

# Impact of Environment and Climate Change Policies on Sustainable Development in Rwanda (2019-2024), Case of Green Gicumbi Project

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**Abstract:** This study examined the impact of Rwanda's Environment and Climate Change Policies on sustainable development, with a focus on the Green Gicumbi Project (GGP) implemented from 2019 to 2024. Although Rwanda has adopted strong environmental policies to promote climate resilience and green growth, limited evidence has documented their effectiveness at the community level. The research therefore aimed to assess how these policies have influenced sustainable development outcomes in Gicumbi District. Three objectives guided the research: evaluating the environmental and climate policies applied in the GGP, identifying sustainable development indicators achieved through the project, and determining the relationship between the policies and sustainable development outcomes. A mixed-methods design was used, involving surveys from 399 respondents across nine sectors, along with interviews with project leaders and observations. Findings revealed high stakeholder awareness of the project and strong support for policies guiding forestry, energy, agriculture, and sanitation. The study also identified notable achievements, including watershed protection, climate-smart agriculture through radical terraces and agroforestry, restoration of 1,244 hectares of forest, distribution of 19,900 improved cookstoves, and promotion of climate-resilient settlements with rainwater harvesting. These interventions contributed to improved livelihoods and reduced carbon emissions. Overall, the research confirmed a strong positive relationship between targeted climate policies and sustainable development in the GGP area. The study concluded that well-designed environmental policies and integrated rural projects like the GGP significantly enhance climate resilience and sustainable development in Rwanda. Recommendations included increasing public awareness, strengthening policy monitoring, scaling up the initiative, and expanding collaboration with surrounding communities. Future studies were advised to examine long-term sustainability, community participation, and social inclusion within similar interventions.

**Keywords:** Environment, environmental policy, climate change, sustainable development, Green Gicumbi Project.

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## I. INTRODCUTION

Environmental degradation and climate change remain major global challenges largely driven by human activities such as industrialization, deforestation, and pollution. Addressing these issues requires strong institutional cooperation, as institutions that promote collective action are essential for managing shared global resources (Ostrom, 1990). International agreements translated into national policies enable countries to collaborate on trade, investment, and transboundary environmental problems including air and water pollution, hazardous waste, and climate change.

The United Nations has led global efforts toward environmental sustainability, beginning with the Millennium Development Goals (MDGs) adopted by 189 member states and targeted for achievement by 2015 (United Nations, 2000). MDG 7 focused on ensuring environmental sustainability through integrating sustainable development principles into policies, reducing biodiversity loss, improving access to safe water and sanitation, and enhancing the lives of slum dwellers. In 2015, the MDGs were succeeded by the broader Sustainable Development Goals (SDGs), consisting of 17 goals aligned with the 2030 Agenda and centered on social, economic, and environmental sustainability (Nations, 2015).

Other key global initiatives continue to mobilize leaders worldwide toward climate mitigation and adaptation. Notably, the Conference of the Parties (COP) under the UNFCCC—established in 1992—meets annually to evaluate climate action and negotiate commitments. Milestones include the Kyoto Protocol (COP3, 1997), Copenhagen Accord (COP15, 2009), Paris Agreement (COP21, 2015), strengthened NDCs and coal phase-down (COP26, 2021), and financing goals for developing nations (COP29, 2024) (UNFCCC, 2024). Similarly, the World Economic Forum (WEF), founded in 1971, advocates for policies balancing economic development with environmental sustainability (Stiglitz, 2020).

Although climate-resilient planning is advancing globally, African cities often struggle to adequately integrate climate concerns into development plans. With the fastest rate of urbanization and population growth in the Global South—projected to reach 50% urban population by 2050—Africa faces housing pressures, slum expansion, infrastructure strain, unemployment, and environmental risks (UN-Habitat, 2016). Recognizing this, African cities increasingly align local actions with international climate frameworks (Mwenje, Kumar, & Herslund, 2024).

Rwanda demonstrates strong commitment to sustainable development through proactive environmental policies and climate resilience measures. These efforts support national transformation while addressing challenges such as deforestation and energy efficiency. The country's environmental governance is anchored in the 2003 Environment Policy and the updated 2019 Environment and Climate Change Policy, which aligns with Vision 2050, NST1, the Green Growth and Climate Resilience Strategy, NDCs, SDGs, Agenda 2063, and EAC Vision 2050 (MoE, 2019).

## II. METHODOLOGY

### 2.1 Research Design

This research employed descriptive research design and exploratory research design.

### 2.2 Target Population

The target population of this study consists of 150,000 beneficiaries of the Green Gicumbi Project.

