.9	7.9	
North	9.3	8.6	9.1	8.2	
South	9.4	9.1	9.4	7.9	
West	9.4	8.9	9.3	8.0	
East	46.0	42.6	43.7	37.2	50-year event
Kigali City	45.7	42.3	43.5	37.7	
North	45.8	41.9	45.0	39.2	
South	47.7	44.9	46.7	37.2	
West	46.6	43.7	46.5	38.2	

Source: World Bank Group (2021c).

9 A 'return period' is the frequency with which, on average, a given precipitation event is equaled or exceeded. The 50th and 66th percentile refers to either half or two-thirds of the model distributions up to 2050.

1.2.4. Anticipated Impacts of Climate Change

To estimate the anticipated impacts of climate change on the economy and society of Rwanda, a damage function approach was followed. These functions were estimated using biophysical models concerning changes in flood severity, crop yields, labor productivity and supply, and tourism, based on a range of climate variables. These are used to estimate the effects of the RCP2.6, RCP4.5, and RCP8.5 ensembles on the economy of Rwanda compared to a baseline.[10]

The impact of floods on manufactured capital and assets is likely to increase over time with the most notable impact on agriculture under the RCP8.5 scenario. Based on the geography of Rwanda, as well as the distribution of the manufactured assets, the possible damages from flood events to capital were estimated. The expected annual damage to capital is presented in Table 4 as a percentage of the country's capital that is exposed every year.[11] For agriculture, this implies either 0.306% or 0.362% of its capital is exposed to flooding every year under the RCP4.5 and RCP8.5 scenarios, respectively, for the period 2036–2065.

Table 4: Expected Annual Damage to Capital

Type	RCP	Baseline	2010–2039	2020–2049	2036–2065	2071–2100
Agriculture	RCP4.5	0.19%	0.23%	0.26%	0.31%	0.37%
	RCP8.5	0.19%	0.25%	0.28%	0.36%	0.74%
Built-up	RCP4.5	0.15%	0.19%	0.21%	0.25%	0.30%
	RCP8.5	0.15%	0.20%	0.23%	0.30%	0.62%

Source: IEc (2022).

With respect to a change in crop yields, the responses to climate change are likely to vary by crop, and in response to changes in temperature and precipitation. Based on a dry/high-impact scenario,[12] the temperature effect generally reduces crop yields, while the precipitation effect has a small moderating impact, reducing the detrimental consequences of climate change. Under the wet/low-impact scenario, the temperature effect has virtually no effect on crop production, while the precipitation effect has a strong positive effect, resulting in a net positive outcome among most crops.[13] Maize, rice, and sorghum production performs better under drier and warmer conditions, while coffee and potatoes are detrimentally affected. However, banana and tea production benefits most under wetter and cooler conditions.

The direct effect of a temperature rise on labor productivity is small. Mean temperatures are generally within a mild range not high enough to severely reduce labor productivity, not even in an RCP8.5 ensemble of projections, which may not be the case for a particular general circulation model (GCM). For this reason, Figure 11 presents a stylized projection of temperatures for the country and the associated impacts on labor productivity.

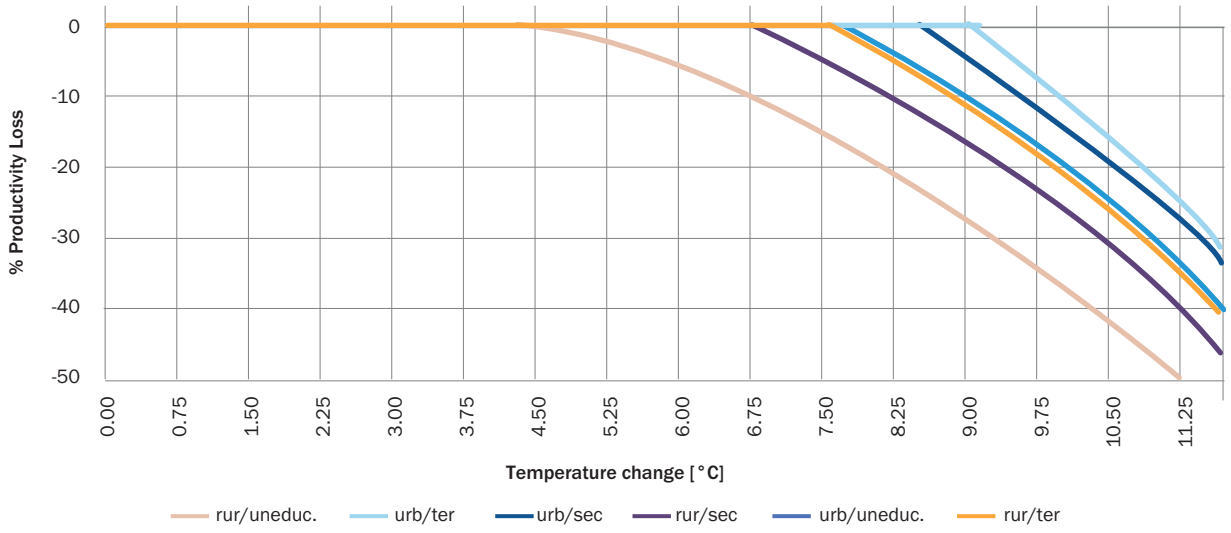
10 The climate baseline for our analysis is 1980 to 1999, developed based on a ½ x ½ degree spatial resolution dataset from Princeton University's Terrestrial Hydrology Group (Sheffield, Goteti, and Wood 2006).

11 Expected damages from flooding disasters with 50- and 100-year return periods are presented in Table 8 of Technical Appendix.

12 Based on the second-driest projection of 28 global circulation models (GCM: MIROC-ESM-CHEM), selected based on the 2040–2059 period in the RCP8.5 ensemble.

13 Based on the second-wettest projection of 28 global circulation models (GCM: GFDL-ESM2M), selected based on the 2040–2059 period in the RCP8.5 ensemble.

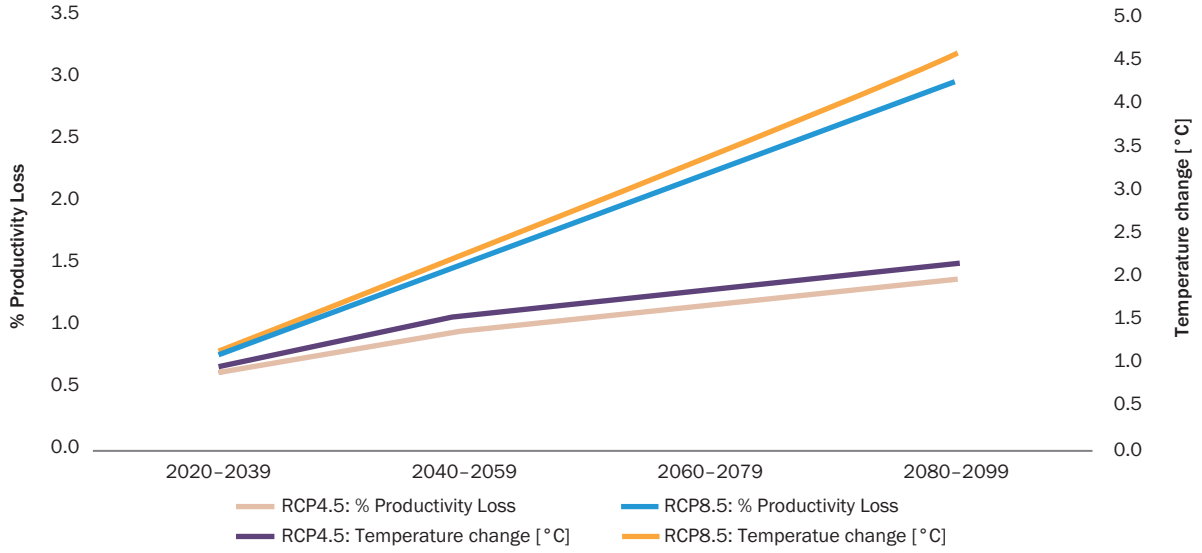
Figure 11: Heat-related Productivity Impacts (Stylized)



Source: IEc (2022).

In addition to direct labor productivity lost due to temperature increases, climate change has an indirect impact on labor productivity by having a detrimental impact on human health. Based on local, regional, and global epidemiological studies, a comparative analysis of the predicted change in temperature under the RCP8.5 ensemble, and productivity loss because of a decline in health, is provided in Figure 12. There is an anticipated reduction in productivity of 1.5% between 2040 and 2059 because of a temperature increase of 2°C. In terms of RCP4.5, the equivalent reduction in productivity is about 1%, given a temperature increase of 1.5°C.

Figure 12: Labor Productivity Loss from Health Effects

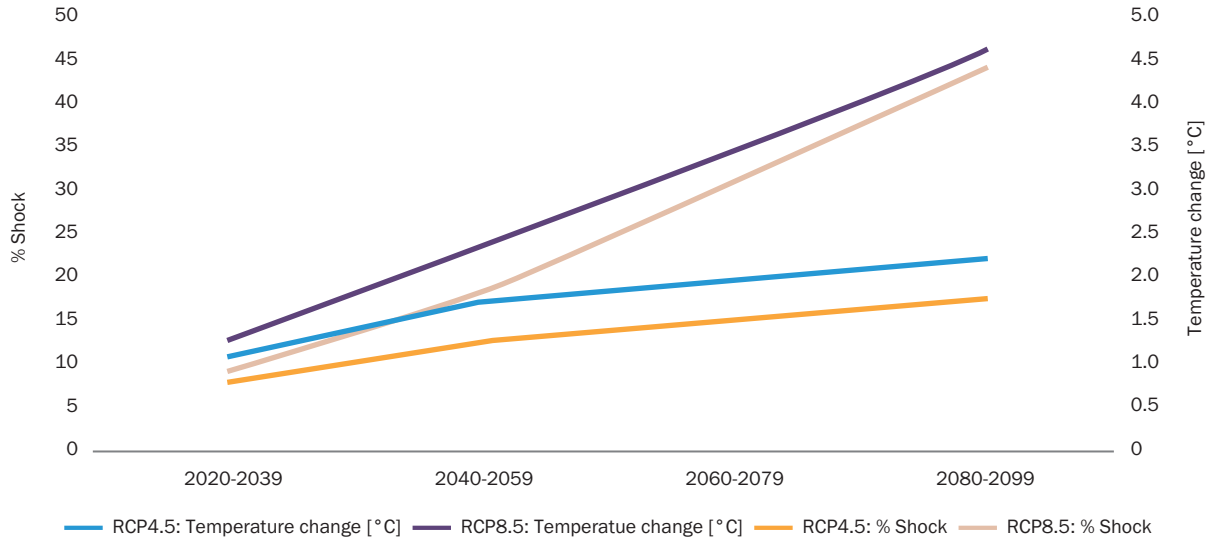


Source: IEc (2022).

An increase in temperature is likely to have a detrimental impact on tourism. Based on historical tourist arrival patterns to countries around the globe, tourism is likely to increase in cooler countries, but warmer

countries are likely to see a decline. Under the RCP8.5 scenario, an increase of 2°C between 2040 and 2059 could lead to a reduction in international tourism demand of approximately 20% (see Figure 13). In terms of RCP4.5, the equivalent reduction in tourism is about 11%, given a temperature increase of 1.5°C.

Figure 13: Tourism Demand Shock from Temperature



Source: IEc (2022).

1.2.5. Climate-related Development Risks

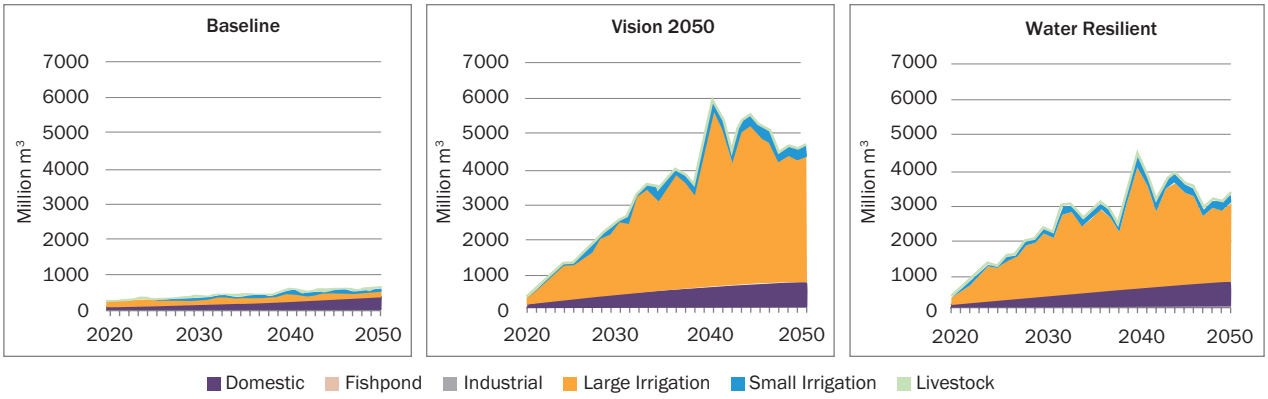
The highly plausible increase in extreme precipitation events is an indicator of the likely increase in erratic weather patterns that, for periods, could also imply an increase in the risk of droughts or water scarcity. This has been demonstrated in the risk atlas where an (agricultural) drought hazard assessment identified that the eastern districts—namely Kayonza, Gatsibo, Kirehe, Nyagatare, Rwamagana, Ngoma, and Bugesera—experience moderate to very high susceptibility to severe drought. As per the atlas, a total of about 62,000 tons and 157,700 tons of major crops are vulnerable to severe drought in the September to December and March to May rainy seasons, respectively (MIDIMAR 2015).

Climate change is likely to increase Rwanda's developmental risk and vulnerability on various fronts. The ND-GAIN Index, an index which ranks 182 countries with respect to the country's vulnerability to climate change and other global challenges as well as their readiness to improve resilience, ranks Rwanda as 124th (GoR 2019c). This vulnerability is because of ecosystem vulnerability and resultant soil erosion. In the floods of 2018, for example, landslides occurred in various parts of the country because of soil erosion, which was triggered by runoff from especially unprotected lands, or from urban settlements (GoR 2019c). In this regard, the National Contingency Plan for Floods and Landslides (GoR 2018c) highlights the fact that the vulnerability of Rwanda to floods and landslides is largely due to its topographic and demographic characteristics. The areas most affected include the districts of the northwestern provinces, such as Nyabihu, Rubavu, Musanze, Burera, Ngororero, Karongi, Rutsiro, and Gakenke. The estimated total economic loss due to road landslide exposure, for example, is equivalent to RWF 54.54 billion (MIDIMAR 2015). It is estimated that in 2015 approximately 45% and 39% of paved and unpaved national roads were exposed to landslides, respectively. In addition, 74% of district roads were also exposed to landslides (MIDIMAR 2015). Most of the road network in Rwanda is currently unprepared for current and future weather events.

Due to increasing population pressures and socioeconomic drivers, there are many incidences of human settlement in areas that are unsuitable, often coinciding with inappropriate land management practices. The increase in the intensity of the precipitation events increases the exposure to landslides and thus also the citizens' vulnerability. In addition, the economy of Rwanda depends mainly on rainfed agriculture, which makes the country highly vulnerable to climate change due to the expected increasing variability in rainfall frequencies and intensity, causing climatic hazards such as droughts, floods, extreme temperatures, and prolonged dry spells, as highlighted above.

The country is likely to experience future water resources challenges across different geographical areas that could hamper future growth and transformation in the country. Annual water demand is expected to increase significantly for all sectors and all scenarios in a recently completed Hydro-Economic Analysis for Rwanda (WBG 2022). According to this assessment, the baseline scenario indicates an increase of 83% by 2050, relative to 2020, with respect to water demand.[14] Implementing Vision 2050 will require an increase in water demand of 1,140%, with the Water Resilient Vision 2050 implying an increase of 740% over 2020 levels (see Figure 14).[15] Domestic use and irrigated agriculture currently make up over 90% of the total water demand. The expected increase in water demand with the expansion of irrigation (particularly large-scale irrigation) is likely to escalate this proportion even further, with irrigation (large- and small-scale) accounting for 43% of the total demand under the baseline—85% under Vision 2050, and 77% under Water Resilient Vision 2050 scenarios.

Figure 14: Projected Annual Water Demand, 2020–2050



Source: World Bank Group (2022).

Under all three scenarios, Rwanda is likely to experience a water supply gap and unmet demands across all sectors. This suggests the need for additional storage to meet the gap between demand and supply. This also implies new development opportunities.

14 The baseline scenario represents a future which assumes 'business as usual', with no major new policies or infrastructure. In this analysis, the baseline scenario is based on historical trends (e.g., for water demand) and excludes commitments in Vision 2050, which is treated as an alternative scenario in the simulations, so that the effects of Vision 2050 on water demand can be formally analyzed. The baseline scenario assumes growth in final domestic demand and exports in each sector, based on recent trends, and represents a long-run value. The long-run growth rate of final demand was set to 7.1%/year.

15 The Water Resilient Vision 2050 scenario identifies pathways that are consistent with the intentions of Vision 2050, but 'factors in' the potential impacts of climate change on water availability, to set more realistic targets, such as irrigation practices and levels of hydropower, as a portion of the overall electricity mix.

1.2.6. Development Opportunities

Investing in climate resilience can bring substantial opportunities with respect to risk reduction and development. With respect to risk reduction, the benefits are significant, since the opportunity cost of disasters, such as floods, is high. For example, the damages and losses from the 2018 floods were estimated at $237 million, with the cost of recovery and reconstruction estimated at $336 million (see Table 5).[16] The physical sectors bore the brunt of the damage, with the impact comprising 57% of the total. This resulted in the disruption of infrastructure-linked services.

Table 5: Estimate Cost of the 2018 Floods, in millions of dollars

	Damage and losses	Reconstruction requirement
Productive sectors	42.6	48.3
Physical sectors	134.5	162.3
Social sectors	58.0	96.8
Cross-cutting issues	1.5	28.9
Grand total	236.7	336.3
Percent of GDP	2.7%	3.5%

Source: GoR (2019c).

These disruptions, in turn, can halt business operations, causing the loss of wages and incomes, and sending shocks through supply chains that can significantly reduce GDP. Hallegate et al. (2019) estimate that power disruptions reduce Rwandan firms' capacity utilization by around 1.5% annually, transport disruptions by 1.0%, and water infrastructure disruptions by 0.5%.[17] Improving climate resilience provides opportunities to reduce the costs of disasters related to natural hazards through cost-effective investments. Investments in improved resilience have a high rate of return, with benefit-cost ratios that range from 2:1 to 10:1 (GCA 2019). Particularly for infrastructure, investments in climate resilience can have $4 in benefit for each $1 invested (Hallegatte et al. 2019). There is also ample evidence as to the benefit of ecological restoration, in both natural as well as urban landscapes, with benefit-cost ratios of up to 35:1 (De Groot et al. 2013, Elmqvist et al. 2015).

Vulnerability to climate change, notably urban flood risks, has also been exacerbated by unmanaged urban growth and the subsequent degradation of natural resources and ecosystem services. To sustain Rwanda's growth trajectory and gains, efforts are needed to enhance resilience by improving adaptive capacity against climate-related risks, such as floods. Rwanda's exposure to climate change and the associated disaster risks can undermine its growth prospects and slow down poverty reduction efforts in the long term. Rwanda's priority now is to carry out adaptive, responsive planning that improves urban development, harnessing the agglomeration economies that are essential for future economic growth and poverty reduction, while taking heed of the country's vulnerability to the climate change. This can be achieved by, among others, mainstreaming climate resilience in all forms of urban planning, and the addressing of institutional and capacity constraints toward urban planning (World Bank Group 2022).

16 Damages represent the estimated value of physical and natural assets destroyed by the floods. Losses represent the reduction in production or income that would have been generated by the destroyed assets (e.g., loss of rental income from destroyed housing). Recovery needs include not only the expected cost of replacing destroyed assets, but also of proposed social programs to support vulnerable populations, credit to restore business activity, and the establishment of a legal framework to provide insurance against natural hazards (GoR 2019c).

17 Using World Bank Enterprise Survey data for a sample of 118 countries, Hallegate et al. (2019) find that unreliable power, water, and transport infrastructure cause annual capacity utilization losses equivalent to 0.6% of sample GDP.

Within a broad range of economic sectors, there are several low-carbon intensive options which offer significant development benefits, while being beneficial to both climate adaptation and mitigation. This will be discussed next.

