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Fact sheet for geothermal development to promote Public Private Partnerships in East Africa

Rwanda

The Republic of Rwanda is located in east central Africa along the Western Branch of the East Africa Rift System (EARS). The country is bordered by Tanzania (East), Uganda (North), Burundi (South) and the Democratic Republic of Congo (West) (Figure 1). The total area of the country is 26,338 km^2 with current population of 13,625,627. Rwanda's long-term strategy is defined in the Vision 2050, a strategy that seeks to transform the country to become an upper middle-income country by 2035 and high-income status by 2050 characterized by better livelihood for its people. This will be implemented through transformational policies, programs, and projects well designed and implemented through medium-term development strategies such as the National Strategy for Transformation (NST1).

Overview of electricity sector status

Currently, The NST1 which is also the Seven Year Government Programme (7YGP) until 2024 is expected to lay the foundations for decades of sustained growth and transformation that will accelerate the move towards achieving high standards of living for all Rwandans. NST1 has set sectoral targets to be achieved by 2024 including achieving universal access to electricity by 2024. This is planned to be achieved through a combination of on grid and off grid electricity connections at 52% and 48% respectively.

Electricity Generation Capacity in Rwanda

The electricity in Rwanda is generated from diverse sources which include both renewables like hydro and solar, and non-renewable energy sources like natural gas, peat, fossil fuel (heavy and light oil). For off-grid electrification, solar and mini/pico grids are the mainly used generation sources. The total installed capacity in Rwanda from both on-grid and off-grid power plants is 276 MW with 135 MW from renewables and 103 MW from non-renewable sources. As of March 2023, hydropower accounted for 123 MW, solar accounted for 12 MW and thermal accounted for 138.6 MW (Rwanda Energy Group, 2023).

Figure 1 shows the grid-connected installed electricity capacity trends in Rwanda from 2012 to 2021. A steady growth of installed electricity capacity increased from 110 MW in 2012 to 230.5 MW in 2021. Renewable energy, including solar photovoltaic, hydropower, and solid biofuels, has increased 2.3 times in the past decade. During this period, installed capacity for solid biofuels remained nearly constant, yet a rapid growth in solar photovoltaic, hydropower was achieved. Non-renewable installed capacity increased approximately two times during the same period. A rapid growth in the installed capacity happened in 2015 because of oil and natural gas, and in 2016 because of coal and peat. Renewable energy sources contributed to about 57% of the total grid-connected installed electricity capacity in 2021 (IRENA, 2022).

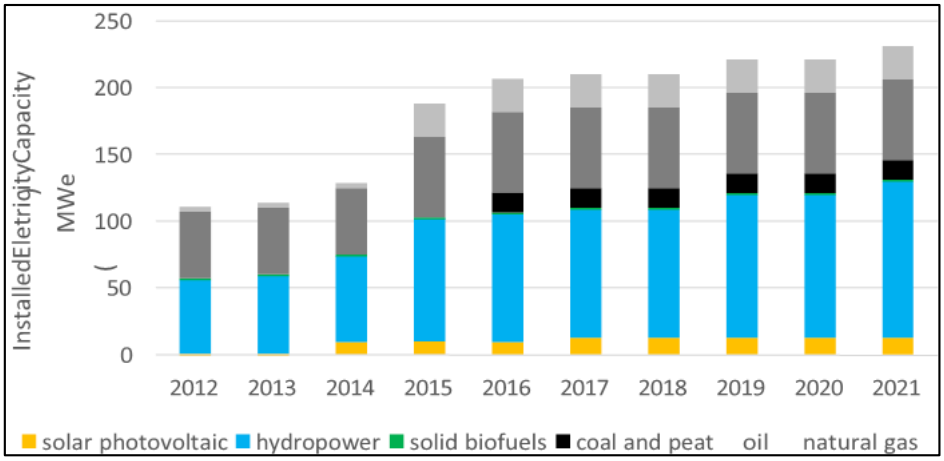

Figure 1: Installed electricity capacity trends in Rwanda by source

Data Source: (IRENA, 2022)