### 2.3 Sampling Techniques

For this study, a multistage sampling procedure was used to choose respondents. Purposive sampling was used depending on category of environmental climate change policy stakeholders.

### 2.4 Sample size

A sample is a discrete set of instances chosen from the larger population or group under inquiry. Consequently, sample size is the number of individuals or objects included in the chosen sample (Manheim, J.B., and Rich, R.C, 1995). Yamane (2007) provides a simplified formula to calculate sample sizes. This formula was used to calculate the sample size for the targeted population (Yamane, 2007).

$$n = \frac{N}{1+N(e)^2} \dots \dots \dots (3.1)$$

**Where:** n: Sample size; N: Population size; e: Marginal error

N=150,000 Direct Green Gicumbi Project stakeholders from the project website.

$$n = \frac{150,000}{1+150,000(0.05)^2} = 398.6 \hat{=} \mathbf{399 \text{ respondents.}}$$

### 2.5 Data Collection Techniques and instrument

#### Survey and Questionnaire

The selected construction sector and inhabitants of the selected buildings got an introduction letter from the head of the department of international development studies at the University of Lay Advent of Kigali asking for their consent. The researcher distributed the questionnaire and have interviews with the respondents after obtaining the necessary consent. In

this study, the research questions were carefully designed, shared with the respondents, and explained to ensure accurate data collection. In contrast, an interview is a structured exchange of ideas and information between two or more individuals.

## 2.6 Data Analysis

The nature and format of the data determined the analysis. The data was analyzed in accordance with the qualitative and quantitative approaches used to collect it.

## III. RESULTS

### 3.1 Socio-demographic characteristics of respondents

The table 1 reveals different socio-demographic characteristics of respondents from gender, age group, education level and sectors of origin of all respondents who participated to the research. 68% of respondents were male while 32 % of respondents were female.

**Table 1: Socio-demographic characteristics of respondents, Source: Researcher 2025**

Socio-demographic profile	Variables	Frequency	Percentage
<b>Gender</b>	Male	272	68.0
	Female	127	32.0
	<b>Total</b>	<b>399</b>	<b>100.0</b>
<b>Age group</b>	18-30	5	1.0
	31-50	184	46.0
	51 and above	210	53.0
	<b>Total</b>	<b>399</b>	<b>100.0</b>
<b>Education level of respondents</b>	Primary	39	10
	Ordinary level	90	22.5
	High School	150	37.5
	Diploma	39	10
	Bachelors and above	81	20
	<b>Total</b>	<b>399</b>	<b>100.0</b>
<b>Sectors of origin of respondents</b>	Rubaya	25	6
	Cyumba	35	9
	Kaniga	35	9
	Mukarange	38	10
	Rushaki	58	15
	Shangasha	38	10
	Manyagiro	47	12
	Byumba	88	22
	Bwisige	36	9
	<b>Total</b>	<b>399</b>	<b>100</b>

In term of age group, 1% ,46% and 53% were respectively in the age group of 18-30,31-50 and above 51 years old. As far as the level of education level of respondents is concerned, 10% of respondents did Primary level, 22.5% of respondent completed the ordinary level, 37.5% did high school while 20% of respondents have bachelor degree or more. Respondents were distributed across the nine sectors in which the project in covering as 6% of respondents were from Rubaya Sector, 9% of respondents were from Cyumba Sector and other 9% of respondents were from Kaniga Sector; 10% of respondents were from Mukarange Sector, 15% of respondents were from Rushaki Sector,10% of respondents were from Shangasha project, 12% of respondents were from Manyagiro Sector, 22% of respondents were from Byumba Sector and 9% of respondents were from Bwisige Sector.

### 3.2 Analysis of Existing Environment and Climate Change Policies in the GGP

#### Forest Policy

The Green Gicumbi Project has taken into account the Rwandan Forest Policy and its integration with climate change adaptation and mitigation strategies. It focuses on adopting sustainable forest management practices, restoring degraded land, engaging local communities, and complying with both national and international climate agreements to ensure environmental and social sustainability. By aligning its objectives with Rwanda's forest conservation and climate resilience goals, the project significantly contributes to the country's broader efforts to combat climate change while enhancing community well-being and promoting economic resilience.