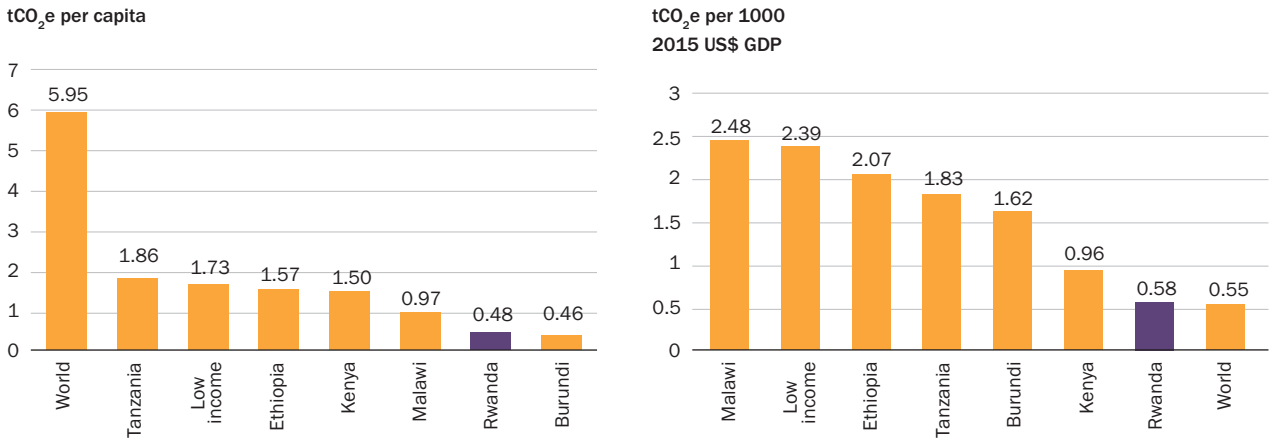
1.3. Risks and Opportunities for a Low-carbon Growth Path

1.3.1. Rwanda's Greenhouse Gas Profile: 2015–2030

Both regionally and globally, Rwanda's contribution to greenhouse gas emissions (GHG) are low with Rwanda contributing 0.003% to global CO_2 emissions.[18] Rwanda's per capita emissions are about 0.5 tCO_2e (see Figure 15), which is around one-fifth of the regional average and just one-twelfth of the world average, reflecting Rwanda's predominantly agricultural economy, based on subsistence farming and low fossil energy demand. Rwanda also has a relatively low emissions intensity—around 0.6 tCO_2e per 1000 2015 US$ GDP.

The first biennial update report (BUR1) revised the original NDC values of Rwanda's GHG emissions for 2015. According to Rwanda's NDC (GoR 2020a), the country's GHG emissions (see Table 6) from sources described according to the reporting guidelines of the Intergovernmental Panel on Climate Change (IPCC 2006) were estimated at 5.3 million tons of CO_2-equivalent emissions ($MtCO_2e$) in 2015. These estimates excluded emissions from forestry and other land use (the FOLU sector) and removals by forestry.

Figure 15: Regional Comparison of Rwanda's Per Capita and GDP Emissions, 2018



Source: World Bank, World Development Indicators.

Note: Emissions exclude the forestry and other land use (FOLU) sector.

Table 6: National GHG Emissions

	2015 $MtCO_2e$
Total emissions: NDC	5.34
FOLU and revised non-FOLU emissions	3.18
Revised total emissions (Figure 16)	8.52
Emission removals from forestry	-6.66
Total net emissions (total emissions minus removals)	1.86

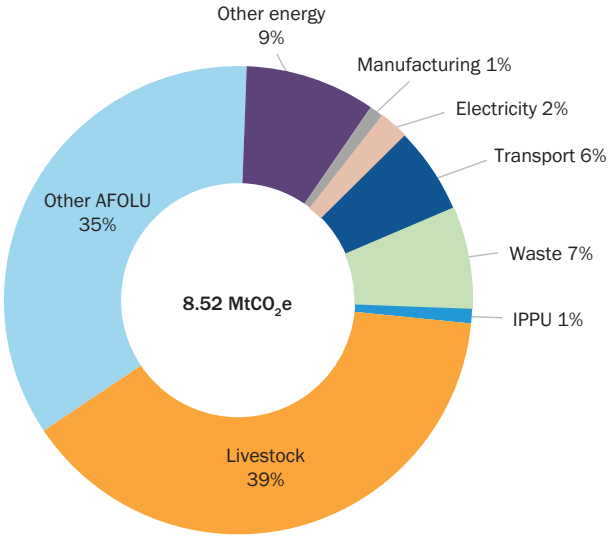
Source: GoR (2020a) and GoR (2021b).

18 https://databank.worldbank.org/source/world-development-indicators#

The BUR1 (GoR 2021b) includes these estimates; see Table 6 for a comparative analysis. The inclusion of FOLU emissions in conjunction with a revision of the emissions from some agriculture and energy sources results in an addition of 3.18 $MtCO_2e$. This resulted in total emissions (excluding removals) of 8.52 $MtCO_2e$ for 2015. The removal of emissions by forestry is estimated at about 6.7 $MtCO_2e$. Therefore, the net emissions for 2015 are estimated at 1.86 $MtCO_2e$. This translates to 0.15 tCO_2e/capita, or 31% of the value excluding removals.

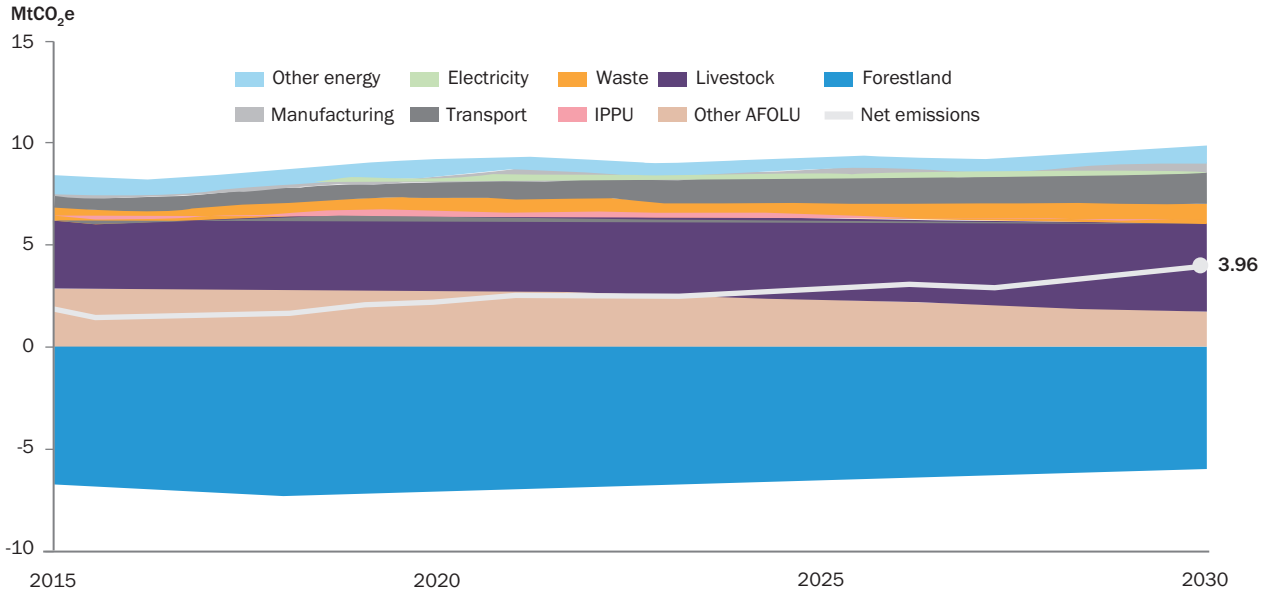
Emissions from livestock dominate the emissions profile of Rwanda. Based on BUR1, the agriculture, forestry, and other land use (AFOLU) sector accounts for approximately 74%, or 6.26 $MtCO_2e$, with emissions from livestock contributing the most (see Figure 16). Energy accounts for 18%, or 1.54 $MtCO_2e$, of the total, mainly from energy combustion in households, and gasoline and diesel use in road transport, with only a small contribution from the country's predominantly hydro-based power generation sector. Industrial processes and product use (IPPU) accounts for just 1% of the total, or 0.08 $MtCO_2e$, mainly representing emissions due to calcination from domestic clinker production. The waste sector accounts for around 8% of the total (0.64 $MtCO_2e$), mainly methane emissions from solid waste disposal sites at unmanaged dumpsites, and from waste-water treatment and discharge. When considering Rwanda's adaptation and mitigation measures included in its updated NDC, the country's net emissions are estimated to increase to 3.96 $MtCO_2e$ by 2030 (see Figure 17).

Figure 16: National GHG Emissions by Source (Excl. Removals), 2015



Source: GoR (2020a) and GoR (2021b).

Figure 17: NDC Emissions Profile, 2015–2030, All Sectors



Sources: GoR (2020a) and GoR (2021b).

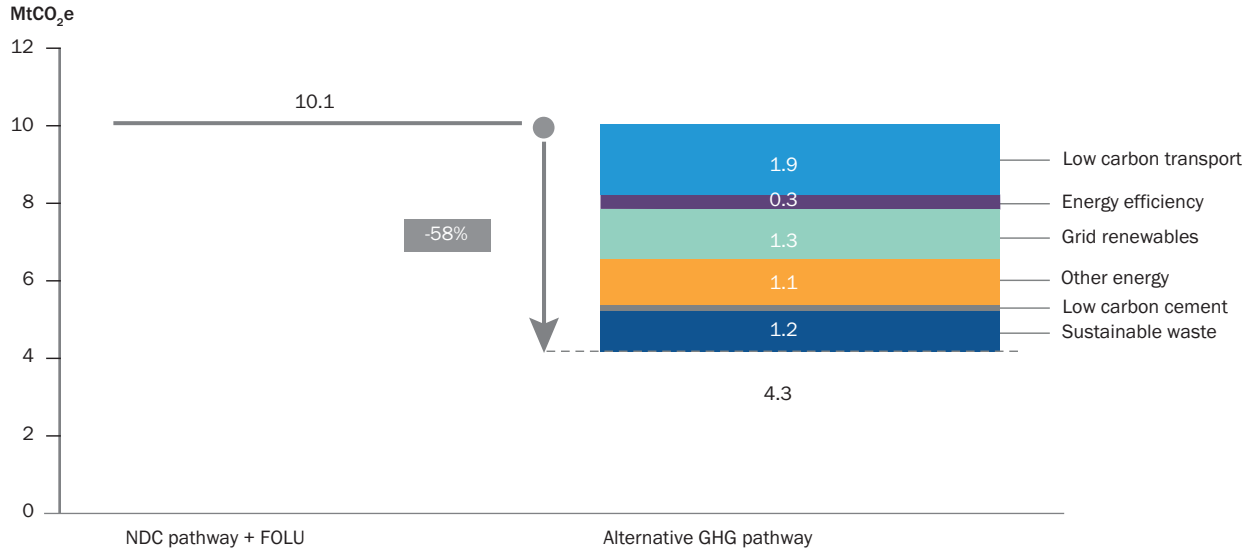
1.3.2. Mitigation: Scenario Description, 2015–2050

To estimate Rwanda's mitigation potential over the longer term an NDC pathway + FOLU scenario is developed and an *alternative GHG pathway* is explored for the period 2015–2050. With respect to the NDC pathway + FOLU scenario the mitigation measures outlined from 2015 to 2030 were continued till 2050 and updated or re-evaluated according to more recent policy developments, plans, and data availability, including updated long-range power generation scenarios, road transport analysis, and, most significantly, the inclusion of the FOLU sector. The alternative GHG pathway considers further efforts to achieve deeper emission reduction outcomes across the energy, waste, and industrial sectors. This includes additional measures and the expansion of actions included in the NDC pathway + FOLU scenario (Carbon Counts 2022). The AFOLU options included under the NDC pathway + FOLU scenario have been considered to represent the maximum feasible scale of implementation and therefore no additional AFOLU reductions are included in the alternative GHG pathway. While assumptions concerning the implementation rates for mitigation measures are intended to be ambitious and not constrained by investment costs, they are considered technically feasible.

Figure 18 compares the NDC pathway + FOLU scenario with an alternative more ambitious GHG pathway. Implementing the NDC pathway + FOLU has the capability to achieve deep emissions cuts (without compromising Rwanda's growth and development potential), thereby putting the country on an emissions trajectory that is lower than the current NDC estimates indicate (see Figure 19); this is mainly the result of FOLU measures included herein. The alternative scenario can result on a net reduction of 4.3 $MtCO_2e$, as a result of the measures outlined above, (see Figure 18 [for 2050] and Figure 19 [showing the evolution over time]).

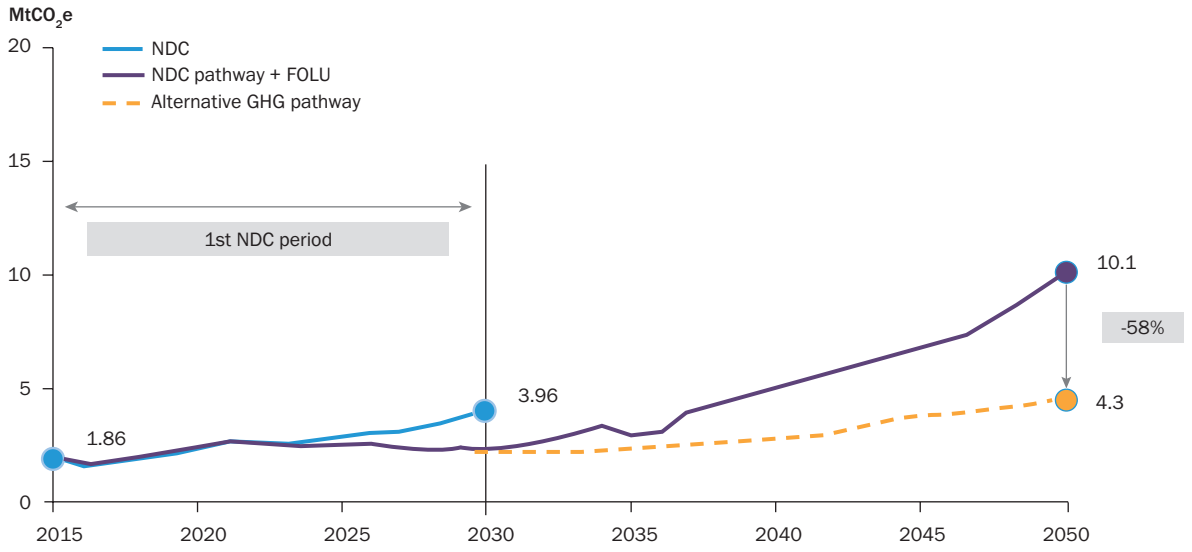
The breakdown of the emissions by sector is provided in Figure 20 for the NDC pathway + FOLU, and for the alternative GHG pathway in Figure 21 (and described in the CCDR Technical Appendix). The substantial contribution of emission removals by the FOLU sector, which has been held constant for both scenarios (as mentioned above) is clearly seen. Likewise, the mitigation potential under the alternative GHG pathway for the energy, industrial, and waste sectors can be observed.

Figure 18: Mitigation Scenarios by Sector, 2050



Sources: GoR (2021b) and World Bank staff analysis (2022).

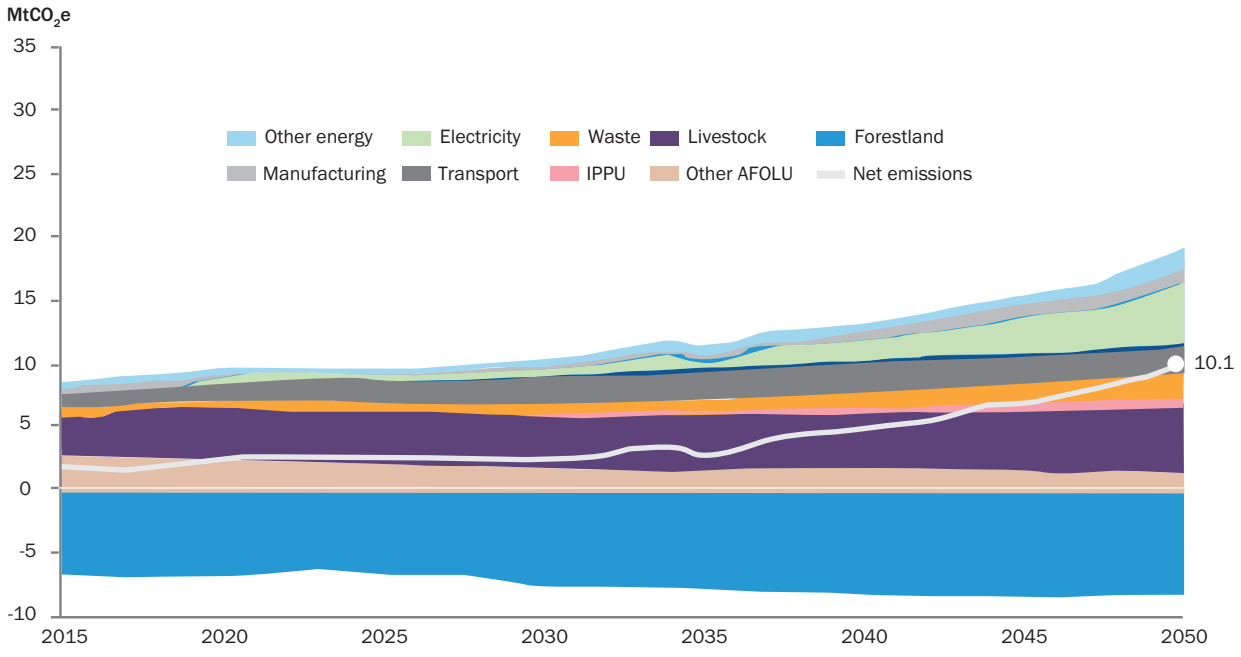
Figure 19: GHG Emission Scenarios



Sources: GoR (2021b) and World Bank staff analysis (2022).

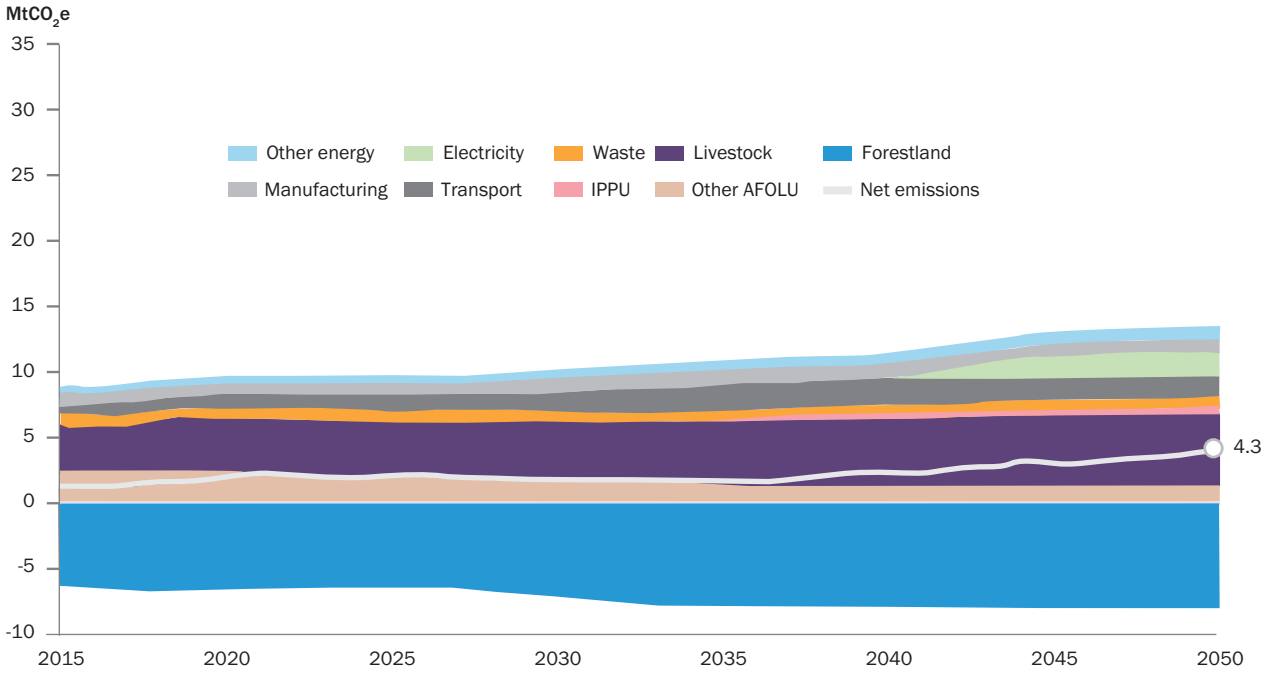
The projected reductions are associated with implementing changes to energy use over the coming decades, including through a combination of fuel switching to lower-carbon energy sources (for example, from peat, diesel, and gasoline to electricity, solar energy, and lake methane), fuel efficiency and fuel switching in the transport sector, and improved operational efficiency. Sustainable waste management measures also contribute a significant share to overall mitigation, through the introduction of technologies such as landfill gas utilization, waste-to-energy, composting and wastewater treatment alongside reduction, reuse, and recycling policies.