Status of Electricity Production

In Rwanda, biomass dominates as the principal source of primary energy for 78% of the population. To date, the total installed capacity to generate electricity in Rwanda is 276 MW and 73% of Rwandan households have access to electricity which include 51% connected to the national grid and 22% through off-grid solutions. To minimize the dependency on energy imports and create conditions for the provision of safe, reliable, efficient, cost-effective, and environmentally appropriate source of energy, renewable energy resources including geothermal energy seems to be the long-term solution.

Figure 2 shows the grid-connected electricity generation trends in Rwanda from 2010 to 2019. Electricity generation has increased two times from 361,265 GWh in 2010 to 777,246 GWh in 2019. Renewable energy is approximately half of the total installed electricity throughout the decade. A rapid growth in installed electricity generation was recorded in 2016 due to the installation of natural gas (IRENA, 2020).

The development of geothermal energy resources in Rwanda is at exploration stage compared to some East African countries such as Kenya and Ethiopia. The exploration of this resource was active in 2006 with a view of diversifying energy sources for electricity generation and meeting the electricity demand in the country. The geothermal potential was estimated at 170-340 MW and later revised down to 90 MW by the Japan International Cooperation Agency (JICA, 2016).

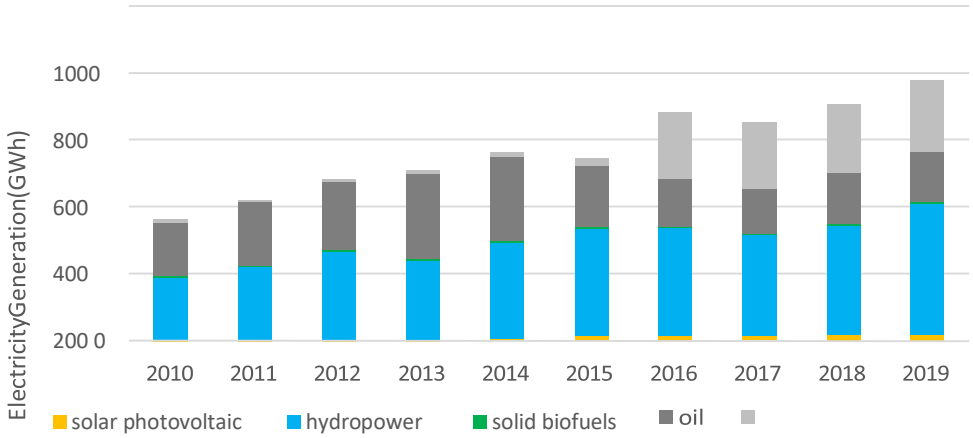

Figure 2: Electricity generation trends in Rwanda by source

Data Source: (IRENA, 2020)

Ongoing & Planned Power Generation Projects

A number of projects were envisioned in the Least Cost Power Development Plan (LCPDP) 2020-2040 in order to ease generation from thermal power plants. According to the LCPDP, projects employing different technology mix that had near-term commissioning were considered. These power plants include 186 MW of thermal installations, 93 MW small hydro plants and 170 MW regional projects (Rwanda Energy Group , 2021).

Demand forecast and Generation Expansion Plan

The existing Rwanda electricity demand was calculated based on recent historical trend using existing hourly electrical load curves. Forecast for peak energy demand was then done for the next 20 years as using different growth scenarios and here projections up to year 2030 are presented (Table 1). Due to uncertainties, a final rate of 10% was adopted to be used for planning and expansion (Rwanda Energy Group , 2021).