**Table 2: Forestry Policy applied to GGP,**

Component	Strongly Agree (4)	Agree (3)	Disagree (2)	Strongly Disagree (1)	Mean	Std. Dev.
Institutional Capacity	80	20	0	0	3.8	0.4
Sustainable Forest Management	84	16	0	0	3.84	0.37
Woody Biomass Energy	90	10	0	0	3.9	0.3
Forest Ecosystem Conservation	40	60	0	0	3.4	0.49
Participatory Forest Management	55	45	0	0	3.55	0.5
Promoting Agroforestry and Trees Outside Forest	10	90	0	0	3.1	0.3

Source: Researcher, 2025

#### Interpretation

The analysis of forestry policy components, based on the mean and standard deviation of Likert-scale responses, reveals valuable insights into stakeholder perceptions. Woody Biomass Energy and Sustainable Forest Management received the highest mean scores of 3.9 and 3.84, respectively, accompanied by low standard deviations ranging from 0.3 to 0.37. This indicates strong support and a high level of agreement among respondents, who consistently recognized these components as effective elements of the Green Gicumbi Project. Institutional Capacity also scored highly, with an average of 3.8, reflecting confidence in the governance and organizational structures that support forestry development. In contrast, Forest Ecosystem Conservation and Participatory Forest Management recorded slightly lower mean scores of 3.4 and 3.55, with higher standard deviations of approximately 0.49 to 0.5, suggesting a wider range of opinions. This variation may be attributed to differing levels of community engagement or awareness. Promoting Agroforestry and Trees Outside Forest received the lowest mean score of 3.1, indicating that while this component was still viewed positively, it was not as strongly endorsed as the others. Nevertheless, the low standard deviation of 0.3 demonstrates that perceptions on this component were relatively consistent among respondents.

#### Energy Policy

The energy policy plays a critical role in shaping the Gicumbi Project by providing frameworks and guidance on integrating renewable energy solutions, promoting energy efficiency, and supporting sustainable practices that align with Rwanda's climate change and environmental goals. By incorporating clean energy technologies, such as solar power, biogas, and improved cookstoves, the Gicumbi Project can contribute significantly to climate change mitigation and adaptation. It can also foster greater energy access and community resilience while supporting sustainable development in the region, thereby aligning with Rwanda's broader Green Growth and Climate Resilience objectives.

**Table 3: Energy policy applied to GGP,**

Component	Strongly Agree (4)	Agree (3)	Disagree (2)	Strongly Disagree (1)	Mean	Std. Dev.
Electricity Access	15	60	25	0	2.9	0.58
Street Lighting	10	10	80	0	2.3	0.86
Electric Mobility	0	10	90	0	2.1	0.3

Component	Strongly Agree (4)	Agree (3)	Disagree (2)	Strongly Disagree (1)	Mean	Std. Dev.
Power Generation	0	15	85	0	2.15	0.36
Clean Cooking & Heating	85	15	0	0	3.85	0.36
Capacity Building	40	60	0	0	3.4	0.49
Gender Mainstreaming	40	60	0	0	3.4	0.49

Source: Researcher, 2025

### Interpretation

The Green Gicumbi Project's energy policy components were assessed using a 4-point Likert scale, with numerical values assigned as follows: Strongly Disagree = 1, Disagree = 2, Agree = 3, and Strongly Agree = 4. The analysis reveals varied perceptions among respondents regarding the effectiveness and impact of different energy initiatives. Clean cooking and heating received the highest rating, with a mean of 3.85 (SD = 0.36), indicating very strong approval and consensus on its positive impact within the project. Capacity building and gender mainstreaming were also well supported, with a mean of 3.4 (SD = 0.49), reflecting recognition of the project's inclusive and skill-development efforts.

In contrast, electric mobility and power generation recorded low mean scores of 2.1 and 2.15 respectively, suggesting limited perceived impact or satisfaction in these areas. The relatively low standard deviations (0.30–0.36) indicate general agreement among respondents about their underperformance or low visibility. Electricity access received a moderate mean score of 2.9, with a wider standard deviation of 0.58, reflecting mixed experiences that may result from uneven service distribution. Street lighting had the lowest mean score of 2.3 and the highest variability (SD = 0.86), highlighting both dissatisfaction and divided opinions among respondents. Overall, while some energy interventions are highly appreciated, others show clear gaps in performance and reach, indicating areas for targeted improvement.

### Agricultural Policy

The Green Gicumbi Project and agriculture policy are closely linked through their shared goal of promoting sustainable agriculture, improving food security, and enhancing rural livelihoods. The project adopts and implements agricultural policies that focus on climate resilience, soil health, sustainable land management, and the empowerment of farmers through education and access to resources. Through these synergies, the Green Gicumbi Project helps to support the broader objectives of national and regional agricultural policies while ensuring the district's agricultural sector remains both productive and environmentally sustainable.