Figure 20: NDC pathway + FOLU emissions



Sources: GoR (2021b) and World Bank staff analysis (2022).

Figure 21: Alternative GHG pathway emissions



Sources: GoR (2021b) and World Bank staff analysis (2022).

The mitigation scenarios show significant technical potential for Rwanda to achieve deep emission cuts across all sectors, alongside its ongoing economic growth and its increasing access to modern energy and services, as part of the country's development goals. To achieve this, considerable challenges will need to be overcome to decouple economic growth from rising emissions growth, while ensuring the country moves along an alternative low-carbon pathway. While some of these challenges are technical in nature, it is important to note that most of the abatement options assessed are globally proven technologies, and that the barriers to their successful implementation at scale are mainly associated with overcoming investment hurdles and capacity needs.

2

Climate Change Commitments, Policies, and Capacities

2. Climate Change Commitments, Policies, and Capacities

2.1. Climate Change Commitments and Policy Framework: Resilience and Mitigation

Rwanda has established a set of climate change commitments and undertaken important efforts to incorporate climate change in the development agenda. Since 1998, when it ratified the United Nations Framework Convention on Climate Change (UNFCCC), the country has been committed to addressing the challenge of climate change. Rwanda submitted its Initial National Communication to the UNFCCC in 2005, the National Adaptation Program of Action (NAPA) in 2006, and the Second and Third National Communications in 2012 and 2018, respectively. It ratified the Paris Agreement and submitted the first NDC to the UNFCCC in 2016. In 2020, the country submitted an updated NDC demonstrating increased ambition, with a more detailed and robust assessment of mitigation and adaptation measures in Rwanda. It included priority interventions which identify synergies between mitigation and adaptation, and alignment with the SDGs.

Rwanda has put in place a legal, policy, and strategic framework to build resilience into climate change impacts. Over the last decade, Rwanda strengthened its climate policy framework through the Green Growth and Climate Resilience Strategy (GGCRS) (GoR 2011a and 2021a), the National Environment and Climate Change Policy (NECCP) (2019), and its updated NDC (GoR 2011a; GoR 2021a; GoR 2019d; GoR 2020a). The commitments established in the NDC draw upon the climate policy and development framework, therefore they are aligned with objectives and priorities established in the GGCRS, the NECCP and sectoral strategies. However, implementation challenges remain—such as funding gaps, institutional capacity, and technical knowledge—to undertake the delivery and monitoring of climate measures. Rwanda is updating the GGCRS to better reflect recent trends, provide more detailed implementation guidance for three key time horizons (2030, 2035, and 2050), and to ensure alignment with the recently developed NST (2018–2024), in conjunction with Rwanda's seven-year Government Programme.

Rwanda has undertaken important efforts to mainstream climate change in key planning instruments and sectoral strategies. Key cross-sectoral planning instruments include the National Land Use and Development Master Plan (NLUDMP) 2020–2050, which was revised in 2020 to harmonize spatial planning and land use with the goals established in Vision 2050, the NST1, and the GGCRS (GoR 2020b). Sectoral policies that support the implementation of NDC commitments are summarized in Table 7.

2.2. Institutional Coordination and Capacities

The executive branch and the Ministry of Environment (MoE) both demonstrate leadership in climate change strategy and policy. The central government engages in environmental policy formulation and implementation through enacting laws and regulations, monitoring and evaluating programs and projects, raising awareness through public relations campaigns, providing training to government agencies, and advising decentralized institutions. Local governments are responsible for policy implementation, application of laws and regulations relating to the environment, and overseeing the protection of the environment within their jurisdiction. The City of Kigali and districts play a major role in the coordination and implementation of several urbanization and climate-related activities—including urban development, mobility and local-level roads, water, sanitation and solid waste management, unplanned settlement upgrading, and urban greening (which includes wetland management). However, they face capacity challenges in incorporating climate considerations into the programs and projects they undertake in sectors such as, road construction, water, and agriculture.

MoE maintains a coordinating role across government agencies regarding climate policy and action, but coordination mechanisms could be reviewed and strengthened. The original GGCRS, issued in 2011,

Table 7: Policy Framework to Support the Implementation of NDC Commitments

Policies	Cross-sectoral	Sectors				
		Agriculture	Forestry	Urbanization	Transport	Energy
National						
Green Growth and Climate Resilience Strategy (2021a)	(A)(M)					
National Environment and Climate Change Policy (2019)	(A)(M)					
Revised National Land Use and Development Master Plan 2020–2050	(A)(M)					
Strategic Plan for Agriculture Transformation phase 4 (PSTA-4) (2018–2024)		(A)(M)				
Strategic Plan for the Environment and Natural Resources Sector 2018–2024			(A)(M)			
Forestry Policy and Strategy Plan (2018)			(A)(M)			
Rwanda National Water Resources Master Plan (2015)	(A)					
National Urbanization Policy (2015)				(A)	(A)	
National Housing Policy (2015)	(A)					
Updated National Transport Policy and Strategy (2021)					(A)	
Rwanda Energy Policy (2015) —*currently under review*						(M)
Least Cost Power Development Plan (LCPDP) (2020–2040)						(M)
National Cooling Strategy (NCS) (2019)						(M)
Biomass Energy Strategy: A Sustainable Path to Clean Cooking (2019–2030) (2019)	(M)					
National Disaster Risk Reduction and Management (DRRM) Policy (2012) — *currently under review*	(A)					
Health Sector Policy (2015)	(A)					
Subnational						
Kigali Master Plan 2050	(A)(M)					
Master plans for Rwanda's six secondary cities	(A)(M)					

Source: Work Bank staff analysis.

Notes: (A) Alignment with NDC adaptation commitments, (M): Alignment with NDC mitigation commitments.

proposed the establishment and operationalization of some institutional arrangements for the provision of technical advice to government agencies regarding climate policy. An organizational and functional review of these institutional arrangements, as well as the planning, staff, implementation, and monitoring and evaluation (M&E) capacity of the key agencies involved, both directly and indirectly, in the implementation of climate policy (that is, MoE, REMA, the National Fund for Climate and the Environment [FONERWA], the Ministry of Emergency Management [MINEMA], and the Ministry of Infrastructure [MININFRA]), would help to delineate whether the current institutional arrangements are conducive to the effective implementation of the NDCs. Considering REMA's broad mandate, the agency could benefit from increased capacity and resources to perform its mandate effectively, including updating regulations as necessary, providing guidance, and monitoring compliance.

The government has achieved important progress regarding incorporating climate change actions into planning and budgeting instruments. The *Checklist for Environment and Climate Change Mainstreaming* helps sectors and districts integrate climate change actions established in the NST, NDC, and GGCRS in their action plans. The checklist extracts the programs, outputs, and indicators established in these three high-level documents and assigns them to the responsible agencies with targets and deliverables. This mainstreaming approach has achieved greater progress at the sectoral-ministries level (with over 60% of key environmental and climate change indicators integrated in sectoral action plans) than at the district level (with less than 30% of indicators integrated into district action plans). Incentives and budgetary mechanisms could be put in place for market development advisors (MDA) to coordinate with each other in pursuing climate outcomes whose achievement requires action across the government. REMA has also prepared a vulnerability assessment that identifies household vulnerability in the districts. However, district governments require capacity building to make better use of the results of the assessment to inform their adaptation planning. In addition, the national government could ensure that climate change aspects are incorporated in the Districts Investment Plans and the Performance Contracts.

The NDC Measurement, Reporting and Verification (MRV) framework has not been made operational (GoR and World Bank 2021). There is a lack of proper coordination between MoE and REMA to implement the agreed roadmap. Also, there is a need to develop or strengthen the interagency arrangements for reporting on the indicators. It is unclear if the ministries and agencies have been sensitized regarding the requirements of the MRV framework, and if they are equipped with staff and tools to perform MRV tasks. Guidance material defining the variables for each indicator and the methodology for calculation, frequency with which it will be measured, source of data, and data collection channel or mechanism, would help to facilitate the adoption of the MRV framework by ministries and agencies.

In Rwanda's parliament, the Committee on Land, Agriculture, Livestock, and Environment is responsible for issues relating to climate change. It is unclear if the law provides for parliamentary oversight of executive actions (and inactions) on climate and for associated sanctions. It is also unclear if the executive is required to table in the parliament the policies, progress reports, and program evaluations related to climate goals. The government could consider conducting and publicly disclosing reviews, regarding the expenditure and implementation performance of climate-related programs and projects. Stakeholder engagement fora that bring together the civil society, the private sector, and the government for climate policy and action do exist. Mechanisms to enhance private sector and civil society involvement in the implementation of the GGCRS implementation were enhanced. These mechanisms were based on the protocols established through the updated NDC process, to include a broader range of sector and district stakeholders through the Sectoral Working Group and the Joint Action Development Forum. The Forum was introduced to facilitate the participation of citizens in governance and service provision processes in the context of the decentralization agenda.

2.3. Public Financial Management and Climate Finance

The laws and regulations governing public financial management (PFM) have shown notable progress in mainstreaming climate considerations. The Manual of Public Financial Management Policies and Procedures (updated in 2019) points to environmental considerations as a guiding principle for the management of government assets, and requires agencies to consider environmental issues, together with social and economic factors, in making service delivery decisions. Despite the absence of an explicit reference to climate change considerations in the legal framework for the PFM, the Planning and Budgeting Call Circular for the 2021/2022 fiscal year required, for the first time, that the lead institutions for the relevant sectors and districts mainstream environment and climate change priorities and associated indicators in their action plans. The circular introduced a *Checklist for Environment and Climate Change Mainstreaming* requiring all budget agencies to submit an annex reflecting environment and climate change priorities in their budget submissions. This information can constitute the analytical basis for the establishment of a climate budget

tagging framework. The performance-based budgeting framework introduced in the 2021 Finance Law also references climate changes issues. While within the context of the budget process, climate change risks are mentioned; such risks could be considered and mitigated more systematically in medium-term fiscal risk assessment and fiscal risk management exercises. In a similar vein, the existing intergovernmental fiscal transfer scheme, and the Local Government Own Source Revenue Mobilization Strategy currently under development, could be reviewed to gauge the extent to which transfers to local governments and local revenue sources, such as property and rental income taxes and trade license fees, can incentivize climate-resilience outcomes at the district level.

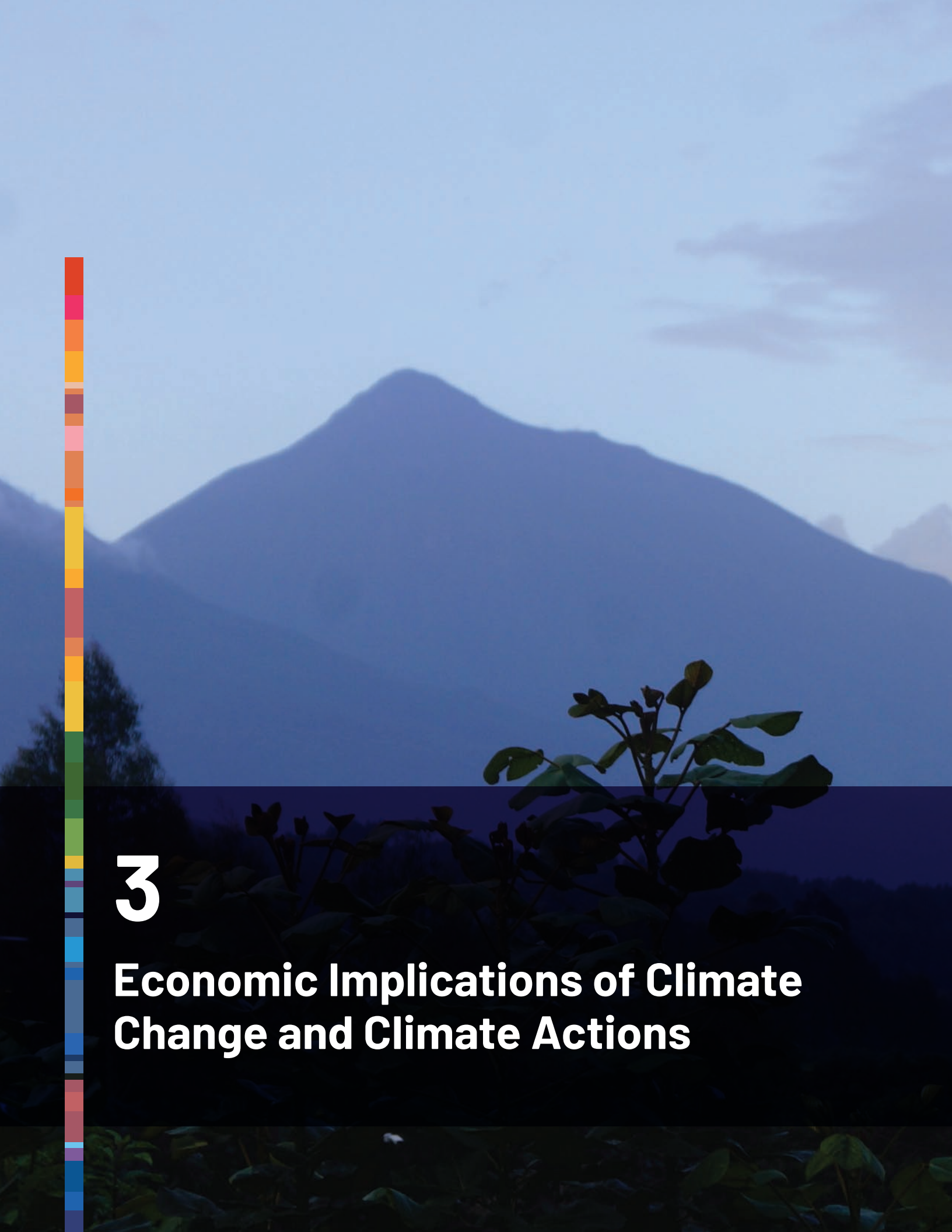
Rwanda's public investment management policy requires the submission of an Environmental Impact Assessment as an annex to the Feasibility Study, for which guidelines exist. Project proposals are required to demonstrate to what extent the project contributes to environmental protection, resource efficiency, and climate change targets. While climate risks and vulnerabilities are mentioned in the guidelines, there is no convincing evidence that these are mitigated throughout the project lifecycle. There is also no evidence that disaster risk, or the concept of the shadow price of carbon, is deployed in the economic analysis and appraisal of public investment projects at the national or district levels. While environmental concerns are considered in the disposal phase of an asset, the asset management framework could be strengthened to promote climate-resilience outcomes through regular maintenance during the operational phase of assets—particularly in sectors that have a direct impact on resilience outcomes, such as water, sewage, and hydropower generation.

The existing public procurement legal framework could be improved to address climate change considerations. The NECCP considers green procurement a high priority. It calls for limiting the procurement of materials with environmental impact to expand markets for green products, while

promoting the development of environmentally friendly technologies and environmental awareness among suppliers and others involved in the supply chain. The policy also highlights the government's commitment for sectors of the economy to put in place mechanisms with the following goals: to develop and promote green technologies in all sectors of economic development; to facilitate appropriate climate change mitigation and adaptation technologies; and to revise legal instruments (including the public procurement guidelines) to promote green technologies and reflect green components in national and district procurement processes. The Rwanda Procurement Authority could develop climate change-related rules in its procurement process or revise its guidelines accordingly.

A comprehensive climate finance strategy, including public and private finance mobilization channels, could help to operationalize the National Strategy for Climate Change and Low Carbon Development in the GGCRS. The primary mechanism through which Rwanda accesses programs, disburses and monitors international and national extra-budgetary climate and environment finance is FONERWA. FONERWA was established with the objective to mobilize and channel domestic and international financing to public and private environment and climate change projects. The semiannual *High-level Dialogue on the Green Growth Report*, issued in 2018, expressed the need to create new pathways for private sector engagement and develop incentives that encourage investment in green growth initiatives, including removing the barriers to green investments at the policy, regulatory, technical, and financing levels.

The focus on promoting private sector engagement in climate finance could be complemented with a public climate finance strategy that considers tools, such as, earmarked budget allocations, carbon and other taxation, green bonds, or auctions and emissions trading systems to finance investments in adaptation and resilient public infrastructure, where private sector engagement is not commercially viable.



3

Economic Implications of Climate Change and Climate Actions

3. Economic Implications of Climate Change and Climate Actions

This chapter assesses how climate change is likely to shape Rwanda's economy over the coming decades and highlights the importance of Rwanda's 2020 updated NDC (GoR 2020a) for achieving the country's development ambitions. The chapter incorporates the main biophysical impacts of climate change on Rwanda that were presented in Chapter 1 into linked macroeconomic and poverty models to identify how climate shocks are felt throughout the economy—at household, sector, and national levels. It then uses these models to simulate how adaptation and mitigation measures in the NDC contribute toward keeping Rwanda on its planned development path. It also identifies trade-offs and synergies facing implementation of these projects—notably challenges associated with financing the investments. The analysis sets the stage for Chapter 3's investigation of opportunities for climate-smart public and private investments.

3.1. Climate Change Prevents Rwanda from Reaching its Development Goals

This section summarizes results from computable general equilibrium (CGE) and poverty models of the Rwandan economy. The CGE model simulates how climate shocks affecting an activity or factor of production are transmitted to the rest of the economy. The model also captures how households, firms, and the government respond to these shocks. The poverty model then combines results from CGE simulations with household survey data to estimate poverty and distributional effects.[19] Simulations suggest that climate change and increased climate variability are likely to prevent Rwanda from reaching its targets for economic output, sustained poverty reduction, consumption, investment, and sectoral transformation.

3.1.1. Modelling Scenarios

Baseline scenario: The CCDR compares the long-run evolution of the economy under several climate change scenarios against a hypothetical baseline economic path in which Rwanda faces no climate variability or damages and undertakes no new climate actions. This baseline aligns with the baseline economic scenario used to develop the 2020 updated NDC (GoR 2020a). It is built around the broad development trajectory articulated in Vision 2050 and related strategies (see Section 1.1 above) and incorporates the macroeconomic and fiscal assumptions from the February 2022 Debt Sustainability Analysis (IMF and World Bank, 2022), with key variables extended through 2050.

Climate scenarios: Climate change enters this CGE model by adjusting factor productivities and damaging capital assets and agricultural land. These effects are structured as functions of expected changes in rainfall and/or temperature associated with RCPs 2.6, 4.5, and 8.5 (ensemble averages) and with wetter, hotter, and drier variants of RCP8.5.[20] Damage functions were estimated for the climate risks relevant for Rwanda that were introduced in Section 1.2 above. An important analytical contribution of this CCDR is that these damage functions were developed using Rwanda-specific data (for example, Rwandan topographical information for flood damages) rather than relying on global averages, which is the conventional approach. Impacts of climate change are measured as percentage deviations of

19 The CGE and microsimulation models are described in the CCDR Technical Appendix. CGE models are well suited for estimating the long-term, economy-wide implications of climate change because they can capture the many complex direct and indirect effects on the structure of the economy that result from both climate change and actors' responses to climate change. These models are arguably less well suited for analyzing the short-term adjustment process of the economy following large discrete shocks, such as disasters linked to natural hazards. All models are simplifications of reality designed to highlight a manageable set of economic relationships or structural factors while abstracting from others. Economic consequences for the financial sector, which are beyond the scope of the CGE model, are also presented.