Table 1: Rwanda annual peak & energy demand growth for different growth scenarios

Year	Scenario: 8% growth		Scenario: 10% growth		Scenario: 12% growth	
	Peak, MW	**Energy, GWh**	**Peak, MW**	**Energy, GWh**	**Peak, MW**	**Energy, GWh**
2022	189	1,135	211	1267	235	1411
2023	204	1225	232	1393	263	1581
2024	220	1323	255	1533	295	1770
2025	238	1429	281	1686	330	1983
2026	257	1544	309	1855	370	2221
2027	277	1667	340	2040	414	2487
2028	300	1800	373	2244	464	2786
2029	324	1945	411	2468	519	3120
2030	350	2100	452	2715	582	3494

Electricity Access

The cumulative household connectivity rate in Rwanda was 72% by June 2022. This comprised of 50% grid connection and 22% off-grid connection especially by solar. The government of Rwanda has a target of 100% household connectivity by 2024 of which 70% will be grid connected while 30% will be connected by off-grid solutions. In order to achieve this ambitious goal, Rwanda Energy Group (REG) intends to increase new connections by 500,000 annually both on-grid and off-grid (Rwanda Energy Group, 2022).

Feed-in-Tariff and Electricity Retail Tariff

The feed in tariffs for Rwanda were set in 2012 by RURA are subject to the project being close to the national grid network (10km). The plant size varies for 50kW to 10 MW at rates of between US$ cents 16.6 to 6.7 US$ cents for the larger size (Rwanda Utilities Regulatory Agency, 2012).

Overview of geothermal development status

Geological setting

Geothermal investigations in Rwanda started in the 1980's and the existence of geothermal resources in Gisenyi, Karisimbi, and Kinigi in the north-western region associated with volcanoes and Bugarama in the southern region associated with faults in the East African Rift (Figure 3). Several researchers have studied the geothermal resources potential in Rwanda including the French Bureau of Geology and Mines (Demange, Fabriol, Rançon, & Verzier, 1983) and Chevron (2006) who carried out geochemistry studies in the Bugarama and Gisenyi geothermal prospects and estimated the geothermal reservoir temperatures to be more than 150°C (Newell, Rohrs, & Lifa, 2006). In 2008, the Germany Institute for Geosciences and Natural Resources (BGR), in collaboration with the KenGen, the Icelandic Geo Survey (ISOR) and the Spanish Institute for Technology and Renewable Energies (ITER) carried out surface studies in the Gisenyi, Karisimbi and Kinigi areas. The results from this study concluded that a high temperature geothermal system (>200°C) may exist on the southern slopes of Karisimbi volcano and that a medium temperature geothermal system may exist around Lake Karago (150-200°C) (Jolie, Gloaguen, Wameyo, Armannsson, & Perez, 2009).

Geothermal fields and prospects

- **Karisimbi geothermal prospect**

The Karisimbi area is located near the Karisimbi volcano within the National Volcano Park and Virunga volcanic chain complex. No geothermal manifestations have been reported in this area. Couple of hot springs are located south and out of the volcanic field with the highest temperature of 64°C at Karago. Detailed surface geo-scientific studies and exploration drilling have been completed. Drilling of three deep exploratory wells was funded by Government of Rwanda but only two wells (KW-01 and KW-03) were drilled (Figure 6).

In 2009, KenGen acquired additional surface studies (geochemistry and geophysics) and carried out baseline EIA on the southern slopes of the Karisimbi Volcano. Findings recommended drilling three exploration wells in the Karisimbi prospect. (Mariita, Wanjohi, Opondo, Kemboi, & Gachau, 210). In

2011, an additional geothermal survey was done by the Institute of Earth Science and Engineering (IESE) through Auckland UniServices, New Zealand aiming at developing a conceptual model for the entire western region and locating sites for exploration drilling in the three prospects, Karisimbi, Kinigi and Gisenyi (Shalev, et al., 2012).