Table 4: Agricultural policy applied to GGP,

Component	Strongly Agree (4)	Agree (3)	Disagree (2)	Strongly Disagree (1)	Mean	Std. Dev.
Collaboration of Institutions	97	3	0	0	3.97	0.17
Technology and Upskilling	92	8	0	0	3.92	0.27
Sustainable Land Production	91	9	0	0	3.91	0.29

Source: Researcher, 2025

### Interpretation

The agricultural policy components under the Green Gicumbi Project received overwhelmingly positive responses, as reflected by very high mean scores and low standard deviations. Collaboration among relevant institutions achieved the highest mean score of 3.97 (SD = 0.17), indicating near-universal approval and strong agreement on the effectiveness of institutional coordination. Technology and upskilling interventions (Mean = 3.92, SD = 0.27) as well as sustainable land production initiatives (Mean = 3.91, SD = 0.29) were also highly endorsed by respondents, demonstrating consistent recognition of their contribution to sustainable agriculture. Overall, these results suggest that agricultural interventions under the Green Gicumbi Project are not only well-perceived but also widely supported by beneficiaries, potentially playing a significant role in achieving the project's sustainability goals.

### 3.3 Sanitation policy and sustainable infrastructure

The sanitation policy, which regulates the management of waste and hygiene to safeguard public health, intersects with the Green Gicumbi Project in several critical ways. Both initiatives share the overarching goal of fostering healthier and more sustainable communities. Their integration is essential for achieving holistic and long-term development outcomes in the region. In this context, the researcher evaluated several key indicators that reflect the relationship between the sanitation policy and the Green Gicumbi Project. These indicators include sanitation coverage, the provision of basic sanitation facilities and services, solid waste management, and sanitation-related cross-cutting issues.

**Table 5: Sanitation Policy applied to GGP,**

Component	Strongly Agree (4)	Agree (3)	Disagree (2)	Strongly Disagree (1)	Mean	Std. Dev.
Sanitation Coverage	70%	30%	0%	0%	3.70	0.46
Provision of Basic Facilities	40%	60%	0%	0%	3.40	0.49
Provision of Sanitation Services	10%	60%	30%	0%	2.80	0.60
Solid Waste Management	60%	25%	15%	0%	3.45	0.74
Cross-Cutting Issues	10%	60%	30%	0%	2.80	0.60

Source: Researcher, 2025

#### Interpretation

The perception of the Green Gicumbi Project's sanitation policy was assessed across five key components using a 4-point Likert scale, with analysis focusing on average satisfaction levels (mean) and response variability (standard deviation) for each component. Sanitation coverage received the highest mean score of 3.70 (SD = 0.46), indicating very high satisfaction among respondents and strong consensus that the project effectively extended sanitation services across the targeted areas. This success likely reflects well-implemented infrastructure and outreach programs that ensured accessibility.

The provision of basic sanitation facilities, including latrines and handwashing stations, achieved a mean of 3.40 (SD = 0.49), suggesting that stakeholders largely agreed on the project's effectiveness, although slight variability indicates that experiences differed somewhat between communities or institutions. Provision of sanitation services recorded a lower mean of 2.80 (SD = 0.60), reflecting moderate satisfaction. While a majority agreed on the adequacy of services, mixed perceptions likely arose from irregular waste collection, maintenance challenges, or staffing limitations, with some areas receiving better service than others.

Solid waste management was generally well rated, with a mean of 3.45 (SD = 0.74). The higher standard deviation indicates considerable variability, suggesting that while some communities benefit from effective waste handling systems, others face challenges such as infrequent collection or limited segregation facilities. Finally, sanitation cross-cutting issues—encompassing gender inclusion, environmental impact, public health integration, and accessibility for persons with disabilities—shared the lowest mean of 2.80 (SD = 0.60). The moderate variability highlights inconsistencies across communities, revealing gaps in policy implementation and emphasizing the need for a more inclusive and comprehensive sanitation framework.

### 3.4 Overall Insights for of Existing Environment and Climate Change Policies in the GGP

The Green Gicumbi Project demonstrates a well-rounded and strategic alignment with Rwanda's national policies on forestry, energy, agriculture, and sanitation, contributing substantially to climate change mitigation, environmental sustainability, and socio-economic development. The analysis of stakeholder perceptions highlights that the project has achieved significant success in areas such as sustainable forest management, clean cooking technologies, institutional collaboration in agriculture, and broad sanitation coverage.

Forestry and agricultural policy components, in particular, garnered consistently high approval, reflecting the project's effectiveness in restoring ecosystems, empowering communities, and promoting sustainable land use. The strong institutional support and focus on participatory forest management and agroforestry also emphasize the importance of inclusive, community-led interventions in ensuring long-term environmental resilience.