20 The CCDR Technical Appendix presents annual and monthly climate data used in damage functions.

the values of output, poverty, employment, and so on, in the climate scenarios from in the baseline scenario.[21]

Table 8: Climate Change Damage Functions

Channel	Description of economic effects and damage function
Flooding, capital, and land	Excessive rainfall destroys the capital stock and agricultural land supply; function based on location of assets, expected frequency of flooding, etc.
Crop yields	Changes in rainfall and temperature affect total factor productivity; effects vary by crop and are sometimes positive.
Heat and labor	Excessive heat reduces labor productivity; impact varies by worker's location (rural vs. urban) and skill level.
Total factor productivity	Higher temperatures reduce total factor productivity of livestock, forestry, and fishery.
Human health and labor	Higher temperatures facilitate diseases that harm human health (measured as years of life lost,) and thereby reduce labor productivity.
Tourism exports	Increases in temperature reduce external demand for Rwanda's tourism exports.

Source: World Bank Group staff.

NDC policy scenarios: Implementation of adaptation and mitigation projects that Rwanda committed in its 2020 NDC to undertake through 2030 are incorporated into an alternative policy scenario.[22] Section 3.2 first analyzes the implementation of the climate measures in the 2020 NDC that are designed to meet Rwanda's unconditional commitments (that is, actions a country commits to undertake using existing resources and capabilities) under a range of financing scenarios. It then investigates the case where Rwanda implements all measures in the 2020 NDC, including those intended to meet conditional commitments, that is, those actions that a country would undertake if new resources were made available.

3.1.2. Damage Channels and Economic Losses

Before examining the detailed ways that these climate shocks spread through the economy, it is worth first looking at the high-level effects on the annual GDP and relative contributions of different damage channels. Figure 22 shows how, in the absence of any NDC policy actions, climate change is likely to push the GDP away from the baseline path under the six climate change scenarios listed above, and economic losses tend to increase over time.[23] Several points bear attention.

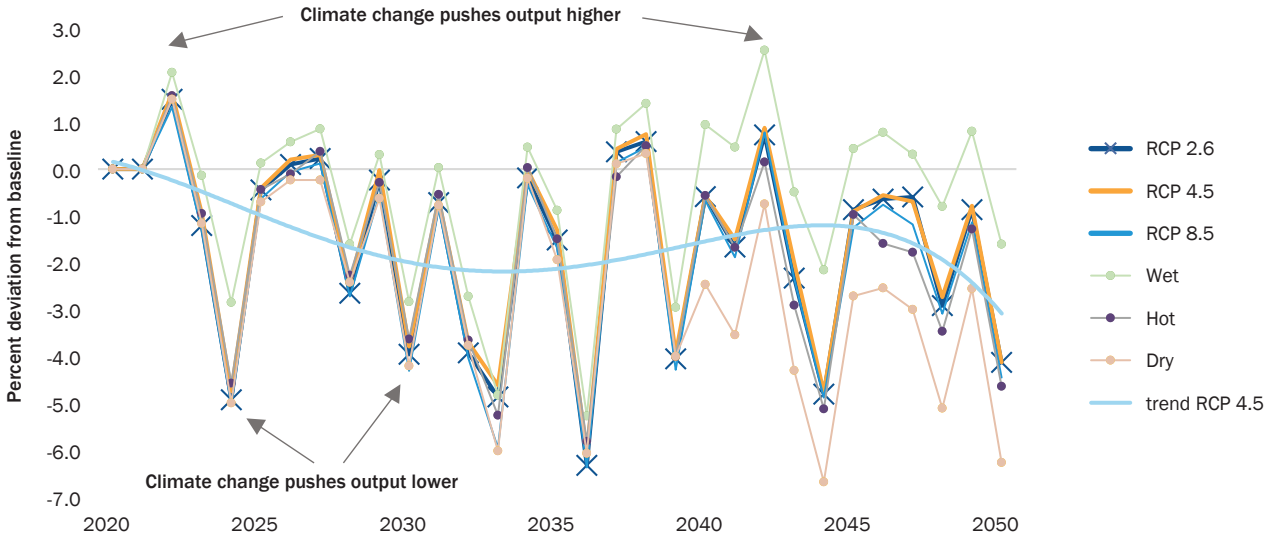
- There is considerable year-to-year variation in the impact of climate change across all scenarios, with output higher than the baseline during some years, but the broad effect is that climate change depresses GDP, leaving it 5–7% lower than the baseline in many years.

21 For economic variables that are conventionally scaled by GDP (e.g., government revenue, debt, balance of trade, etc.), the impact of climate change is presented as differences in the shares of the GDP. In the case of poverty headcount, poverty gap, vulnerability rate, and Gini coefficient, the impact is expressed as changes in percentage points.

22 These actions represent existing policy commitments, which conventionally are treated as 'business as usual.' However, modelling them in the alternative scenario allows for measuring the extent to which these actions are likely to reduce losses and damages suffered from climate change (as simulated in the climate scenarios) thereby enabling Rwanda to remain on the development path that was envisioned when the 2020 NDC was approved (as simulated by the baseline scenario). In addition, it is not unreasonable to include the revised NDCs in the alternative scenario, when one considers that competing spending pressures imposed by the COVID-19 pandemic have delayed their implementation. Therefore, the macroeconomic and fiscal framework that is used to construct the baseline scenario does not reflect the investment spending that was originally projected in the NDC document (GoR 2020a).

23 The figure presents percentage deviations between GDP *levels* in baseline and climate scenarios, rather than differences in GDP *growth rates*. GDP levels capture the cumulative effects of climate change over time, making them a better basis for assessing the extent to which climate change pushes Rwanda off its planned development trajectory. Comparing annual growth rates would be misleading, given the considerable variability in the climate data, and therefore, GDP growth rates.

Figure 22: Deviation of GDP from the Baseline, by Climate Scenario, 2020–2050



Source: World Bank Group staff estimates.

Notes: The trendline for RCP4.5 is a fourth-order polynomial fitted to the annual values.

- Variation across climate scenarios begins to emerge in the 2040s. Rainfall variability is the biggest factor contributing to differences across scenarios; deviations of GDP from the baseline are most severe in drier conditions and least severe (and sometimes positive) in wetter conditions, underscoring the need to invest in irrigation.
- Both results are driven by the variation in expected precipitation and temperature in the climate models rather than by the economic adjustment taking place for the CGE model.[24]

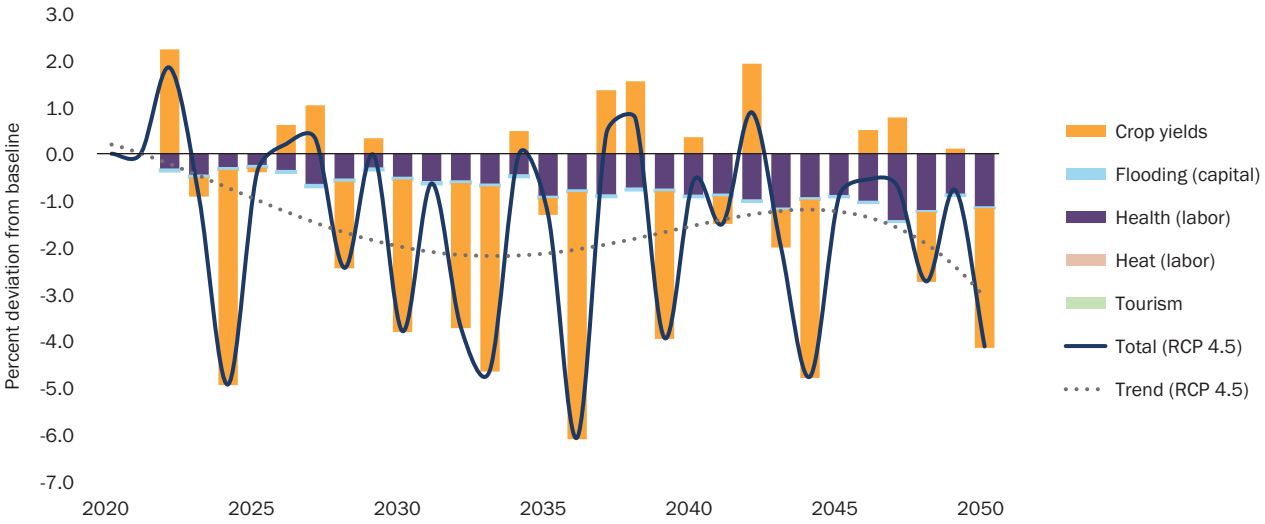
The modelling suggests that the biggest risk to economic output in Rwanda are weather shocks to agricultural productivity and the reduced labor productivity caused by the increased incidence of diseases, both communicable and non-communicable that is associated with rising temperatures (see Figure 23). By comparison, damages to capital caused by flooding result in smaller losses to annual GDP in these simulations, in part because the probability of severe floods that would cause widespread damages is expected to rise only after 2050, but also because economic production in Rwanda tends not to use capital intensively.[25] Similarly, extreme temperatures are not expected to rise enough by 2050 for heat to play a direct role in reducing labor productivity (see Figure 12 in Section 1.2 above), although the indirect effect of heat through increased disease incidence is substantial. External demand for tourism exports falls in the simulations, but the hospitality industry's share of total GDP is too small for the decline in output to show up at the aggregate level.[26]

24 This is consistent with the overlapping ranges of precipitation and temperature values across RCPs in Figure 9–Figure 11, in Section 1.2.4 above.

25 Several other considerations are worth noting. The estimated share of capital exposed to climate damages each year is small relative to the standard depreciation rate that the CGE model applies to the economy's capital stock: only an additional 0.30–0.36% per year in 2036–2068 under RCP8.5, on top of the 5.0% applied to all capital. Figure 24 presents results from a scenario with a single large flood that destroys over 11% of capital in a single year. In addition, Figure 23 presents loss of a flow (annual GDP) rather than damage to a stock (such as capital). The replacement value of the physical and natural assets damaged by flooding may be large relative to the GDP, but the value of output or income lost because of damages to the assets need not be. For example, GoR estimated the cost of buildings, roads, land, forests, and economic assets destroyed during Rwanda's 2018 flooding at 2.4% of 2018 GDP, but the estimated value of lost production (e.g., crops) and income (e.g., rental income from destroyed housing) caused by these damages was only 0.3% (GoR 2019c). Finally, economic losses are partially offset by increased flows of investment to replace damaged capital. The long-term, cumulative effects of flood damages are chronically lower private investment, and consequently, a lower capital stock and lower level of GDP than the baseline.

26 Agriculture, transport services, food and beverage manufacturing, and other industries besides hospitality services, also contribute to Rwanda's tourism exports and would suffer losses from a reduction in export demand. The CGE simulations also include these effects.

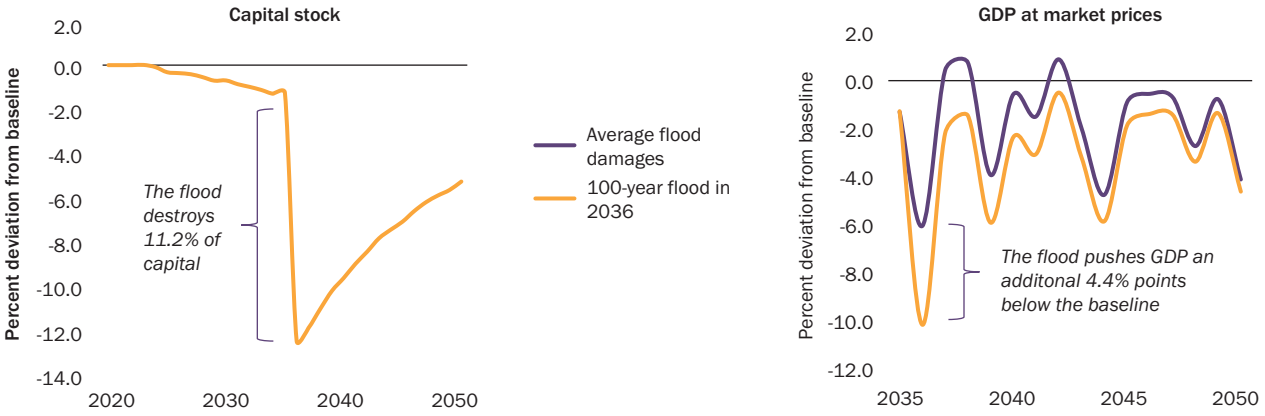
Figure 23: Relative Contributions of Damage Channels, 2020–2050



Source: World Bank Group staff estimates.

Damages from infrequent but severe floods would amplify short-run economic losses. Figure 24 contrasts a scenario with a 1-in-100-year flood occurring in 2036 (the year with the largest losses in most of the simulations) under RCP4.5 with the scenario discussed above, where flooding risks are averaged over decades.[27] A major flood with a 100-year return period is estimated to destroy 11.2% of capital under RCP4.5. The country's capital stock slowly recovers toward baseline levels after the disaster as damaged capital is gradually replaced, but the capital stock remains 5.3% lower than the baseline in 2050. Flooding pushes the GDP an additional 4.4 percentage points lower than the baseline compared to in the standard RCP4.5 scenario. As damaged capital is replaced over time, this additional loss of GDP gradually diminishes, and in 2050, GDP is 4.6% lower than the baseline in the disaster scenario compared to 4.1% lower in the standard scenario.

Figure 24: Damages and Losses from a Single, 1-in-100-year Flood, RCP4.5



Source: World Bank Group staff estimates.

27 This disaster scenario linked to natural hazards includes all non-flooding damages and only replaces the small average annual flood damages with a single flood in 2036.

The CGE simulations overstate the degree of economic volatility that Rwanda is expected to face in coming decades because climate volatility is present only in the alternative scenarios and not in the baseline scenario. Nevertheless, global climate change is expected to progressively increase the variability of rainfall and temperature in Rwanda, and the simulations show that even episodes that fall short of being disasters can have severe economic consequences. This underscores the need for firms, households, and the government to find new ways to manage risks, including (and not limited to) insurance, economic diversification, and shock-responsive cash transfer programs.

3.1.3. Other Macroeconomic Consequences

Delving down below the level of GDP, climate change is likely to undermine welfare, sectoral transformation, foreign trade and, to a lesser extent, private investment, and fiscal sustainability in Rwanda.[28]

Sectoral transformation: Climate change is expected to slow the pace of sectoral transformation in Rwanda, that is, the shifting of employment out of low-productivity subsistence agriculture into higher productivity activities, such as manufacturing and high-value tradable services—a process that is critical for sustained economic growth and poverty reduction. Agricultural employment tends to be higher and industrial employment lower in all climate scenarios than the baseline, and the deviations generally increase over time. Although the agriculture sector suffers in all major damage channels—land, capital, labor productivity and (depending on the actual levels of rain and heat) crop yields—the sector's demand for labor remains relatively high. Labor productivity is lower than in other sectors, the demand for food is inelastic, and the demand for labor remains high, despite production falling relative to the baseline until around 2040 in most scenarios. Job losses in mining, household services, and to some extent, construction, contribute the most downward pressure on employment in almost all scenarios.

Rural to urban migration: Both rural and urban employment is lower in core climate scenarios, although by small amounts: employment in rural areas is around 0.1–0.2% lower than the baseline and urban employment is 0.2–0.3% lower, with deviations increasing over time in both cases. Lower employment in rural areas explains most of the decline in total employment toward mid-century.

International trade: Exports generally average around 1.0–2.5% lower than the baseline starting in the late 2020s. The difference between the wetter and drier scenarios under RCP8.5 is striking and reflects the sensitivity of export crops to rainfall. Imports fell as well due to lower household income.

Private investment: The model assumes that, in the baseline scenario, all capital depreciates by 5% per year. Flooding increases this depreciation rate in climate scenarios. Firms' choices about investing in replacement capital are shaped in the simulations by sector-specific shocks to productivity (for example, crop yields are higher or lower depending on rainfall and temperature), land, and labor. Furthermore, since climate change also reduces household income, the pool of savings available for firms to use for investment is smaller. Private investment falls below the baseline in all scenarios by small amounts. Consequently, the economy's total capital stock gradually declines over time, reducing the GDP.

Consumption: Household income falls—and with it, private consumption—as climate change reduces output in selected activities and labor productivity throughout the economy. Private consumption is generally 1.5–3.0% lower than the baseline, falling by as much as 4% below projections per year towards the middle of the century in the drier scenario.

Government finances: Government tax revenue averages around 0.5–1.0% lower than the baseline through 2030 in most scenarios and fall to around 1.5–2.0% towards 2050, responding to lower incomes, consumption, and production. By construction, the simulations assume that the government maintains total

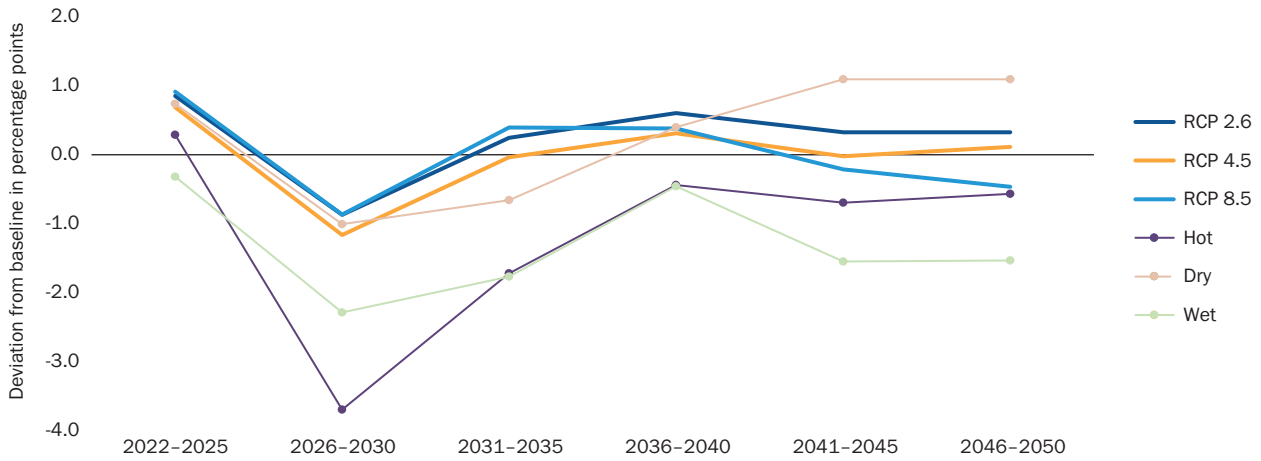
28 The CCDR Technical Appendix presents detailed results from these simulations.

spending at baseline levels when revenue fluctuates to avoid magnifying the climate shocks to the economy (that is, to avoid procyclicality). Both domestic and external debt trend higher over time, except in the wet scenario, but the magnitude of the additional debt accumulated above the baseline is small.

3.1.4. Distributional Implications

Given the high share of the poor living in rural areas who depend on agriculture for nutrition and as their main source of income, and taking into account the increasing share of agriculture in total employment, the impacts of climate shocks on poverty are mainly driven by changes in agricultural productivity and employment. Largely driven by increases in agricultural employment, under all damage scenarios, the poverty headcount decreases with respect to the baseline until 2026–2030. It then moves back to levels closer to the baseline levels, because of deepening job losses, especially in manufacturing (see Figure 25). As expected, due to the importance of agricultural employment in poverty dynamics, the decline in poverty is larger in rural areas. Under the dry scenario after 2035, increases in poverty headcount are driven by the large declines in agricultural yields.