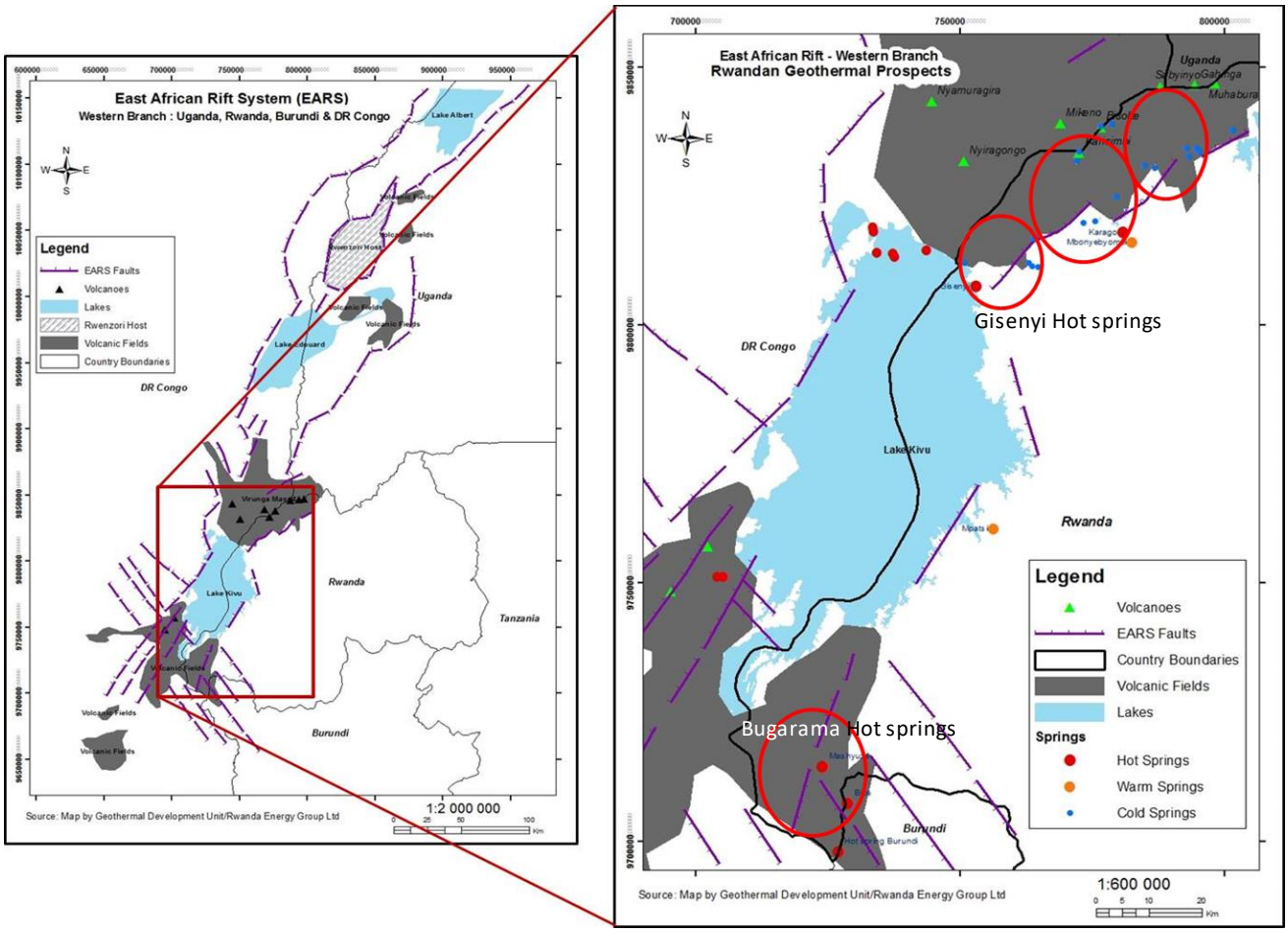

Figure 3: Location of Rwanda geothermal prospects

(Geothermal Development Unit, 2013)

Workshops were organized in 2012 and 2013 with panel of experts aiming at merging all findings to come up with one unified conceptual model for the Karisimbi area allowing for the definition of the location of sites for exploration drilling in Karisimbi (EWSA, 2013). In 2013-2014, two exploration wells were drilled in the southern slopes of the Karisimbi volcano to 3,015 and 1,367 m depth, respectively. Alteration mineralogy and measured temperatures in the two wells are consistent with normal continental geothermal gradient (i.e. ~30°C/km) conclusively demonstrating that there is no indication of a geothermal reservoir under the southern slopes of Karisimbi.