In the energy sector, while clean cooking solutions and gender mainstreaming were highly appreciated, components such as electric mobility, power generation, and street lighting were perceived as underperforming or lacking visibility. This reveals critical gaps in energy access and technological integration that need to be addressed to meet broader climate and energy goals.

Sanitation-related efforts were recognized for extending coverage and providing basic infrastructure, but service delivery and cross-cutting issues—such as equity, accessibility, and environmental health—showed moderate satisfaction and greater variability. This suggests a need for more targeted, equitable, and holistic sanitation strategies tailored to local needs.

Overall, the project illustrates the potential of integrated, policy-aligned development approaches in building climate-resilient and sustainable rural communities. However, for maximum impact and inclusivity, future efforts should focus on enhancing service quality, addressing implementation disparities, and strengthening underperforming sectors through evidence-based planning and continuous community engagement.

### Tracing the effects of climate and environmental policies on sustainability development in the Green Gicumbi Project

#### Overall insight of environment and climate change policies

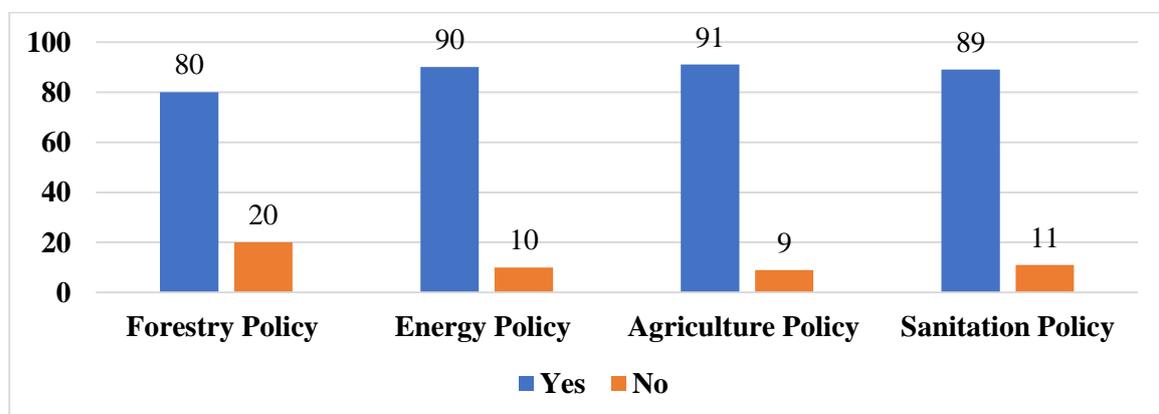


Figure 1: Relationship of other policies to the Environment and Climate Change Policy, Source: Researcher, 2025

#### Figure 1: Relation of other policies to the Environment and Climate Change Policy

As far as the relation of other policies to the Environment and Climate Change Policy toward implementation of Green Gicumbi Project, the researcher summarized his findings in figure 2 which depicts that 80% of respondents confirmed the relationship of forestry policy to Environment and Climate Change Policy and 20% of respondents disagreed; regarding the energy policy, 90% of respondents agreed that energy policy has a closer relation with Environment and Climate Change Policy while 10% disagreed to this statement. 921% of respondents revealed that agriculture policy was considered during the development and implementation of Environment and Climate Change Policy while 9% do not know the exact relationship between agriculture policy and environment and climate change policy. Sanitation policy was reported by 89% of respondents to be related with Environment and Climate Change Policy while 11% of respondents disagreed to the relation of Sanitation policy to environment and climate change policy.

#### Review of forest Policy for the Green Gicumbi Project

The findings from the desk review, questionnaires, and interviews show that the Green Gicumbi Project aligns closely with Rwanda's Forest Policy, which emphasizes environmental sustainability, climate resilience, and improved community livelihoods. As Gicumbi District is highly affected by soil erosion and deforestation, the project's forest-related interventions are central to achieving sustainable development goals. The Forest Policy strengthens the project's efforts in soil erosion control through agroforestry, reforestation, and terracing, which help restore degraded land and support sustainable agriculture. It also enhances climate change mitigation, as increased forest cover contributes to carbon sequestration and may offer opportunities for carbon credit revenue. Biodiversity conservation is supported through the protection of natural forest ecosystems and the promotion of native species, safeguarding long-term ecological health. In line with policy requirements for community participation, the project integrates local residents in forest management activities such as tree planting, non-timber forest product use, and eco-tourism, expanding livelihood opportunities while encouraging environmental stewardship. The adoption of agroforestry further supports food security and sustainable forest resource use.