Figure 25: Deviation of Poverty Headcount from the Baseline, 2022–2050, by Climate Scenario



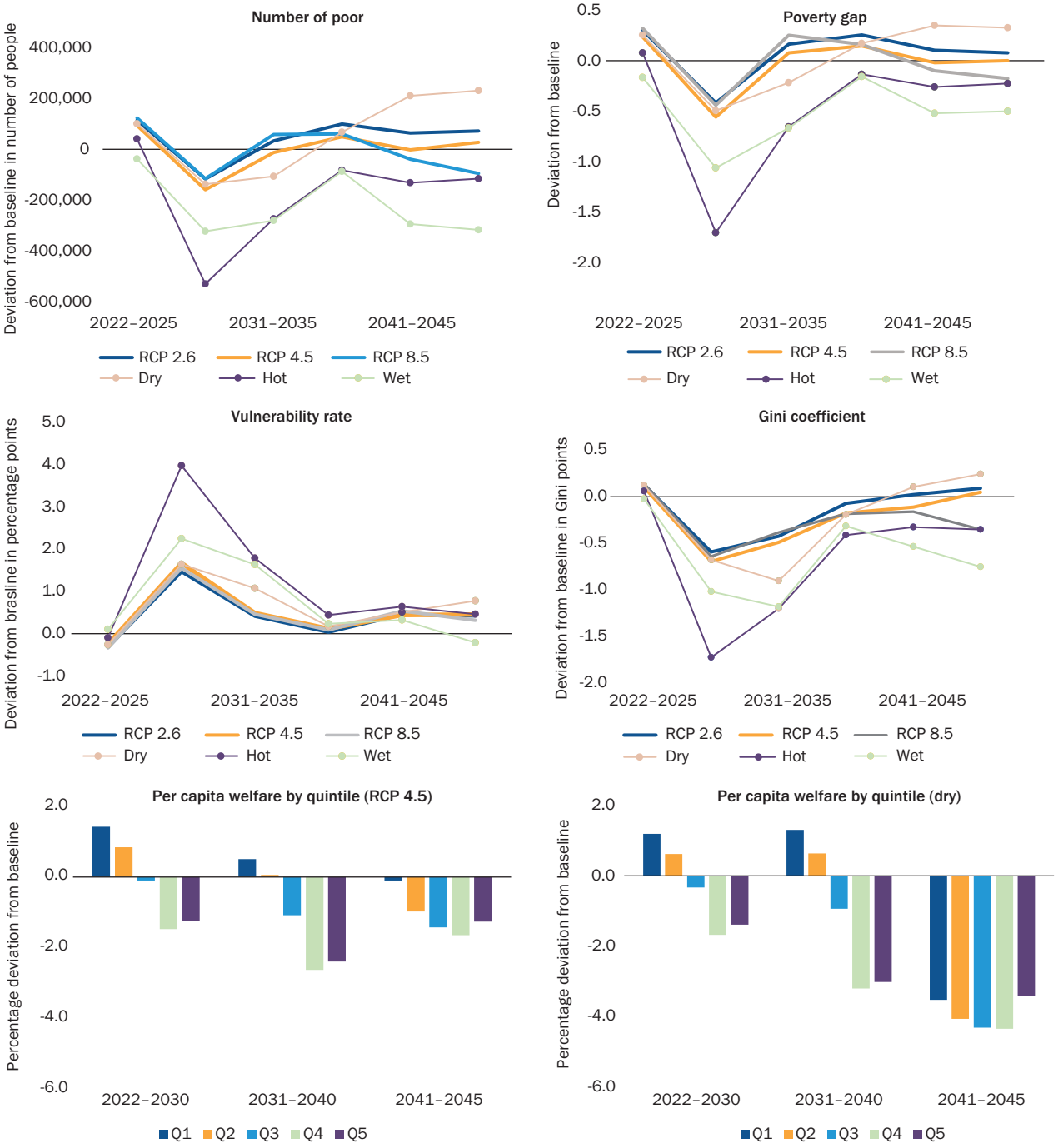
Source: World Bank Group staff estimates.

Note: Microsimulation results are averaged over five-year periods.

The number of poor and the poverty gap—defined as the average difference between household consumption for the poor and the poverty line—are likely to oscillate around the baseline levels under most scenarios. Climate shocks also increase the share of the population who are at risk of falling into poverty if other shocks materialize. Using twice the poverty line as a proxy for a vulnerability line, the share of the population above the poverty line, and below the vulnerability line (vulnerable to falling into poverty), increases under all scenarios until 2031–35.[29] The increase in vulnerability is consistent with climate shocks having a higher impact on households with higher consumption, especially after 2030, as well as with the movement of the population out of poverty and into vulnerability. The bottom panels in Figure 26 present two profiles of the impact of climate shocks on household welfare that illustrate this point. Despite some differences across scenarios, in terms of the size (and even sign) of the impact on household welfare, the negative impact of climate shocks is larger for richer households. This redistribution results in decreases in inequality measured by the Gini coefficient.

29 The proposed vulnerability line expressed in local currency is close to the value of the lower-middle income international poverty line of $3.20 a day, which is considered appropriate as a vulnerability line for low-income countries.

Figure 26: Other Distributional Implications, by Scenario, 2022–2050



Source: World Bank Group staff estimates.

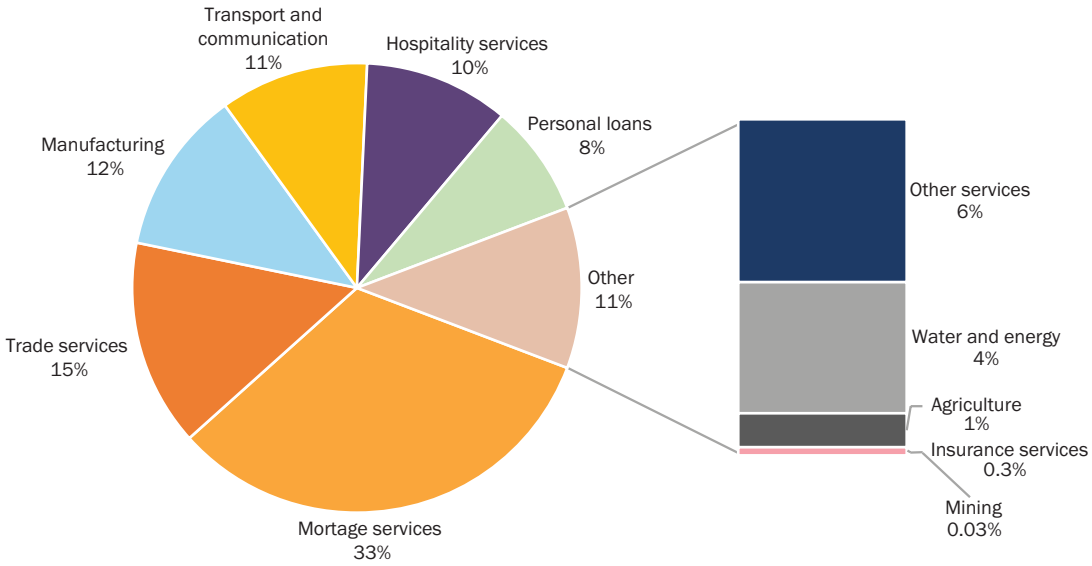
Notes: Microsimulation results are averaged over five-year periods.

3.1.5. Risks to Rwanda's Financial Sector

Climate change also poses risks for Rwanda's financial sector, primarily through the banks' exposure to disasters linked to natural hazards. Rwanda's financial system is small and dominated by banks. As of June 2021, the financial sector assets were equivalent to 69.8% of GDP. The banks account for 66.9% of the assets, and microfinance institutions (MFIs) and savings and credit cooperative organizations (SACCOs)

account for 5.6%.[30] The mortgage portfolio, representing 33% of total lending at the end of June 2021 (Figure 27), is likely to be exposed to risks related to natural hazards, although it is impossible to quantify these risks with the available data. Other climate-sensitive sectors of the economy, such as agriculture, water, and energy, absorb a relatively small share of the total bank credit. Given the structure of the economy and lending portfolio, transition risks are possibly limited.

Figure 27: Sectoral Allocation of Bank Credit, 2021



Source: National Bank of Rwanda 2021 (Annual Report, 2020–2021); data as of end-June 2021.

Rwanda's insurance sector remains at an early stage of development and has limited exposure in property, agriculture, and other sectors that are vulnerable to climate change. Insurance penetration is low, with total premiums at 1.7% of GDP. Nonlife insurance represents 88% of gross written premiums and is heavily dependent on motor and medical insurance products. Property insurance accounts for only 11% of total premiums. Less than 2% of the Rwandan population use microinsurance, of which agricultural insurance is a subcategory. After being piloted in 2011, agricultural insurance peaked in 2013 and failed to scale up thereafter.[31] However, coverage in terms of crops and locations is low, insurers' technical knowledge and financial capacity is constrained, and the range of crop and livestock insurance products available is restricted and not well suited to the risk management needs of smallholder producers.

Although climate change certainly poses some risks to Rwanda's financial system, the main challenge is to ensure that the financial system continues to develop in a manner aligned with the vision of a low-carbon, green, sustainable economy. Rwanda's GGCRS notes that one of the major impediments to the adoption and scale-up of green technologies is the lack of finance for such investments (GoR 2021a). Rwanda has recognized the need for suitable financing mechanisms and facilities to acquire and transfer green technologies. The government set up the National Fund for Climate and the Environment (FONERWA) in 2012 to mobilize financing for the environment, climate change, and green growth in order to accelerate sustainable national economic development. The fund is the largest of its kind in Africa and has mobilized $216 million, supporting 44 projects that have assisted approximately 118,000 people to cope with climate change (FONERWA 2021). The fund provides grants and loans administered by BRD. One of the important aspects for FONERWA is mobilizing private finance.

30 The pension sector represented 17% of assets, 95% of which is in the public scheme (Rwanda Social Security Board (RSSB)), and the remaining 9.2% is in the insurance sector (data from the National Bank of Rwanda, 2021).

31 Currently, there are three insurance companies and two reinsurance companies in Rwanda that underwrite agricultural insurance programs.

3.2. Rwanda's 2020 NDCs Will Help Overcome Climate Impacts

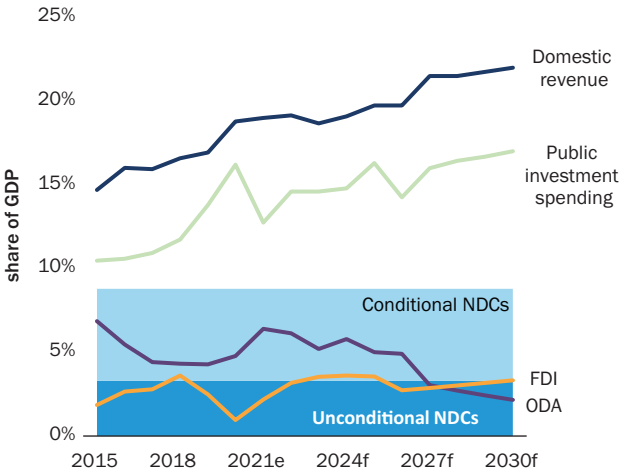
The CGE and poverty simulations of scenarios where Rwanda implements the climate actions presented in its 2020 NDC, suggest that these measures will attenuate economic losses from climate change and enable the country to realize its broader economic development objectives. In addition, these actions will also honor Rwanda's international climate commitments. The actions in Rwanda's 2020 NDC are largely investments in agriculture, forestry, urbanization, public health, and infrastructure. They are designed to improve Rwandans' socioeconomic welfare and enhance the country's natural capital, as well as meet its climate adaptation and mitigation commitments. It is notable that each action presented in the NDC document lists the Sustainable Development Goals to which it contributes, as well as its expected adaptation and mitigation benefits. Projects in areas such as urban planning, irrigation, or disease management, would likely have been prioritized, even in the absence of climate considerations.

3.2.1. Policy Scenarios and the Financing Challenge

Simulations of the NDC implementation also underscore the challenges associated with financing these actions. The projected cost of undertaking investments is large. GoR 2020a estimated that implementing the projects to meet unconditional commitments would cost $4.2 billion between 2020 and 2030, and that adding the measures needed to meet conditional commitments, would raise the total cost to $11.0 billion. Figure 28 shows that this is equivalent to spending an average of 8.8% of GDP each year through 2030—exceeding the recorded and projected inflows of ODA and FDI between 2015 and 2030—and representing a large share of domestic revenue collection or public investment spending during the same period.[32]

Figure 28: Projected NDCs Costs Compared to Current Fiscal and External Flows

	Unconditional	Conditional	Total
	(Millions of U.S. dollars)		
Mitigation	2,010	3,667	5,677
Adaptation	2,145	3,218	5,364
Combined	4,155	6,885	11,041
Avg. annual share of GDP, 2022–2030	3.3%	5.5%	8.8%
Share of 2020 GDP	43%	71%	114%



Sources: World Bank Group staff calculations using GoR, Updated Nationally Determined Contribution, 2020, and IMF-World Bank, Debt Sustainability Analysis (DSA), 2022.

Notes: Average annual spending is calculated starting in 2022, the first year of forward-looking projections in the DSA and the CGE model.

32 Whether this $11.0 billion should be treated as already part of' versus additional to projected public investment spending, is an open question. There is no evidence that all or most NDC projects are already part of Rwanda's public investment program, or that the authors of the NDC document assumed that the NDC projects would replace others in the pipeline. In principle, some of the NDC projects could substitute for other planned projects (for example, renewable energy projects in the NDC might displace planned fossil fuel projects), and therefore not add to Rwanda's projected public investment spending displayed in Figure 28, while others seem more likely to have been conceived of as new projects that would supplement the public investment portfolio. The $6.9 billion estimated as needed to finance conditional NDC projects would be additional to projected public investment spending, and the $4.2 billion needed for unconditional NDC projects is sufficiently large to require a substantial reorganization of the public investment program, whether or not it is additional to planned spending.

To explore the trade-offs arising from the financing challenge, separate simulations were run for five financing options—government borrowing, tax increases, external grants to the government (ODA), FDI, and cuts to government spending to offset increased spending on climate actions—as well as a scenario that combines all five options. Scenarios presented in this section include actions in the 2020 NDC aimed at meeting Rwanda's unconditional adaptation and mitigation commitments. All were run using the RCP4.5 climate scenario to represent a middle path among the six climate change scenarios presented in Section 3.1.[33]

3.2.2. Unconditional NDCs: Macroeconomic Implications

The central finding that these simulations support is that implementing the unconditional NDC climate actions would sufficiently reduce the damages to total factor productivity (TFP) and factors of production to enable the GDP to return to the baseline path by 2050, under all the financing scenarios considered. However, each method available to policymakers to mobilize money for these investments imposes significant costs on one part of the economy or another:[34]

- Financing climate investments solely out of Rwanda's domestic resources through increased taxation would reduce household consumption (and therefore economic welfare)—pushing consumption per capita to levels that are lower in 2022–2030 than if the country took no climate actions at all—and would also tend to absorb the funds available for domestic firms to make new investments.
- The influx of foreign capital associated with financing the investments solely with foreign resources—such as ODA, FDI, or external borrowing—would appreciate the real exchange rate, thus weakening Rwanda's competitiveness in foreign markets. Real exports are 4–13% lower than the baseline during the 2020s in these three scenarios, while imports average 2–7% higher. In these financing scenarios, the trade balance is, on average, around 2–5% lower as a share of GDP (that is, the deficit is larger) during the implementation period, before converging close to the baseline after 2030.
- Relying solely on government borrowing places fiscal sustainability at risk, with limited effects on the GDP in the short-to-medium term. In the simulations, public debt rises to 90% of GDP in 2024, and does not fall back to 2021 levels until 2034. Although most of the new debt is external, the government also increases its borrowing from the domestic capital market in this simulation, which crowds out private investment.
- The government could, alternatively, offset the costs of new climate actions by adjusting (that is, cutting) government consumption. This avoids raising fiscal sustainability risks, but it, of course, prevents the government from achieving other policy commitments. In addition, cutting spending on items such as health systems, agricultural research and extension, or transfer payments to vulnerable households, would weaken Rwanda's resilience to climate change. Cutting government spending also reduces private consumption in the short-and-medium term, although this effect disappears in the long term because of the transfer of resources from less productive to more productive activities in the economy.

33 The CCDR Technical Appendix presents detailed simulation results.

34 The simulations conducted here assume no differences across financing sources in the modalities of implementing the climate measures. In practice, the type of financing influences how a project is managed, and there can be important differences in the efficiency and effectiveness of projects implemented as PPPs versus donor projects versus taxpayer-financed government projects.

Relying solely on any one source of financing for implementing NDCs is therefore undesirable. To balance the costs and benefits of different financing methods, simulations also include an illustrative simulation where unconditional NDCs are financed through a mix of public and private sources, external and domestic savings, and borrowing versus tax increases and spending adjustments. This mix is shown in Table 9. The mixed option would generate a more balanced outcome in terms of preserving fiscal sustainability and protecting household welfare in the long term.

Table 9: Distribution of Financing Sources in the Mixed Financing Scenario, Unconditional NDCs

Financing instrument	Average annual share of GDP	Average annual US$ million (2022–2030)	Cumulative US$ million (2022–2030)	Share of total financing of climate actions
New ODA	0.35%	49	442	10.6%
Spending cuts/offsets	0.35%	49	442	10.6%
New tax increases	0.35%	49	442	10.6%
New govt borrowing (i.e., increased deficit)	0.7%	98	884	21.3%
New FDI for private investment (as PPPs)	1.6%	216	1,945	46.8%
Total unconditional NDCs	**3.3%**	**462**	**4,155**	

Source: World Bank Group staff estimates using GoR 2020a.

Fiscal policy: The government would need to increase its investment spending by an average of 1.8 percentage points of GDP above currently planned levels each year during 2022–2030 to meet its unconditional NDCs in the mixed financing scenario. Doing so would require increasing tax revenue by around 0.3 percentage points of GDP above the baseline, through 2030.[35] It would also require maintaining spending on government consumption and transfers at a level that is around 0.5 percentage points of GDP lower than the baseline through 2030. The scale of these fiscal adjustments is potentially feasible, but adjustments could prove challenging in practice, as Rwanda's current fiscal framework already assumes a measure of fiscal consolidation to rein in debt accumulation.

Sectoral transformation: Where climate change pushes the economy away from the planned transition out of traditional agriculture and into industry, climate investments tend to pull the sectoral composition of GDP and employment back to the baseline path. Spending on the investment projects directly generates new activity and jobs in construction, forestry, and livestock. Except in the tax-financing scenario, urban employment is somewhat higher than the baseline during the NDC implementation period.

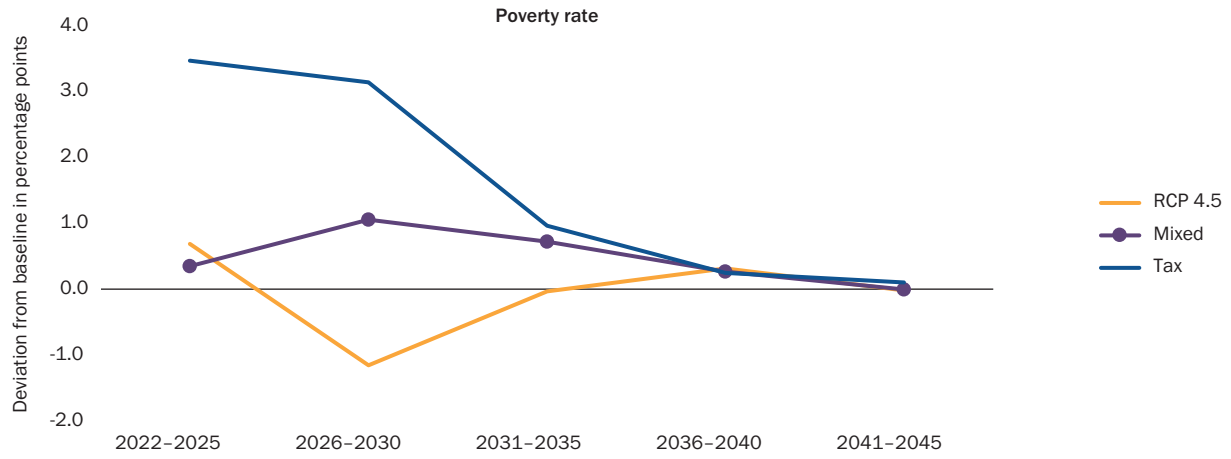
3.2.3. Unconditional NDCs: Distributional Implications

Consistent with the large declines in household consumption caused by funding the unconditional NDCs solely through increased taxation, the poverty headcount is expected to be higher than under mixed financing (see Figure 29). Combining financing methods would lower the increases in the poverty headcount, the poverty gap, and poverty severity (not shown).[36]

35 The simulations assume that the government increases tax collection from all sources: international trade, goods and services, and income and profits.

36 Poverty severity is the squared poverty gap. This measure assigns higher weights to poor people, the further their consumption is from the poverty line.