Exploration drilling started at the Karisimbi prospect in July 2013 with the first well KW01 to a depth of 3,015 m followed by the second well KW03 in December 2013 to a depth of 1,367 m. From the findings of nature of the underground geological formation and well testing from the two wells, it was observed that there was no evidence of a geothermal system in the Karisimbi area. The drilling activities were halted in March 2014 to review the data and the exploration strategy. The existing geo-scientific data and drilling data were reviewed by ISOR, the United Nations Environment Programme-

African Rift Geothermal Development Facility (UNEP-ARGeo) and JICA. The outcome of this analysis was the basis for the elaboration of a new strategy for Rwanda geothermal exploration and development.

Figure 6: Location of Karisimbi geothermal prospect

- **Kinigi geothermal prospect**

The Kinigi geothermal area is located to the east of Karisimbi (Figure 3). Detailed surface studies as well as Environmental and Social Impact Assessment (ESIA) have been completed and supplementary studies were recommended to decide on the way forward for the exploration of this prospect. Additional geoscientific surveys to update the Kinigi geothermal conceptual model were carried out in 2015 by West Japan Engineering Consultants (WestJec) funded by JICA. Remote sensing data analyses, volcanic rock sampling and gravity surveys were completed followed by the construction of a conceptual model. Results of the study were shared during a Technical Review Meeting (TRM) organized by UNEP-ARGeo and the Icelandic Ministry of Foreign affairs in May 2016 which resolved that there is probably no viable geothermal system at Kinigi area.

- **Gisenyi geothermal prospect**

The Gisenyi geothermal prospect is located south-west of Karisimbi along the shores of Lake Kivu in Rwanda (Figure 3). Hot springs discharge at about 75 °C in the prospect at the shores of Lake Kivu. Geoscientific investigations have been carried out in the area. Additional studies to complement existing data in the Gisenyi area were carried out in 2017. Detailed geological, geochemical, and geophysical studies revealed a shallow geothermal reservoir at about 100°C and a deep reservoir with

a temperature of 160°C - 200°C (GDC and Geo2D, 2017). Considering that the geometry of the reservoir could not be well defined due to the limitations of the geoscientific methods deployed and the available data; MT measurements and slim holes drilling at the fault and across the peninsula were recommended. However, the Gisenyi geothermal reservoir is most likely suitable for direct use applications and a lower probability that a small ORC power plant could be developed.

- **Bugarama geothermal prospect**

The Bugarama geothermal prospect is in the southern province of Rwanda (Figure 3) and has two important geothermal areas known as Ruhwa and Mashyuza. The geothermal manifestations at Mashyuza are hot and warm springs and travertine deposits, which is being mined as feedstock for a nearby cement factory. The highest temperature for the springs is about 55°C. Surface exploration and drilling of thermal gradient wells in the Rwandan part were completed and a conceptual model was developed (Turinimana, 2018). The conclusion of the study indicates that Bugarama is a typical low enthalpy system with heat source due to deep circulation along the main fault at the site. The predicted subsurface temperatures mainly based on silica geothermometers is about 115°C at depth of about 500-1,000 m. Additional geoscientific surveys and a market study for direct uses in the surroundings of the site are planned to cover the information gaps from this survey. A thermal gradient well in Ruhwa prospect was drilled to 102 m of depth and discharges hot water at a flow rate of 6-7 l/s and fluid temperature around 70°C. The main purpose of this pilot project was to evaluate the potential for the shallow geothermal reservoir for cascaded drying and cooling processes for agricultural products and aquaculture. The project at Ruhwa was undertaken at the border between Rwanda and Burundi along the Rusizi rift region.