Policy implementation and institutional collaboration are also critical. The project must work with national forestry authorities to ensure compliance with regulatory frameworks and effective governance of forest activities. Additionally, the Forest Policy underpins climate resilience strategies by promoting forest-based adaptation measures that improve water retention, stabilize microclimates, and protect communities from extreme weather impacts. Overall, Rwanda's Forest Policy provides a strong foundation for the Green Gicumbi Project by guiding sustainable forest management practices that enhance environmental quality, climate resilience, and socio-economic well-being in the district.

### **Implications of the Energy Policy for the Green Gicumbi Project**

Rwanda's Energy Policy closely aligns with the objectives of the Green Gicumbi Project by promoting clean, accessible, and climate-resilient energy solutions. The policy supports the transition from traditional biomass energy toward renewable sources such as solar power, biogas, and improved cookstoves. This creates an opportunity for the project to reduce deforestation and indoor air pollution by scaling up clean energy technologies across households and community facilities. In addition, the Energy Policy emphasizes decentralized energy systems to expand electricity access in rural areas. By establishing solar mini-grids and home systems in off-grid communities, the Green Gicumbi Project can directly enhance local development and strengthen energy access for schools, health centers, and small businesses.

The policy also promotes energy efficiency in productive sectors, including agriculture, which is central to the project's goals. Integrating technologies such as solar-powered irrigation, crop drying systems, and energy-efficient cold storage can boost agricultural productivity while reducing energy consumption and post-harvest losses. Furthermore, the Energy Policy contributes to national climate change mitigation and adaptation efforts by encouraging the adoption of low-carbon energy solutions. Through the use of climate-smart energy systems—such as solar-powered water pumping—the project can improve resilience to climate variability within vulnerable communities in Gicumbi.

Capacity building is another important component of the Energy Policy, which encourages the development of local technical skills in renewable energy. The Green Gicumbi Project can take advantage of this by training local communities, especially women and youth, in the installation, operation, and maintenance of solar and biogas systems. This enhances local ownership, creates green employment, and supports long-term system sustainability. Finally, the policy's alignment with national and global climate commitments, as well as its focus on future integration of decentralized systems into the national grid, ensures that the project contributes meaningfully to Rwanda's low-carbon transition while establishing scalable energy solutions. Rwanda's Energy Policy provides a strong enabling framework for integrating sustainable energy initiatives within the Green Gicumbi Project.

Aligning with the policy allows the project to expand access to clean energy, reduce reliance on biomass, promote climate resilience, and strengthen community livelihoods, thereby advancing sustainable development within Gicumbi District.

### **Implications of the agricultural Policy for the Green Gicumbi Project**

Rwanda's Agricultural Policy strongly supports the Green Gicumbi Project, given the central role agriculture plays in national livelihoods and economic development. The project aligns with policy goals by promoting sustainable agricultural practices, increasing productivity, improving food security, and enhancing rural incomes.

Through climate-smart agriculture, the project encourages practices such as conservation tillage, crop rotation, and efficient irrigation to help farmers adapt to climate change. It also promotes crop diversification to reduce reliance on single crops and strengthen food security. Improved market linkages and better storage infrastructure further contribute to reduced post-harvest losses and expanded income opportunities for farmers. Agroforestry interventions, including planting fruit, timber, and leguminous trees alongside crops, support soil fertility, erosion control, and additional income streams. On Gicumbi's steep slopes, soil conservation techniques such as terracing and cover cropping are applied in line with policy guidance.

Access to agricultural finance is also strengthened by facilitating credit for improved seeds, fertilizers, and equipment, enabling farmers to adopt modern technologies. Capacity-building initiatives—including training, extension services, and Farmer Field Schools—equip farmers with skills in climate-smart farming, pest management, and agribusiness. The project also advances gender inclusion by ensuring women farmers receive equal training and support. Rwanda's Agricultural Policy provides a strong framework that enhances the Green Gicumbi Project's contribution to sustainable agriculture, climate resilience, and improved community livelihoods.

### **Implications of sanitation policy and sustainable infrastructure for GGP**

The success of the Green Gicumbi Project is strongly supported by its alignment with Rwanda's Sanitation Policy and principles of sustainable infrastructure, which together promote improved public health, environmental protection, and long-

term development. Through the development of proper sanitation facilities and community hygiene education, the project contributes to reducing waterborne diseases and enhancing overall health conditions. Expanded access to improved latrines, waste management systems, and public sanitation facilities reinforces Rwanda's goal of universal sanitation coverage while fostering community ownership through approaches such as Community-Led Total Sanitation.