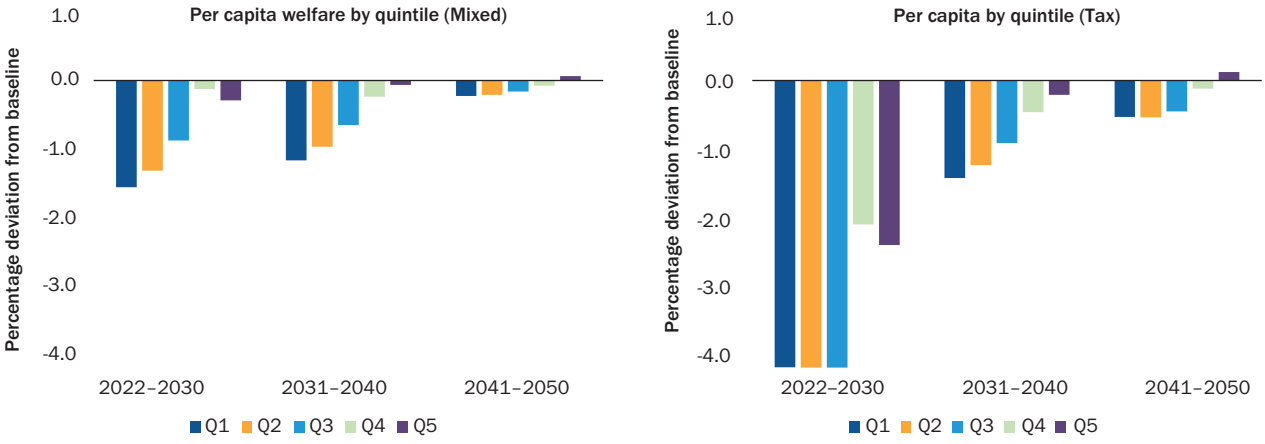
Figure 29: Deviation of Poverty Headcount from the Baseline, 2022–2045, by Financing Method



Source: World Bank Group staff estimates.
Note: All scenarios assume RCP4.5.

Using increased taxation as the only source of financing would not only increase poverty, but also have much larger negative effects across the consumption distribution (see Figure 30).

Figure 30: Deviation of Per Capita Welfare from the Baseline by Quintile, 2022–2050



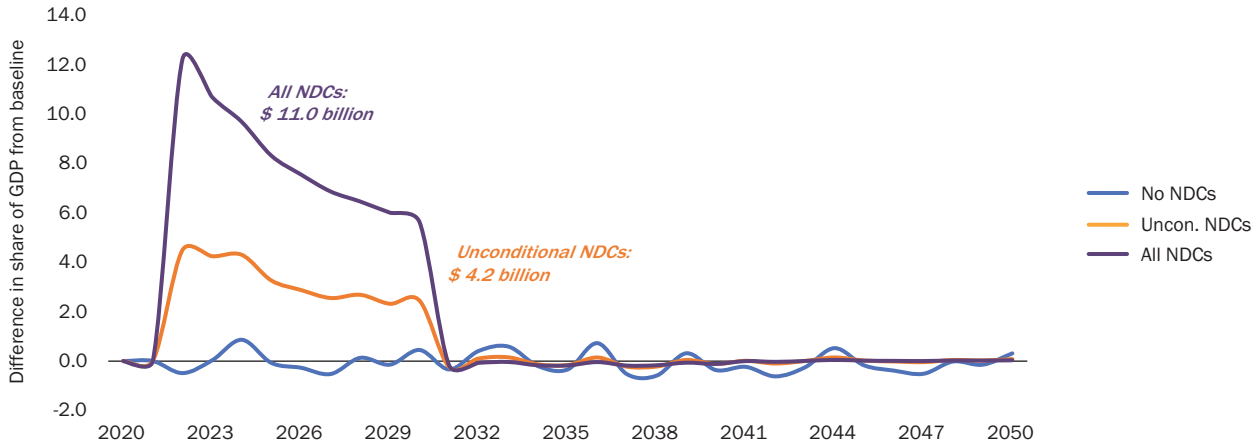
Source: World Bank Group staff estimates.
Note: All scenarios assume RCP4.5.

3.2.4. Implementing Conditional Climate Measures in the 2020 NDC

Rwanda's updated 2020 NDC also includes a range of proposed adaptation and mitigation measures that the authorities would undertake on the condition that additional financing is made available. As presented in Figure 31, the government estimated that it would cost $6.9 billion to implement these conditional climate measures. To analyze the economic implications of implementing all climate actions—unconditional and conditional—the scenario allocates the full $11.0 billion in spending associated with the 2020 NDC, according to the sectors described in GoR 2020a, and the sources of financing this spending, using the same shares as in Table 9.

As discussed earlier, $11.0 billion represents a large sum compared to historical and expected flows of FDI and ODA, as well as government financial operations. Figure 31 shows that the injection of this spending

Figure 31: Investment Under Different NDC Scenarios, RCP4.5, 2020–2050



Source: World Bank Group staff estimates.
Note: All scenarios assume RCP4.5.

dramatically increases investment well above the baseline during the 2030s, while the projects are being executed. One should note that the CGE model abstracts from the real-world institutional capacity constraints that are discussed in Chapter 2, which would likely reduce the effectiveness of the investment spending modelled in this section. This suggests that there could be benefits to lengthening the implementation period (perhaps especially for conditional NDC projects) and prioritizing projects that enhance resilience and increase productivity.

Implementing all proposed measures in Rwanda's updated 2020 NDC intensifies the effects on economic performance discussed in Section 3.2 above. This section reports deviations from the baseline for simulations of alternative scenarios with no NDC actions, with unconditional NDC measures only, and with all NDC measures. To simplify the analysis, all alternative scenarios use only the RCP4.5 climate assumptions, and the two policy scenarios use only the balanced mix of financing sources and include both adaptation and mitigation projects. Below are the main findings.[37]

- Simulations suggest that, starting from around 2025, implementing all climate actions in the 2020 NDC would more than fully offset the reduction in per capita private consumption caused by climate change.
- Adding the conditional actions increases capital accumulation throughout the modelling horizon, boosting the capital stock above the baseline by more than 4% on average in the late-2020s, and by 1% toward the mid-century. The industry sector accounts for most of the increase.
- The additional climate investments in agriculture, energy, and infrastructure arguably overcorrect for the effects that climate change has on slowing the pace of structural transformation. Increased construction associated with investment projects is a large part of this story—construction employment and output are each around 25% higher than the baseline during the 2020s. The additional supply of electricity from mitigation measures would support the growth of manufacturing output. Urban job growth outpaces rural job growth. Meanwhile, employment in most crops is lower, as is employment in the service sectors associated with the government (public administration, education, and health)—a consequence of the reallocation of government spending out of consumption and into climate projects.

37 The CCDR Technical Appendix contains detailed simulation results.

- Although tax revenue is almost one percentage point of GDP higher than the baseline, primary spending is three percentage points higher. The accumulation of public debt is substantially greater than the baseline during the implementation period and remains higher over the long run. There is also considerable reallocation of spending from recurrent to capital spending within the government budget. As discussed earlier, this hampers the government in meeting non-climate policy commitments, but in the long run, the climate may contribute to increased economic productivity.
- Increased taxation and government borrowing crowd out private sector investment (excluding privately executed climate projects) during the 2020s. From 2031 onwards, the effects are the same as in the scenario where only unconditional climate investments are implemented.
- Similarly, the additional capital, debt, and grant inflows into Rwanda, in this scenario, result in large trade deficits during the NDC implementation period: exports are around 3.5% lower in the 2020s as a share of GDP than the baseline, while imports average around 3.3% higher.

3.3. Conclusions and Considerations for Achieving Resilient Development

3.3.1. No Trade-off Between Climate and Development

The modelling simulations in this chapter drive home the point that Rwanda does not face a dilemma of choosing either climate or development. Climate change pulls the economy away from the country's desired development trajectory; the measures outlined in Rwanda's 2020 NDC will help move it back to Rwanda's desired development trajectory. Moreover, these are sound development actions that would be likely candidates for the public investment program, even if climate change were not a concern.[38] The major challenges lie, instead, with the scale of spending associated with the planned projects. The analysis above identifies different economic costs that arise with each source of financing and shows that Rwanda will need to diversify sources to reduce these costs. Three additional steps towards addressing the cost problem are to increase fiscal space, develop a green capital market, and pursue institutional reforms that can create markets for ecosystem services.

3.3.2. Increase Fiscal Space

Increasing fiscal space will be essential for Rwanda to implement climate commitments (and indeed to achieve its other development objectives). In the policy scenarios above, the government is assumed to make fiscal adjustments (both spending cuts and new taxes) averaging 0.7% of GDP per year through 2030, for unconditional NDCs, and 1.8% of GDP annually, when conditional actions are added. Seeking efficiencies in expenditure management and tax administration can avoid the need to cut critical programs or raise tax rates. The recently completed Public Expenditure Review finds that reducing tax exemptions and improving compliance could mobilize an additional 1.5% of GDP in domestic revenue, and that increasing spending efficiencies through improved project management and procurement could generate an additional 1% of GDP (World Bank 2022). It will also be important to contain fiscal risks from SOEs and PPPs, so that any realization of contingent liabilities does not consume fiscal space.

3.3.3. Develop a Green Finance Market

Developing a green finance market, as part of the broader capital market development effort, could be an important component in resource mobilization for financing infrastructure and housing (see Box 1 below). There are significant infrastructure needs arising from Rwanda's Vision 2050 and identified in Rwanda's

38 For example, investments in irrigation, improved seeds and livestock breeds, and post-harvest management, presented in GoR (2020a), are essential for increasing agricultural productivity; clean cooking stoves are good for human health, not just for reducing GHGs; and better urban planning is important not only to increase resilience to flooding, but it also facilitates the rural-to-urban transition that is part of structural transformation.

green growth strategy. Chapter 4 will analyze the scope for developing a pipeline of bankable green projects. To unlock new sources of external green financing for this pipeline, it is important to align these projects with environmental, social, and governance principles and standards. Similarly, in the context of mortgage finance, there is an opportunity to potentially tap into these new sources of finance by ensuring that mortgage loans, and the assets they finance, adhere to environmental, social, and governance standards and consider climate change risks. Adopting the necessary regulatory and supervisory measures and building on the experience of FONERWA and the BRD could help create a green finance market.

Mobilizing finance for green growth and climate change adaptation will require actions by financial regulators and supervisors to foster the development of a green finance market. Action by Rwandan regulators to introduce standards in line with the recommendations of the International Sustainability Standards Board would be needed to support the development of a green finance market, and to tap into the new international capital sources that are expected to open up as economies around the world work towards a net-zero future.

Strengthening the quality and effectiveness of agriculture insurance offered through the National Agricultural Insurance Scheme (NAIS) is an important element of building the resilience of the agricultural sector. To scale up agricultural insurance, NAIS needs to overcome challenges, including limited public and private sector capacity to design appropriate agriculture insurance products, limited availability of high-quality crop yield data and livestock data to develop insurance products, and limited financial and insurance awareness among farmers.

Box 1: Key Recommendation: Develop a green finance market as part of the broader capital market development effort to help mobilize financing

Developing a green finance market, as part of the broader capital market development effort, can help mobilize financing. This will require actions by financial regulators and supervisors to implement environmental, social, and governance standards in operations of Rwanda's financial institutions as well as developing a pipeline of bankable and monitorable green projects. Introducing new financial products would also require new technical knowledge, e.g., to develop crop and livestock insurance products tailored to meet the needs of smallholders.

3.3.4. Strengthen Public Investment Management

Improving public investment management is essential for Rwanda to undertake the substantial public investment push needed to meet climate commitments in the 2020 NDC, as well as in the national strategies reviewed in Chapter 2. This is true, irrespective of the share of expected costs that is 'within' versus 'additional to' projected spending on public investment in Rwanda's current fiscal framework. PPPs and other private financing of climate projects only adds to the complexity of the public investment management challenge.

As recommended above in Section 2.3, it is critical for GoR to integrate climate concerns throughout the public investment management cycle and introduce resilience outcomes into the asset management framework. These should be backed by legislation and/or regulations. The Public Expenditure Review offers additional recommendations for improving project appraisal, selection, and implementation, and for reallocating resources from poorly performing projects (World Bank 2022).

3.3.5. Complement Investment Projects with Policy and Institutional Reforms

The measures presented in Rwanda's 2020 NDC are primarily investment projects. Especially for problems where natural capital is not priced by the market (that is, it is treated as free), or is underpriced and therefore

overexploited, or used inefficiently, policy and institutional reforms that change incentives shaping the behavior of firms and households throughout the economy may be more effective. Pigouvian taxes and subsidies are a traditional tool for addressing externalities so that actors see the true social benefits and costs when they make private decisions.

There may also be opportunities to create markets by changing property rights, or by introducing new institutional mechanisms that give households and firms an economic interest in preserving natural assets that provide ecosystem services.[39] Chapter 4 explores several innovative nature-based solutions (NBS) to the problems of the misuse of forests, water, and land. These solutions are likely to be self-sustaining (in contrast to one-off projects) because they alter incentives that people face in their everyday savings, investment, consumption, and production decisions. In some cases, the NBS also provide new revenue streams that can be used to finance other climate actions.

39 Private and communal conservancies in Namibia provide one useful example of how redefining property rights can create markets for ecosystem services. Lindsay et al. (2013) and Naidoo et al. (2011) analyze how legal reforms beginning in the 1960s gave private landowners and later, traditionally disadvantaged communities living on communal lands, the rights to various consumptive and non-consumptive uses of wildlife in return for adopting biodiversity conservation practices. Not only has this institutional change greatly expanded the area of land under conservation regimes in Namibia, and increased critical wildlife populations, but it has also sparked the development of the country's nature-based tourism industry, generated jobs and new streams of income, and contributed to increased food security in communal areas.

Box 2: Key recommendation: Balance investment projects (private and public) with policy reforms that change incentives facing firms and households and create markets for ecosystem services

The scale of spending associated with the climate-smart development projects highlighted herein, introduces new economic challenges that would require managing important trade-offs. The authorities place the price tag of its NDCs at $ 11 billion (of which $ 6.9 billion is conditional on new financing)—an amount that exceeds 2020 GDP. Each method for financing investments comes with costs: taxation depresses consumption, borrowing crowds out the private sector and risks making debt unsustainable, and ODA and capital inflows appreciate the exchange rate and increase the trade deficit. Using a mix of sources balances many of these costs. The analysis also indicates that there could be benefits from balancing investment projects (private and public) with policy reforms that change incentives facing firms and households.

3.3.6. Information Gaps: Assessing Adaptation

Developing a public investment program for climate-smart development will require better information about how effective investment spending is at reducing expected climate damages.[40] While different proposed mitigation measures can be evaluated using the common metric of the abatement of GHG emissions, indicators for evaluating adaptation are highly instrument-specific, and are sometimes several steps removed from the damage.[41] Without a way to compare contributions to climate resilience across projects, planners therefore have little basis for choosing among competing proposals, deciding whether to budget more or less money for projects, or evaluating performance ex post. This information gap is by no means unique to Rwanda. However, Rwandan planning authorities can take a meaningful step toward narrowing the information gap by including data on a project's contribution to reducing damages to land, labor, capital, and productivity (and other items needed to quantify economic losses from climate change) as part of the project appraisal, monitoring, and evaluation processes.

40 In more technical language, this is the elasticity of damage reduction with respect to spending.

41 For example, GoR 2020a proposes diverse indicators such as percentage changes in a national climate vulnerability index, per capita water storage, and level of user satisfaction in using weather information systems.

4

Climate and Development: Towards Implementation of Selected Priorities

4. Climate and Development: Towards Implementation of Selected Priorities

An important message emerging from Chapter 3 is that the public sector cannot shoulder the burden of addressing climate change on its own; instead, it requires a shared partnership between the private sector and the government.

4.1. Climate-smart Development Opportunities for the Private Sector

4.1.1. Agriculture

Agriculture plays a significant role in the economy, accounting for approximately a quarter of the GDP and employing, including people engaged in subsistence agriculture, approximately 69% of the population (NISR 2022a).

Several private sector opportunities exist to increase agriculture's resilience to climate change while contributing to economic development. Some of these opportunities are given below.

- **Developing and distributing climate-resilient livestock and seed.** For instance, the Alliance for a Green Revolution in Africa (AGRA) supported 15 private seed companies from 2017 to 2019, which sold 4.5 metric tons of improved seeds in 2020.[42]
- **Investing in affordable post-harvest and storage solutions.** It is estimated that over 30% of farmers' losses in Rwanda comes from poor post-harvest handling and storage. Drying and storage facilities can help secure income for farmers. Private investments in warehousing can provide post-harvest storage. Improved storage bags (like Purdue bags) can be part of the solution.[43]
- **Expanding access to irrigation to build resilience to droughts.** Small-scale irrigation infrastructure—such as solar water pumps or large-scale irrigation infrastructure—funded by public-private partnerships (PPPs) build resilience, (see also World Bank Group [2022]). The World Bank-funded Commercialization and De-risking for Agricultural Transformation (CDAT) project will rehabilitate and develop new irrigation schemes on over 17,500 ha and will apply water-use efficiency technologies; the Gabiro Agribusiness Hub Project will provide 15,000 ha of modern irrigation infrastructure.
- **Improving crop and livestock management through climate-responsive extension services within a rainfed agricultural system.** There is room to extend agronomic information and training to farmers to farm effectively and efficiently in a rainfed environment (Word Bank Group 2022). A few small-to-medium-scale private agents are starting to provide these services. Managing soil health and water carrying capacity via zero-/limited-till and intercropping could be key.
- **Insurance innovation.** Efforts are currently underway to scale agricultural insurance for all farmers under the National Agriculture Insurance Scheme. Innovations to reduce the cost of this scheme, as well as transparent and timely payouts, are needed to increase access and reach financial sustainability.
- **Biochar production for carbon removal.** Agricultural waste can be leveraged to produce biochar which has substantial soil fertility benefits, as well as the benefit of controlling the pollution of groundwater through the reduced use of chemical fertilizers. Additionally, biochar sequesters carbon, which can be sold on carbon markets. While largescale biochar production is expensive, there are several small-scale biochar innovations that are being piloted, tested, and commercialized on a

42 AGRA. 2021. AGRA Supports the Seed System in Rwanda. https://agra.org/wp-content/uploads/2021/03/success-story-rwanda.pdf

43 Purdue bags are a triple-layer sealed plastic bag that cuts off the oxygen supply to create hermetic conditions, thereby eliminating insect damage in storage of dry grain. See https://www.purdue.edu/postharvest/purdue-improved-crop-storage-pics/.

small-scale across Africa that can be leveraged.[44] Some of these are on-farm solutions and others are on the community-level. Given the pace at which technology, applications, and business models are evolving, these technologies are likely to play an increased role in the next few years, particularly if they are successful in leveraging carbon finance.

- **Financing the expansion of tree crops such as coffee, avocado, and macadamia.** The planting of trees including intercropping, provides additional safety nets for farmers, such as diversifying income, improving soil fertility and preventing erosion.[45]

There are solutions to the barriers for further private sector involvement in the agricultural sector, and these are presented in the CCDR Technical Appendix.

Box 3: Key recommendation: Soil-conscious conservation agriculture

Deforestation and land degradation as well as the conversion of water catchments to agricultural land have resulted in reduced vegetation cover. The land area with high vegetation cover (forests, woodlands, grasslands, and shrublands) declined from 1.6 million ha in 1990 to only 914,000 ha in 2015, with croplands increasing from 614,000 ha to 1.3 million ha. This reduction in natural vegetation has led to increased runoff and river flows, which have increased water yield. However, this vegetation reduction has also led to an increase in landslides, soil erosion and, because of the reduced vegetation, to a decrease in infiltration and groundwater recharge. Districts such as Ngororero, Nyabihu and Rutsiro in the Western Province, and Gakenke and Gicumbi in the Northern Province, are most affected by soil erosion of 130t/ha/year, or more. The impact of erosion on the agrarian population of Rwanda is vast, compromising its social protection and increasing poverty. To combat further loss of soil and to enhance development as well as food and income security in the wake of climate change, it is recommended that a program on soil-conscious conservation agriculture and payment-for-ecosystem services be implemented, with the emphasis on the expansion of the network of terraces (both radical and progressive), which will increase soil carbon retention. This should be done with a strong emphasis also on crop rotation and intercropping—such as the use of bananas in coffee plantations—which will furthermore result in increased biomass production, increased yield, and the higher quality of the coffee. Another pillar of conservation agriculture is the use of no-tillage methods on most, if not all, croplands, which will result in an increase in soil organic carbon. In this context, it is important to eliminate the current subsidy on mineralized fertilizers, while enhancing the support of the production of organic and locally produced compost to promote soil fertility benefits and reduce the pollution of groundwater resources. There is thus a great opportunity and need for a country-wide educational program with respect to the principles of conservation agriculture and the implementation thereof. In addition, to encourage private sector investment in land and water infrastructure as well as related environmental interventions aiming at landscape and ecosystem restoration, payment for ecosystem services (PES) should be considered, and the proposed program could link to other PES initiatives.

Supporting actions should include the development and distribution of climate-resilient seed, the investment in affordable post-harvest and storage solutions and the improvement of crop and livestock management through climate responsive extension services. There is room for growth to extend agronomic information and training to farmers. This could be supported by innovation with respect to insurance to reduce the cost thereof and to link it to climate-smart response mechanisms.