Direct use applications

Spa or hot-spring pools are currently the main uses of geothermal energy in Rwanda. Gisenyi and Mashyuza are already popular tourist destinations for enjoying hot spring pools. In this regard, a dedicated study (JICA, 2016) was focused on evaluating the possibility of establishing a high standard spa pool at Gisenyi but was ruled out due to limited space at the site (Nshimyumuremyi, 2014). The same limitation was pointed out in regard to the Karago hot springs. Mashyuza town was also singled out as a potential site, however, it was reported that a 4.4 and 5.0-magnitude earthquakes affected the area in 2020 which chocked the flow of the local hot spring but the spring is slowly recovering.

Without providing further details, the CTCN study (CTCN, 2020) singled out activities at four divisions where efforts on geothermal direct uses might be focused: tea leaf drying in Bugarama, fish drying in Bugarama and Gisenyi, vegetables drying in Gisenyi and Karago, and milk pasteurization in Karago. Nevertheless, the implementation of economic activities may require higher temperatures than those currently available at the hot springs. LEAPRE research project incorporating researchers from Europe and Africa including EDCL are currently implementing a research project at Mashyuza that is anticipated to lead to drilling of shallow wells that would deliver fluid at temperatures of more than 120 °C.

Policy, regulatory and institutional framework for development of geothermal resources

Institutional Framework

The Rwandan electricity market is operated by the state-owned national utility. IPPs also participate in the electricity sector.

- **The Ministry of Infrastructure**

The Mission of the Ministry of infrastructure is to ensure sustainable infrastructure development covering transport, energy, water supply and sanitation, housing, and human settlement sectors aiming to drive Rwanda's economic growth and enhance quality of life of the citizen. Vision to provide modern infrastructures for sustainable economic growth and socioeconomic development.

- **Rwanda Utilities Regulatory Authority (RURA)**

The energy sector in Rwanda is managed by RURA, which has the mandate to regulate four energy subsectors, namely, Electricity, Renewable Energy, Gas, and Downstream petroleum, with objectives to ensure sufficient, reliable, affordable, and sustainable energy supply fairly to all consumers. The main regulatory activities in regulating Energy sector include among others; establishing different regulatory tools governing activities in the sector, advise the government on the energy sector-related policies, licensing, end-user tariffs setting to non-competitive regulated services, dispute and complaints handling, and monitoring licensees' performance to ensure the compliance with terms and conditions of their licenses.

- **The Ministry of Environment**

The Ministry of Environment is the coordinating institution of Environment and Natural Resources Sector in Rwanda. It was established to ensure development of the environment. It must also ensure the safeguard of green and climate resilient for growth of the economy and ensure optimal and rational utilization of Water Resources, Lands, and Forests for sustainable national development. The Ministry of Environment was established to ensure the protection and conservation of the environment and ensure optimal and rational utilization of Water Resources, Lands, and Forests for sustainable national development.

- **Rwanda Environment Management Authority (REMA)**

Rwanda Environment Management Authority (REMA) is under the supervision of the Ministry of Environment, from the Law n°63/2013 of 27/08/2013, determining the mission, organization, and function. REMA reserves the legal mandate for national environmental protection, conservation, promotion, and overall management, including advisory to the government on all matters pertaining to the environment and climate change.

- **Rwanda Energy Group Limited (REG)**

Rwanda's government adopted the corporatization model to implement the required reforms in energy sector and established Rwanda Energy Group Limited (REG). The law repealing EWSA Law of 97/2013 of January 31, 2014, paved the way for the creation of two corporate entities, which were subsequently incorporated in July 2014, with 100% government shareholding, the Energy Utility

Corporation Limited (EUCL) and the Energy Development Corporation Limited (EDCL). Energy Utility Corporation Limited (EUCL) is tasked with generation, transmission and distribution of electricity in the whole country, and it also manages the operation of the grid. Energy Development Corporation Limited (EDCL) is the body tasked with planning and development of the energy infrastructure. IPPs produce and sell bulk power to EUCL which is has the monopoly over transmission, distribution and sale of electricity to connected customers. Therefore, the main objectives of REG are to have sector-focused and efficient operations, attract more investment, improve planning and accountability, and increase access to services by the population to drive sector performance toward the targets.