Sustainable waste disposal measures, including biogas production and composting, convert organic waste into valuable resources and help minimize environmental pollution. The project also supports climate resilience by integrating rainwater harvesting, water-saving technologies, and climate-proofed sanitation systems capable of withstanding floods or landslides. These interventions ensure reliable access to clean water and maintain infrastructure functionality amid changing climatic conditions. The integration of sanitation policy and sustainable infrastructure enhances the Green Gicumbi Project's capacity to deliver environmental sustainability, public health improvement, and community resilience. By prioritizing clean water, eco-friendly waste management, and durable infrastructure, the project contributes significantly to Rwanda's vision for a green, inclusive, and sustainable future.

#### Indicators of sustainable development within Green Gicumbi Project in Rwanda from 2019 to 2024

**Table 6: Sustainable forestry & sustainable energy for sustainable development,**

Indicator	Strongly Agree (%)	Agree (%)	Mean Score	Std. Dev
Forest rehabilitation	90	10	3.90	0.30
Promotion cooking stove	93	7	3.93	0.26
Provision of high-quality seedlings	94	6	3.94	0.24
Training on tree nursery management	80	20	3.80	0.40
Construction of domestic biogas units	84	16	3.84	0.37
Provision of modern beehives to coops	87	13	3.87	0.34
Provision of large stoves for institutions	89	11	3.89	0.31
Reduction of emissions	79	21	3.79	0.41

Source: Researcher, 2025

The first component of sustainable development in the Green Gicumbi Project—focusing on sustainable forestry and sustainable energy—received overwhelmingly positive evaluations across all indicators, with mean Likert scores ranging from 3.79 to 3.94 out of 4. The provision of high-quality seedlings achieved the highest rating, with a mean of 3.94 (SD = 0.24), reflecting strong consensus and high satisfaction with reforestation support efforts. Reduction of emissions (Mean = 3.79, SD = 0.41) and training on nursery management (Mean = 3.80, SD = 0.40) recorded slightly lower mean scores and higher standard deviations, suggesting some variation in respondents' opinions or potential implementation challenges in these areas. Nevertheless, all standard deviations remained below 0.5, indicating a high level of agreement and consistency among respondents. Overall, these results underscore that the project's environmental and energy-related interventions have made a significant contribution to achieving sustainability goals between 2019 and 2024.

#### Watershed protection and climate resilient agriculture

**Table 7: Watershed protection and climate resilient agriculture,**

Indicator	Strongly Agree (%)	Agree (%)	Mean Score	Std. Dev
Radical terraces	90	10	3.90	0.30
Sustainable management of land and agroforestry trees	95	5	3.95	0.22
Protective forestry on rivers, roadsides, and steep slopes	91	9	3.91	0.29
Sustainable management of coffee and tea plantation	92	8	3.92	0.27
Construction of automated weather stations	97	3	3.97	0.17
Girinka Program (livestock redistribution)	30	70	3.30	0.46

Source: Researcher, 2025

This component reflects the implementation and perceived effectiveness of climate-resilient agriculture and watershed management strategies. Overall, most interventions were rated very highly, with mean scores above 3.9, indicating strong satisfaction among respondents and widespread agreement on their contribution to sustainable development. The construction of automated weather stations received the highest rating, with a mean of 3.97 (SD = 0.17), suggesting near-universal strong support and recognition of their value in climate adaptation. Sustainable land and agroforestry management (Mean = 3.95) and radical terraces (Mean = 3.90) also received high ratings, reinforcing the positive impact of soil and watershed conservation efforts.

The Girinka Program was the only outlier, with a lower mean score of 3.30 (SD = 0.46) and the highest variability in responses. This indicates that while the majority of respondents still agree on its relevance, there may be concerns related to implementation challenges, access, or effectiveness across different communities. Overall, Component 2 demonstrates that natural resource management interventions in agriculture and water systems are highly appreciated by beneficiaries. However, livestock redistribution programs, such as the Girinka Program, may require further review or targeted improvements to ensure equitable and effective implementation.

### Sustainable settlement Health and well being

The findings on the indicators of climate-resilient settlements for sustainable development through the Green Gicumbi Project are presented in Figure 8. A significant majority of respondents reported positive perceptions of the project's interventions. Specifically, 89% of respondents agreed that the Green Gicumbi Project implemented household rainwater harvesting tanks, while 11% strongly agreed. Regarding the construction of climate-resilient dwelling units for vulnerable families relocated from high-risk zones, 88% of respondents strongly agreed and 22% agreed that these units had been effectively constructed. The implementation of underground tanks and cisterns was widely recognized, with 91% of respondents strongly agreeing and none expressing disagreement. Additionally, 95% of respondents strongly agreed that the Green Gicumbi Project conducted various training programs for beneficiaries on climate resilience, with no respondents disagreeing with this statement.