4.1.2. Forestry, Land, and Ecosystem Services

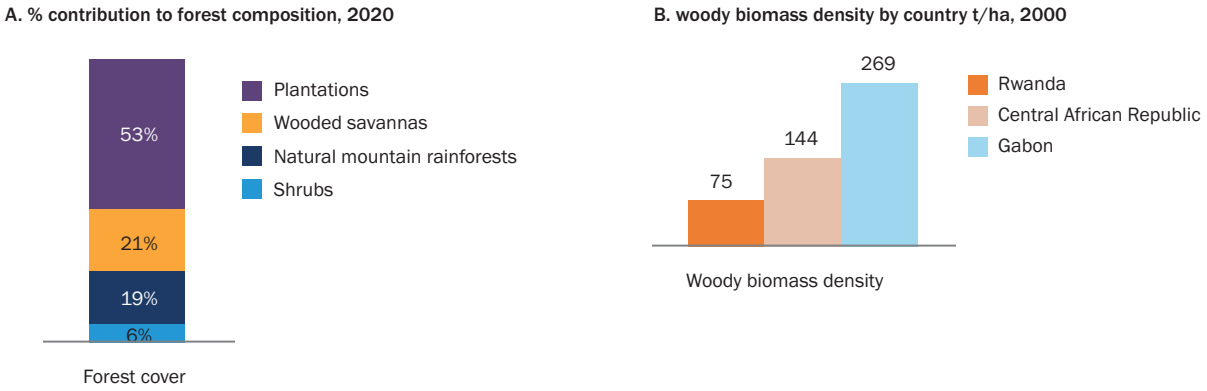
Forestry

Despite highly commendable efforts leading to more than 30% of forest land cover by 2020, the quality and density of current forests is low, which limits productivity and mitigation gains.

44 One example is the use of gasifier cook stoves by farmers to produce biochar in Kenya (see Mahmoud, et al. 2019).

45 One Acre Fund, Trees and Agroforestry, accessed in 2021.

Figure 32: Rwanda Forest Cover and Woody Mass Density



Source: Ministry of Environment (2021).

To improve the efficacy of the sector, the private sector, which owns 70% of woodlots, will have to play a more prominent role. Sustainable forestry and agroforestry can provide environmental and lucrative opportunities, with significant co-benefits to both the agricultural and conservation sectors. Some of these opportunities are listed below:

- **Sustainable and productive forestry for financial and environmental benefits:** Sustainable and productive forestry led by private entities can support the production of renewable biomass that can be leveraged to boost incomes.
- **Agroforestry, including a wider variety of trees to protect soil fertility, moisture, and so on:** The Rwanda National Resources Authority estimates that a 9.5 million m^3 wood deficit exists in Rwanda, and that annual soil loss is at 1.4 million tons. Among other benefits, agroforestry can support farmer resilience on small plots through more diversified income and prevent land degradation.
- **District-level reforestation plans:** Districts can, on a smaller scale, plan for reforestation in areas where land is readily available. If aggregated at the district or sector level, reforested areas can tap into carbon finance.
- **Densifying existing forests and woodlots** can increase their productivity and carbon capture.

The barriers to private sector involvement in the forestry sector and their respective solutions are highlighted in Table 17 of Technical Appendix.

Land

Land is a cross-cutting resource across forestry, water, agriculture, and provides a habitat for biodiversity as well as natural resources such as minerals. Private investment in land conservation practices, however, is still limited, and most uses are commercial such as housing, manufacturing, and mining.

There are several conservation opportunities that include wetland restoration for ecotourism, reforestation on slopes and intercropping. Some of these opportunities are listed below:

- **Conservation through ecotourism:** There is an opportunity to encourage private investments in wetlands that could serve as hubs for ecotourism and recreation through collaborative management partnerships. Additional investments are also possible in national parks. An example of a restoration project is the Nyandungu Urban Wetland of 130 ha that will include botanical gardens for tourists and residents, as well as walking and cycling trails.

- **Reforestation and terracing on slopes to prevent soil erosion:** Though these activities have been mostly government-led, there is an opportunity to engage the private sector where there are potential cost savings—for instance, tea farms operating downstream, or hydropower developers that could suffer from siltation. The energy and agricultural co-benefits offer opportunities for the development of a payments-for-ecosystem-services system to co-fund the enterprises.
- **Intercropping:** There is already a movement to encourage smallholder farmers as well as large-scale exporters, such as coffee exporters, to practice intercropping. Benefits include more economical use of land, erosion mitigation, added nutrient benefits, and soil fertility. Intercropping with high-value longer-term crops (for example, avocado or macadamia) represents a commercial opportunity for off-takers willing to provide saplings.

Mainstreaming resilience and providing incentives could raise private sector interest in conservation. The barriers to such, and their solutions, are highlighted in Table 18 of Technical Appendix.

Ecosystem services

Ecosystem services provided by nature need to be protected across a range of sectors, such as forestry, water, and land. The protection of ecosystem services is crucial in the face of climate change that is altering natural cycles and degrading resources across these sectors. Ecosystem services, such as nutrient recycling, clean air, and storm water management, need to be protected across key sectors. The synergies between these sectors and investments must be evaluated across them, such as land use that can support livelihoods and relieve pressure on forests. The benefits to agriculture include water retention and storm water management, as well as pollination services, to mention a few.

Box 4: Key recommendation: Sustainable and productive forestry and collaborative management partnerships for protected areas with the focus on trade

The Rwandan economy is heavily dependent on tourism for foreign exchange earnings. In 2019, tourism generated foreign exchange earnings of $ 498 million, which is about double the combined earnings from tea, coffee, and minerals. This necessitates the development of the network of protected areas (PAs), more so, because the PAs are surrounded by areas with a high population density. The development of the PA network with an outward focus to maximize foreign exchange earnings will benefit people, as well as general ecosystem service delivery and biodiversity. To this end, collaborative management partnerships could be used by the PA network to fast-track, among others, improving PA operational and management efficiency, the reviewing and adjustment of the entry fees, the application of concession fees, and the introduction of traversing rights, whereby concessionaires are awarded rights to operate routes in the PAs on the basis of a tender (especially for the Akagera National Park and the Gishwati Mukura Park). To ensure that the maximum benefits flow to the local communities, there should be a rollout and expansion of revenue-sharing schemes to communities and local landowners for the co-management and maintenance of PAs beyond the Virunga National Park. It is also important to introduce an investment-friendly environment, especially for foreign nationals with respect to new PAs, including Gishwati Mukura.

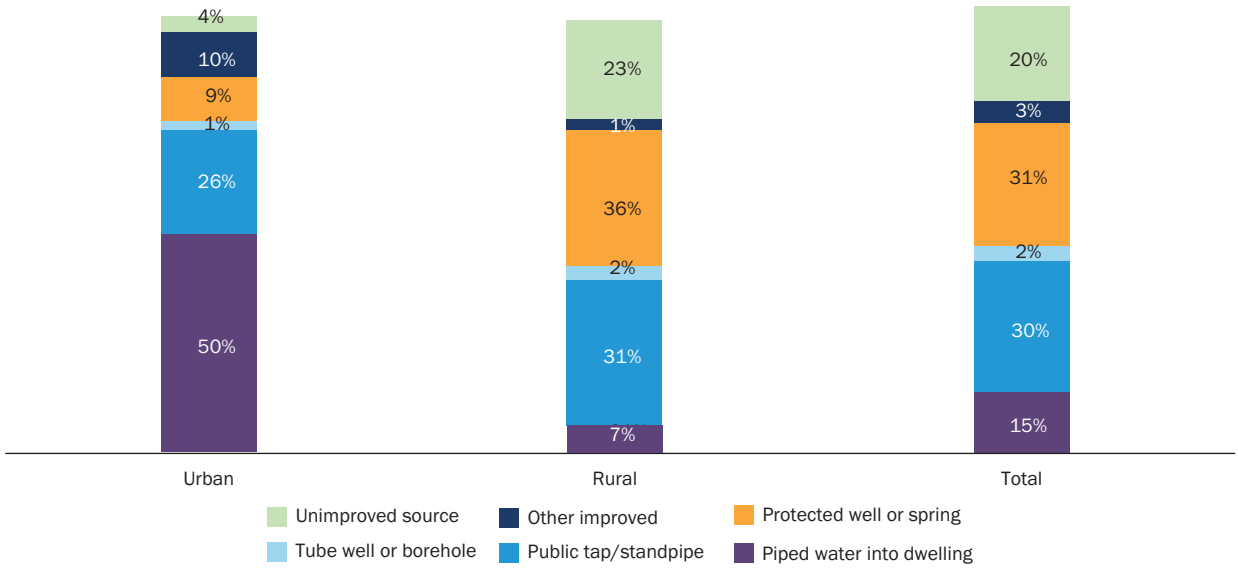
The development of the PA network will be enhanced by the development of an outward focused, trade-orientated professional and productive forestry sector that could act as a buffer zone to the PA network. To enhance the profitability and commercial nature of the forestry, the afforestation and reforestation in high-risk erosion zones is required while improving forest resource harvesting and protection to reduce illegal activity. Improved forest land tenure and agglomeration of forested resources will also contribute to the improved management of the resource. These changes will pave the way for the involvement of private sector entities and a sustainable and productive forestry sector. Agroforestry can also support farmer resilience on small plots through more diversified incomes, social protection, and prevent land degradation, among other benefits.

Nature-based solutions (NBS) are an opportunity to conserve ecosystems and the services they provide. NBS allows the protection and conservation of ecosystems through effective approaches that provide co-benefits for people and nature. There are opportunities to apply these solutions across multiple sectors in Rwanda: (i) agroforestry to increase soil fertility and provide additional income to farmers who could plant tree crops and potentially leverage carbon finance, (ii) biochar production through recycling biomass waste, such as agricultural waste, to enhance carbon sequestration and provide organic fertilizer benefits, (iii) wetland rehabilitation for ecotourism to restore natural habitats for aquatic life and biomass, while simultaneously creating income through sustainable tourism, and (iv) reforestation of the slopes and riverbanks to prevent soil erosion and the siltation of water bodies that are important sources of power for grid energy producers. Payment for ecosystem services can raise financing for providers, but the process is complicated by the lack of frameworks and incentives.

4.1.3. Water

While notable success has been achieved in expanding access to clean water, per capita water availability in Rwanda is still low, and disparities in access exist between urban and rural areas. In addition, water resources in Rwanda have experienced increased degradation as well as increased demand pressure.

Figure 33: Household Drinking Water by Source, percentage of Households, 2020



Source: NISR (2021c).

Increasing siltation of water bodies because of land degradation (hence the need for soil-conscious agriculture, as mentioned above), contamination through urban and rural use, and poor wastewater management, are among the causes of growing water degradation. This degradation is detrimental to the country's ability to generate hydropower electricity and to its continuous reliance on this source of power generation (World Bank Group 2022). Rehabilitating watersheds, scaling affordable clean drinking water, and developing sewage systems could lead to co-benefits for businesses and communities. The following are possible actions that would engage the private sector:

- **The use of nature-based solutions together with the rehabilitation and management of watersheds to mitigate floods:** Sediment management near river basins can prevent a high discharge of soil and nutrient loads into waterbodies, which complicate treatment, impede hydropower generation and other water uses. Rehabilitation has financial benefits for commercial users of watersheds, such as hydropower developers, who could help cover the cost (World Bank Group 2022).

- **Flood control and water storage:** As Rwanda's population keeps growing and industrial development takes place, the sustainable management of water resources is crucial—even more so, with the variability of precipitation poised to increase because of climate change. Flood control and water storage could reduce risks and manage uncertainty, thereby helping to increase adaptability—thus enabling several human activities that would otherwise be adversely impacted by these phenomena. These include, for example, the access of water on demand, the containment of soil erosion, the ability to grow crops in dry seasons, animal survival in dry seasons, the generation of hydroelectricity, and many other important economic activities and stakeholder benefits.
- **Scaling access to affordable clean drinking water and point-of-use treatment:** The average Rwandan uses 3 to 8 liters per day in rural areas, and 20 liters per day in urban areas (for drinking, bathing, cooking, and other uses)—well below the minimum of 50 liters/day recommended by the World Health Organization (WHO). There is an enormous gap that needs to be filled to increase access, particularly in rural towns. The private sector can be involved in setting up and running water kiosks that provide both affordable and bulk, clean drinking water. These businesses can also leverage carbon credits in the long term, by the carbon saved through not boiling water using firewood, charcoal, or any other forms of energy-intensive processes—should regulations allow.
- **Opportunities to develop small-scale sewage systems and wastewater treatment for new urban areas:** Kigali still lacks a centralized wastewater treatment system, but mini-scale treatment plants and sewage systems can serve developments, such as the Green City pilot. These can prevent wastewater leakage and protect water and biodiversity. These systems are often cheaper than building systems for every building and can thus be funded with construction budgets. These systems can also yield carbon credits through methane capture.

Barriers and solutions to private sector involvement in the water sector are provided in Table 19 of Technical Appendix.

Box 5: Key recommendation: People- and resource-orientated water infrastructure development and management

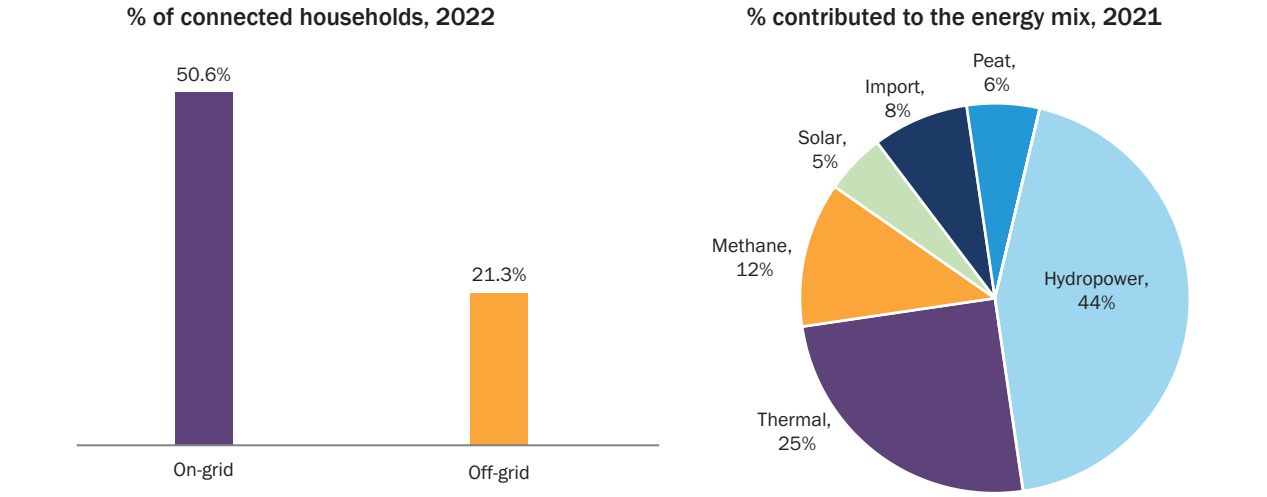
Rwanda has reached the point where it will be difficult to sustain high growth without greater private sector engagement and investment; besides, the private sector is a significant user of water resources. Further high growth necessitates improvements in the water supply infrastructure and the implementation of water demand management practices. To coordinate this effort, the establishment of the Multi Stakeholder Partnership and National Water Climate Centre that would facilitate the collective action of both the private and public sectors with respect to water, is recommended. It should further be recognized that while the expansion of water storage through infrastructure development is a critical component for achieving the economic growth envisioned by Vision 2050 and other supporting policies, storage alone is insufficient. Demand-side interventions are also required. These include, in addition to climate-smart agriculture, the reduction of nonrevenue water though improved infrastructure and improved metering and institutional strengthening, the introduction of efficient domestic water-use technologies, and the creation of economic incentives by applying block-rate tariffs. This will require an educational program about the effect and impact of these demand-side measures, and thereby also sensitizing all water users as to the value and importance thereof.

It should be noted that the water resources sector will benefit greatly from the measures indicated under other priority areas such as climate-smart urbanization, soil conscious conservation agriculture and outward focused forestry and the development of the protected area network. The development of the water resources sector will also enhance social protection greatly by allowing more people access to it and reducing poverty. In like manner, with water being a cross-cutting catalyst for development and essential for quality of life and the development of human well-being, there is also an opportunity to develop a payments-for-ecosystem services system to enhance water security while promoting forestry, conservation agriculture and the development of protected areas.

4.1.4. Energy

Rwanda has made significant strides in increasing access to energy, outpacing many of its peers in Sub-Saharan Africa. The government has set a target to reach 100% electrification by 2024, with a revised target of getting 70% of the population connected to the grid and 30% off-grid. While the target of universal electrification by 2024 remains ambitious, the rapid scale-up of grid electrification and the recent ramp-up of off-grid electrification (with over 120,000 households connected in 15 months) indicates that it might be achievable. The shift from biomass to electricity and clean cookstoves, with the expansion of hydropower and lake methane, and the minor reduction in thermal, will significantly contribute toward the country's resilient and low-emissions pathway.

Figure 34: Energy Access and Energy Mix



Source: REG (2021b, 2022).

While biomass continues to dominate the cooking space, with more than 80% of people using it for cooking, a range of solutions and private sector businesses are beginning to take on this challenge (MININFRA 2018). The following are examples of private players: i) more than 40 solar companies, ii) more than seven hydropower companies, iii) more than 14 liquefied petroleum gas (LPG) companies, and iv) more than nine clean cookstove companies.

Clean energy providers can contribute to mitigation outcomes and could tap into carbon finance in the medium-to-long-term. A selection of the opportunities include:

- **Leveraging carbon finance for mitigation outcomes delivered by renewable energy actors:** Carbon finance is still largely untapped by Rwanda's clean energy solutions—solar energy providers, mini-grids, clean cookstoves, and hydropower could all benefit from carbon financing from selling carbon credits.
- **Scaling clean cooking solutions across the country:** Over 80% of Rwandans rely on some form of biomass for cooking which contributes to air pollution, respiratory diseases, and deforestation. A range of activities are underway to address the cooking challenge, and there is likely to be significant, carbon-led, commercial upsides for investors behind successful solutions.
- **Investing in transmission and distribution:** Rwanda is quickly approaching a surplus in energy generation. More efforts will be needed to scale transmission and increase use through new industries. With government funding for grid expansion currently insufficient to meet the target of 70% grid access by 2024, PPPs to accelerate grid expansion could fill a key funding gap. While many projects in the power sector have been developed by domestic players, partnering with international

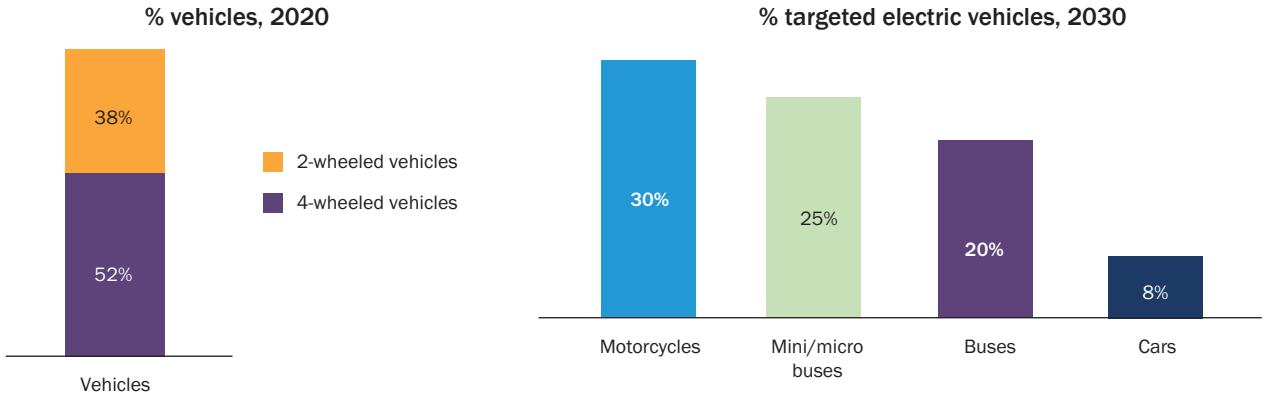
sponsors can be beneficial for projects that are based on more complex technologies (for example, methane-to-power) or require sizeable long-term financing.

Barriers to private sector involvement and proposed recommendations for the grid energy subsector are highlighted in Table 20 of Technical Appendix, with that for off-grid energy in Table 21 of Technical Appendix, and for the cooking subsector in Table 22 of Technical Appendix.