- **Ministry of Finance and Economic Planning (MINECOFIN)**

The responsibilities of the Ministry include preparing and presenting the national budget, managing the Treasury and the National Bank of Rwanda, and national economic planning. The institutional purview of the Ministry includes the School of Finance and Banking in Kigali and the Rwanda Revenue Authority (Rwanda Utilities Regulatory Agency, 2023).

Policy and regulatory Framework

- **Rwanda LCPDP**

The development of the LCPDP was undertaken as part of the key exercises under the REG Reform program. The purpose of the plan is to have a systematic development of the Rwanda Generation Resources prioritizing the least cost options to ensure that the tariff affordability objectives are being optimized. The least cost study has been segmented into three phases: before entry (2019 – 2020), entry of committed projects (2021 – 2027), and the long term (2028 – 2040). The results within this report provide a least-cost optimal development path, which still meets the forecasted electricity demand. This is expected to propel the country's economic growth, both in terms of providing support for the emerging industry sector and improving the standard of living for Rwanda's citizens. However, because geothermal potential of Rwanda has not yet been fully ascertained, no concrete plans have been made in LCPDP 2019-2040.

- **Environment and Climate Change Policy**

The Environment and Climate Change Policy was approved by the Cabinet on June 7, 2019 and is a revised version of a previous policy which was introduced in 2003. The updated policy contains a number of new provisions to better align it with Rwanda's overarching medium-term National Strategy for Transformation, long-term Vision 2050 as well as multilateral commitments to the EAC Vision 2050, African Union Agenda 2063, and the Sustainable Development Goals. While the previous policy addressed a broad range of topics, climate change was not reflected in the policy objectives and statements. The new policy resolves this challenge by drawing on the latest science and research to guide how climate change should be incorporated into cross-government planning. It also provides a framework for the role of international climate finance in the country's efforts to build a low-carbon nation that is resilient to the impacts of a warming planet.

The policy also lays the groundwork for Rwanda to realize opportunities related to environmental management and green growth. The circular economy, which promotes economic growth by utilizing resources to their full capacity and eliminates waste, is now embedded throughout the document. The policy encourages shifts toward the use of renewable energy and eliminates the use of toxic chemicals. In addition, the new policy will support Rwanda to put environment and climate change at

the heart of decision-making across the public and private sectors, as well as civil society by including these topics in government performance contracts, civil service, and general school and university curricula. The policy was intended to ensure Rwanda has a clean and healthy environment that is resilient to climate variability and supports a high quality of life for all who call the country home. The implementation of the policy will be guided by the spirit of inclusiveness, economic and ecosystem value, adaptation, and cooperation.

- **National Strategy on Green Growth and Climate Resilience**

The Rwanda National Strategy on Climate Change and Low Carbon Development was developed from November 2010 to July 2011. The strategy calls upon national planners to chart a new development pathway for integrated sector planning which balances cross-cutting issues of resource management.

- **Regulation for Environmental Impact Assessment**

Organic Law No. 04/2005 determines the modalities of protecting, conserving, and promoting the environment in Rwanda. Ministerial Order No. 003/2008, No. 004/2008 relate to the requirements and procedure for environmental impact assessment and establish the list of works, activities, and projects that must undertake an environmental impact assessment. Regulation for PPP - PPP Law 14/2016 Law 14/2016 governing PPPs in Rwanda requires the Rwanda Development Board (RDB) to issue general Guidelines for the procurement of PPP projects and advise the government on matters related to PPPs. RDB is designated as the PPP unit.