To further analyze these components of climate-resilient settlements in Gicumbi, the data can be quantified using a Likert scale, where Strongly Disagree = 1, Disagree = 2, Agree = 3, and Strongly Agree = 4, allowing for the calculation of mean scores and standard deviations to provide a statistical summary of respondents' perceptions.

**Table 8: Climate Resilient Settlements for Sustainable Development in Gicumbi,**

Indicator	SA (%)	A (%)	D (%)	Mean Score	Std. Dev
Rain water harvesting tanks	89	11	0	3.89	0.31
Construction of climate-resilient dwellings	88	22	0	3.78	0.41
Construction of underground tanks & cisterns	91	9	0	3.91	0.29
Training on climate resilience	95	5	0	3.95	0.22
Training new techniques to farmers	90	10	0	3.90	0.30
Creation of green jobs for locals	87	13	0	3.87	0.34
Digitalization & M&E activities	20	30	50	2.70	0.84

**Source: Researcher, 2025**

This component assesses the extent to which settlement-based resilience interventions have contributed to sustainable development under the Green Gicumbi Project. The findings indicate that most initiatives were highly valued by beneficiaries, with training on climate resilience receiving a mean satisfaction score of 3.95 and the construction of underground water systems scoring 3.91, both showing low variability and suggesting strong consensus regarding their effectiveness. Other interventions, including rainwater harvesting, green job creation, and climate-resilient housing, also performed well, with mean scores ranging between 3.78 and 3.90.

A notable exception is the component related to digitalization and monitoring and evaluation (M&E) activities, which received a mean score of 2.70 and exhibited the highest standard deviation (0.84). This indicates significant disagreement or limited awareness among beneficiaries regarding digital monitoring tools and their impact. The fact that 50% of respondents expressed disagreement highlights potential gaps in communication, training, or accessibility that may need to be addressed to improve the effectiveness of these activities.

### Relationship between climate change policies and sustainable development within Green Gicumbi Project, from 2019 to 2024

To address the third objective of this research, to determine the relationship between environment and climate change policies and sustainable development within the Green Gicumbi Project a correlation analysis was conducted. This analysis explored how the implementation of climate change policies aligns with outcomes across three core components of sustainable development: Sustainable Forestry & Energy, Climate-Smart Agriculture, and Climate-Resilient Settlements. The results of the correlation analysis are visually presented in the table 12.

**Table 9: Correlation between environment and Climate change policies**

	Climate Policies (X)	Sustainable Forestry (C1)	Climate Resilient Agriculture	Resilient Settlements (C3)
Climate Policies (X)	1.00	0.82	0.79	0.74
Sustainable Forestry	0.82	1.00	0.68	0.65
Climate Resilient Agriculture	0.79	0.68	1.00	0.72
Resilient Settlements	0.74	0.65	0.72	1.00

The results of the study indicate that climate policies are strongly correlated with Sustainable Forestry ( $r = 0.82$ ), Climate-Smart Agriculture ( $r = 0.79$ ), and Climate-Resilient Settlements ( $r = 0.74$ ). Among these, Sustainable Forestry and Energy demonstrated the strongest association with climate change policy implementation ( $r = 0.82$ ), suggesting that initiatives such as forest rehabilitation, distribution of improved cookstoves, and expanded use of biogas systems are perceived as highly impactful in advancing sustainability goals. These findings align with Rwanda's national strategies for sustainable forest and energy management.

Similarly, Climate-Smart Agriculture exhibited a strong correlation ( $r = 0.79$ ), highlighting the significance of watershed restoration, agroforestry practices, and improved land management in enhancing food security and environmental resilience. Although slightly lower, the correlation with Climate-Resilient Settlements ( $r = 0.74$ ) remains substantial, indicating that investments in climate-resilient housing, water storage infrastructure, and community training programs are contributing meaningfully to adaptive capacity in rural areas. These strong positive correlations show that climate change policies implemented under the Green Gicumbi Project are not only well-aligned with development priorities but are also actively driving sustainable outcomes across sectors. The findings therefore emphasize the importance of integrated, policy-driven interventions in strengthening long-term resilience and environmental sustainability.

#### IV. CONCLUSION

This study concludes that the Green Gicumbi Project has made notable strides in aligning local actions with national and global climate policies, resulting in tangible sustainable development outcomes. The correlation between policies and impact is evident across forestry, agriculture, and settlement components. While overall performance is strong, targeted improvements are still needed in digital tools and livestock support systems.

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