4.1.5. Transport

Transport and related services in the form of the maintenance and repair of motor vehicles, and wholesale and trade account for 15% of total nominal GDP.

Figure 35: The state of the transport sector and e-mobility targets



Source: NBR (2019) and GoR (2020a).

The growth in the number of vehicles is estimated at 12% per annum, and Rwanda aims to gradually increase the number of electric vehicles (EVs) which necessitates a sustainable supply of electricity, as discussed above. Various incentives such as zero VAT and withholding tax on EVs, rent-free land, vehicle parts, batteries and charging infrastructure, have been put in place. Several firms including Ampersand, Guraride, Volkswagen Rwanda and Rwanda Electric Motorcycles have started to operate on the small-scale side of e-mobility. The contribution of the transport sector to air pollution was estimated at 13% in 2015 and will continue to rise due to urbanization and population growth.

Untapped opportunities to scale e-mobility can be capitalized on by leveraging carbon finance and addressing existing challenges. This can be done as follows:

- **Untapped opportunity for large vehicles such as e-buses:** With short distances between cities, frequent stops, and a slow speed combined with a relatively clean and over-supplied electricity stack, Rwanda is very well suited for electric buses. However, due to high up-front capital expenditure (CAPEX) costs, limited dedicated infrastructure and technical capacity gaps, the technology does not yet exist in the country.
- **There are opportunities to scale small-scale solutions faster**: Scale-up plans for existing e-bike and bicycle solutions may be sufficient to meet Rwanda's 30% target of electric motorcycles. Given cost competitiveness, the assets' lifetime, and recharging/battery swap networks being constructed, there is an opportunity to move even faster, and go beyond 30%. Climate finance has yet to be accessed by existing solutions and could create a price advantage, while lowering the risk of larger-scale investments.

Barriers to private sector involvement and proposed recommendations in the transport sector span policy, as well as institutional and market-related components are highlighted in Table 23 of Technical Appendix.

Box 6: Key recommendation: The expansion of the energy and transport sectors while maintaining a low emissions pathway

It is recognized that Rwanda is a low-emission country and can maintain such a trajectory by the introduction of low-carbon energy and transport solutions, yet it can still contribute to the development of the economy. From an energy sector perspective this involves, among others, switching from peat-based electricity generation to the expansion of lake methane and the increased use and adoption of both off-grid solar electrification and rooftop solar generation and solar water heaters, and the expanded use of the anaerobic digestion of organic waste, as well as landfill gas utilization. Furthermore, given the costs and technical challenges involved in large hydropower, and its susceptibility to climate variations and the current high dependence thereon, it is recommended that hydropower's contribution to the overall electricity mix be reduced from 40% to 20%. Rwanda can further diversify its power supply mix through regional power trade and the development of other renewables to reduce climate shocks. In this context, a policy dialogue between the water and energy sectors is recommended in order to review the country's reliance on hydropower and expand small hydropower schemes. This should also be done to align Rwanda's electricity expansion plan with the NDC. The elimination of tax duties from all renewable or cleaner sources of energy should also be considered. This is to be done in conjunction with the rapid implementation and national rollout of clean cooking stoves, which will lead to a reduction in unsustainable firewood, charcoal, and fossil energy consumption for cooking, and their associated emissions.

Other actions should include the expansion of the program for national dissemination of compact fluorescent lighting and low emitting diode lamps as well as the enhancement of energy efficiency in industry, specifically the phasing out of diesel gensets for on-site electricity consumption in mining, the phasing out of the use of clamp kilns and applying energy efficiency measures in the brick industry, and the use of waste heat recovery and rice husks as fuel within clinker production. The in-house improvement of both lighting and cooking solutions will greatly improve the quality of life of all Rwandans and improve the conditions for learning and productivity.

Lastly, from a transport sector perspective, the introduction of fuel economy and emission standards in conjunction with an accelerated vehicle retirement program, or 'scrappage' schemes, is important. Not only can these be used to incentivize the removal of the most polluting vehicles from the road, but it can also assist in the development of the country and assist in road safety.

4.1.6. Urbanization: Housing

Although 18.4% of Rwanda's population lives in urban areas (DBR 2020), approximately 61.3% of people living in urban areas live in informal settlements, the majority of which reside in Kigali (NISR 2018b). Informal settlements are sometimes built-in flood zones and slopes that are less resistant to disasters, such as floods and landslides. This puts the population in a tenuous position when disasters hit, and therefore necessitates the need for more affordable housing units that are climate resilient. To achieve this, Rwanda will need a considerable number of new units per year. Estimates from the Center for Affordable Housing in Africa project that 69,000 units will be needed per year—most of which need to be affordable.[46] However, formal housing developed does not fit under the affordable housing bracket. The highlighting a significant housing deficit.

Developing greener low-cost construction materials, improving processes, and enforcing green building regulations could reduce the costs and climate effects of housing. This can be achieved by the following measures:

- **Reducing the housing cost with innovative, local, greener and low-cost materials, inclusive of nature-based solutions**: Current construction materials are mostly imported leading to both higher

46 Center for Affordable Housing in Africa, Assessing Rwanda's Affordable Housing Sector.

carbon footprints and costs. Import taxes and transport and logistics costs are estimated to increase construction materials prices by up to 43%. Benchmarking housing costs show that costs are 30% higher in Rwanda than in South Africa, driven by building costs and infrastructure costs, even though other cost drivers (access to land, professional services, limited market competition, and building codes and standards) exist. While not all materials can be substituted competitively, innovative alternatives can be evaluated. Locally made construction materials such as autoclaved aerated concrete (which require less cement than traditional clay), compressed stabilized earth blocks, mud bricks (*rukarakara*) and modern clay bricks could reduce carbon emissions compared to traditional concrete bricks and cement blocks. A few developers are starting to use these technologies, but more scale is still needed, especially as most of the housing is built using burned clay. Other sustainable materials and building methods include cross-laminated timber (CLT) in place of steel and concrete that could help grow forestry industries in the country, while benefiting the housing market with climate subsidies.

- **Process innovation to reduce the cost of affordable housing construction**: Continued innovation in construction processes and building designs holds a promise to further reduce the cost of construction. Significant costs related to delays in, and the poor management of, construction projects can be reduced with innovation in management processes and replicable designs. One of the ways for improved management is to form joint ventures with international developers and contractors to share technology and capabilities, and ultimately, to build the capacity of local developers.
- **Introducing and enforcing the requirement for Excellence in Design for Greater Efficiencies (EDGE) building certification for new buildings:** In addition to investing in new, affordable construction materials and process innovations to reduce the cost, and hence increase the affordability, of additional buildings, building green to ensure climate resilience of these buildings should be considered as well. Current regulations do not require a green building certification. Introducing and enforcing the EDGE building certification for all new buildings will ensure that contractors achieve a zero-carbon rating, contributing to climate change adaptation and mitigation. This can also contribute to affordable housing initiatives through access to green finance. Ensuring that the infrastructure designed and developed is resilient to climate risk will also be important to increase the resilience of cities to climate change.

Barriers to private sector involvement and proposed recommendations in the housing subsector are highlighted in Table 24 of Technical Appendix.

4.1.7. Urbanization: Waste

Rwanda has been a regional pioneer regarding sustainability in waste. It was the first country in the East African Community to ban the use of nonbiodegradable plastic bags in 2008, and it recently passed a legislation to ban the importation, production, and sale of single-use plastic. Despite this legislative progress, waste management is still underdeveloped in the country as very little formal waste collection is done outside the capital.

Private sector opportunities exist in waste collection, separation of the reuse for energy, and production. Poorly managed waste systems lead to environmental pollution that degrades ecosystems and worsens climate change impacts. By using a combination of high-tech and low-tech solutions, next generation waste processing facilities have the potential to profitably address Rwanda's waste problem. Additionally, building the necessary infrastructure to carry out waste separation could create a point of entry for waste-to-energy (WtE) businesses that have been reluctant to invest given the high costs of setting up baseline infrastructure.

Barriers to private sector involvement and proposed recommendations in the waste subsector are highlighted in Table 25 of Technical Appendix.

Box 7: Key recommendation: Climate-compatible urbanization

The City of Kigali and the secondary cities have recently developed master plans that aim to incorporate climate change and environmental concerns. This is of great importance given the expectation that urbanization is projected to occur rapidly in Rwanda. To reduce the growth of unplanned settlements to a minimum, and reduce the vulnerability of the average urban household to climate change hazards, the government should engage in land readjustment, in parceling peripheral (but well-linked) urban land into grids in advance of settlement, and in sites and services. This will enhance the inclusion and the economic participation of more people.

Urban planning, zoning, and building codes will have important and profound (lock-in) impacts on the energy and the transport systems as well. The government and the stakeholders in the energy sector needs to be involved early in the urban planning process, including reviewing, and providing inputs in master plans from an energy efficiency perspective, building on international experience. The government and the energy sector should also start developing energy efficiency and green building codes, including integrating and incentivizing rooftop solar and net metering. From a transport perspective, the introduction of electric vehicles and charging infrastructure (e-mobility), together with an enhancement of the public transport system, could also enable the development of the country. This is especially so, when considering e-bicycles and low-emissions motorcycles, and the promotion of the modal shift from private-to-public and zero-carbon transport modes, through the increased use of public and nonmotorized transport.

In implementing the above, there are a few key challenges: i) the urban planning capacity in the One-Stop Centers which create and enforce master planning zoning regulations, ii) the fiscal capacity at the central and local government levels, and iii) the legal and regulatory framework to implement the plans as written. Key to addressing these challenges is the property tax, which is implemented centrally, on behalf of districts. The current property tax regime is one of the lowest in the world, even after the 2019 reforms, and municipal revenues are greatly needed to implement measures to promote climate resilience and low-carbon growth. The government should both implement the property tax levels mandated by the 2019 law, and work to enforce the law efficiently and fairly, to maximize municipal revenues.

In close support of the revisioning of the property tax is the restructuring of the construction permit fee from the current flat fee regime to a percentage of 0.1% or 0.2% of the value of the bill of quantities. This has great potential to fund the One-Stop Centers, which are likely to improve capacity to proactively generate local-level urban plans. This capacity is to entail, in part, the capability to conduct flood modelling and landslide susceptibility, which includes an analysis of the cost to assets and the broader economy that will be incurred in extreme flooding and precipitation events. In this context, and from a disaster risk management perspective, the adoption and implementation of the New National Disaster Risk Reduction Management Policy is important. Protection should therefore be offered to critical infrastructure within floodplains, which will require a detailed study delimiting the flood plain boundaries.

4.2. Cross-cutting Constraints and Recommendations

4.2.1. Improving Private Sector Participation: Cross-cutting Aspects

In addition to the area-specific constraints mentioned in Section 4.1, there are cross-cutting constraints that will need to be addressed to ensure effective private sector involvement in climate action. On the policy side, clarity on carbon regulations and taxation will help provide certainty for investors. In Table 26 of Technical Appendix on the institutional capacity side, local commercial banks need support to understand and assess the risk of climate businesses and leverage blended finance, to finance climate-positive businesses in Table 27 of Technical Appendix.

On the market side, active engagement of the private sector is necessary to understand the nuanced needs when designing programs. Capacity building of climate businesses will be needed to unlock growth and scale. Additional financial innovation and new agents will also be needed to provide long-term climate finance in Table 28 of Technical Appendix.

4.2.2. Crowding in Private Sector Investment for High-impact Projects: Blended Concessional Finance

Blended finance is one of several tools developed by the international development community to mitigate the risks of highly impactful projects or programs. De-risking or rebalancing the risk-reward structure may allow the financing of such projects or programs, moving them closer to commercial sustainability. For projects with high expected development impact, especially in high-risk environments, persistent market failures—exacerbated by challenging investment climates or inherent risks from innovative projects and technologies—may make such projects financially nonviable, even with the standard development finance institution (DFI) help. In these cases, finance at concessional terms, via blended concessional finance structures, may enable a project (or program) to proceed, providing significant development impact to the country.

The DFI Working Group on Blended Concessional Finance for Private Sector Projects, a group of 23 DFIs, has adopted the following definition of blended concessional finance for their private sector operations:

"Combining concessional finance from donors or third parties alongside DFIs' normal own-account finance and/or commercial finance from other investors, to develop private sector markets, address the Sustainable Development Goals (SDGs), and mobilize private resources".[47]

Strong rules are needed to avoid the misuse or ineffective use of scarce concessional capital. DFIs, like the International Finance Corporation (IFC), maintain rigorous and well-established policies and procedures that govern its blending operations. This has enabled them to develop a track record as a disciplined investor of concessional funds, where one of the key focus areas is minimum concessionality to avoid market distortions and maximize crowding-in of the private sector. A clear-cut strategy for the eventual exit of development finance is critical—investments must show a well-mapped path to sustainable commercial financing without subsidies. The IFC publicly discloses the transaction-level subsidy levels for each project, along with justification for why it is necessary, in the *Summary of Investment Information* posted on IFC's external website.

Blended concessional finance can reduce risk through various types of risk-sharing mechanisms, longer tenors, subordination, and guarantees. It could also provide an incentive to the project sponsor to adjust the size or design of the project to access a broader group of consumers. However, de-risking private investments through blended finance cannot substitute for systematically addressing public policy failures or capacity constraints. As such, alongside blended finance investments, there is often the need for DFIs to provide advisory services as well as policy or other interventions that support the country to remove barriers to investment, and to enhance the operating environment for private business.

4.2.3. Low-income and Fragile Countries: A Role for Blended Finance in Rwanda

There is increasing recognition that the private sector can play an essential role in stabilizing fragile and conflict-affected situations (FCS), such as Rwanda. Blended concessional finance is designed to address the issues of high risk and potential low profitability found in many private sector projects in fragile states by offering below-market terms for finance and risk-mitigation products. In this context, blended finance can help buffer contextual risks that would otherwise make it impossible or unaffordable to invest, even when the underlying business proposition is sound. With a maturing small and medium enterprise (SME) sector, small businesses in Rwanda could benefit greatly from both patient/flexible capital and technical assistance to help them achieve scale and create employment.

47 https://www.ifc.org/wps/wcm/connect/6923bcfa-36cd-4d76-889c-229ae373e175/202112-DFI-BCF-Joint-Report.pdf?MOD=AJPERES&CVID=n.xxCH0

The IDA-IFC-MIGA Private Sector Window (PSW)[48] was created to catalyze private sector investment in International Development Association (IDA)-only countries, with a focus on FCS. Resources allocated to the IDA PSW are a critical source of co-investment funding and guarantees to address market failures, to de-risk projects for all capital providers, and to enable the IFC and the Multilateral Investment Guarantee Agency (MIGA)[49] to support projects outside of their normal risk acceptance criteria in IDA-only and IDA-FCS countries like Rwanda. The IDA PSW is deployed through four facilities—three managed by IFC and one by MIGA:

- Blended-Finance Facility to mitigate various financial risks by providing loans, equity, and guarantees to pioneering IFC investments across sectors with high development impact.
- Local-Currency Financing Facility for markets with limited currency-hedging capabilities.
- Risk-Mitigation Facility to provide project-based guarantees—focusing on infrastructure or public-private partnership projects—without sovereign backing.
- A MIGA Guarantee Facility to expand coverage of MIGA guarantees from MIGA.

As a result of the COVID-19 pandemic, emerging market banks have already seen liquidity either become more expensive or dry up altogether. This trend is more pronounced in markets such as Rwanda, compared to larger or less leveraged emerging markets. Additionally, heightened risk aversion has caused banks to shorten available tenors, currently providing for a maximum of three to six months. This is in direct contradiction to the current needs of businesses, which require the extension of tenors, as delays in sourcing, shipment, supply chain issues, and generally reduced sales due to lockdowns, have caused an increase in the duration of trade and working capital cycles.

Blended finance can help reduce perceived risks, by investors and financiers looking to enter new markets, and eventually demonstrate the business case for sustainable private sector investment in the sector and the country. Concessional finance can allow the provision of much needed long-term capital during the more risky stages of a first-of-its-kind project, providing financial support until the business is fully developed and, eventually, operating on a fully commercial basis.

Historically, the majority of the IFC's blended finance investments in Rwanda have been through the Private Sector Window (PrSW) of the Global Agriculture and Food Security Program (GAFSP). Working alongside the IFC, the GAFSP PrSW applies blended finance solutions and IFC's expertise and knowledge to invest in projects that may not attract commercial funding, due to perceived high risks in the agricultural sector. GAFSP funding is co-invested alongside IFC funding, but the private sector window takes it one step further: addressing market failures by providing affordable funding with less demanding terms. This enables the private sector window to invest at an early stage, or in riskier projects, in the IDA and in fragile and conflict-affected states that have a high potential for development impact and financial sustainability.

4.2.4. Early-stage Market Creation: Improving Nutrition in Rwanda[50]

A strong example of a blended finance solution in an early stage of market creation is the IFC's work to address chronic malnutrition and its negative impact on human capital development in Rwanda. A 2015 IFC project consisted of financing a 45,000 ton/year processing plant to produce fortified cereals to treat malnutrition in nearly one million children, and pregnant and nursing women. Using maize and soy, sourced and grown locally by Rwandan farmers, the processing plant is developing fortified food for young children and their mothers, supporting the prevention and treatment of malnutrition among this vulnerable

48 https://ida.worldbank.org/financing/ida18-private-sector-window/what-is-ida-private-sector-window

49 www.miga.org

50 https://www.ifc.org/wps/wcm/connect/8e7889db-2860-4ed3-a465-54d1070ff2fb/EMCompass_Note_51-BlendedFinance_FIN+April+13.pdf?MOD=AJPERES&CVID=mbkK6Id

population. IFC's $26 million investment in Africa Improved Foods (AIF) was made possible with funding from a GAFSP PrSW—blended finance was the subordinated debt, and equity was essential to allow the project to go ahead, since extensive risk factors made financing on strictly commercial terms unachievable. The identified risks included the following vulnerabilities: greenfield and market risks; fluctuations of raw material commodity prices; a lack of consistent supplies of quality maize and soy; limited access to long-term capital; and an untested private partnership model in this sector. Advisory services were also an important component in the overall structure to strengthen sourcing and build the commercial market for the products. A key lesson from the project was the early identification, at the concept stage, of the need for blended finance through the GAFSP PrSW, to move the transaction forward. This made it possible to create a strong partnership and align the project with GAFSP PrSW' objectives of supporting food security and rural incomes in a market with high risks for commercial investments. By supporting local production of this fortified cereal, the AIF is positioned to set a new standard in food production in the country and the region, as well as strengthen the supply chain, as farmers learn to improve both the productivity and the quality of the key raw materials.

The project provides a strong example of how blended finance can play a key role in kick-starting a new market and achieving strong long-term development impact. Once the project reaches commercial sustainability, it will be a strong demonstration of a working model for other countries facing similar challenges.

4.2.5. Supporting Growth and Jobs in Rwanda's Tourism Sector[51]

Tourism makes a major contribution to jobs and economic activity in Rwanda, famed for its mountain gorillas, but the sector was hit hard by the COVID-19 pandemic. Many tourism-focused businesses struggled during the depths of the pandemic, making increased investment in the sector even more urgent. A 2018 IFC investment is supporting the 3B Group of Hotels, one of Rwanda's leading ecotourism groups, to expand its network of mid-tier lodging in Rwanda. The investment supports the completion of the 30-room Akagera Safari Camp in the Lakes District in the Eastern Province of Rwanda, and the refurbishing and upgrading of a 61-room hotel in Kigali. Completion of the Akagera Safari Camp will allow 3B to offer its clients a tourism circuit that would include gorilla trekking, Lake Kivu excursions, and the Akagera big game safari—with Kigali as the central strategic logistic hub. The Akagera safari is expected to be a big draw for tourists and is strategically viewed as an important driver of the expansion plan.

The IFC has mobilized a loan package of the tenor and repayment profile that is not readily available in Rwanda. The IFC's financing package included a $1.7 million concessional subordinated loan from the IDA PSW Blended Finance Facility—a facility designed to support private sector growth in lower-income countries. The blended finance investment enables 3B to proceed with its expansion, create quality jobs, and complete a strategic tourism circuit in Rwanda. Combined, the projects are expected to create more than 90 permanent jobs, and more temporary jobs during the construction phase. 3B is committed to developing local communities and expects to source as much as possible through local suppliers, and to train its suppliers to help them reach the required quality standards.

51 https://pressroom.ifc.org/all/pages/PressDetail.aspx?ID=26838

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