

# Environmental Security Practices and Sustainable Development of Kigali City in Rwanda

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**Abstract:** This research project examined environmental security practices and their impact on sustainable development in Kigali City, Rwanda, with a focus on three primary objectives: 1. To assess the environmental security policies and how they affect sustainable development in Kigali City; 2. To evaluate environmental security practices compliance on the sustainable development of Kigali City and lastly 3. To investigate environmental security technologies and how they enhance sustainable development in Kigali City. A mixed-methods research design was employed, targeting both residents and environmental experts in Gasabo District, Kigali City. The sample size was determined using Yamane's formula, and a stratified sampling technique was applied to ensure representation across different demographics. Purposive sampling was used for selecting environmental experts, while simple random sampling was utilized for resident participants. Data was collected through questionnaires, interviews, and online surveys (Google Forms). Data analysis was both quantitative and qualitative, using statistical techniques to examine the relationship between environmental security practices and sustainable development. The findings revealed Environmental Policies shows a significant positive correlation with Dependent Variable- DV (Sustainable Development), with a correlation coefficient of 0.370 ( $p < .001$ ). This indicates a moderate positive relationship, suggesting that as familiarity with or the effectiveness of environmental policies increases, sustainable development in Kigali City tends to improve. Compliance with policies and environmental security practices is significantly positively correlated with DV (Sustainable Development), presenting a correlation coefficient of 0.303 ( $p = .004$ ), which implies that improved compliance with environmental security practices enhances sustainable development in Kigali City. IV3 (Environmental Technologies) also shows a significant correlation with sustainable development, with a coefficient of 0.303 ( $p = .004$ ), indicating that the adoption of environmental technologies positively impacts sustainable development. However, gaps were identified in air quality management and waste disposal practices. The recommendations, based on empirical data and stakeholder feedback, emphasized the need for stronger policy enforcement, enhanced public awareness programs, and investment in advanced environmental technologies to ensure long-term sustainability. The study's findings are expected to inform policy development, guide urban planning strategies, and contribute to academic discourse on environmental security and sustainable urban development in Kigali City.

**Keywords:** Environment Security, Sustainable Development, Environmental Security Policies, Policy Compliance, Green Infrastructure, Waste Management and Green Areas Management.

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## I. INTRODUCTION

### 1.0. Introduction

This chapter presents the Background of the study on Global, Regional and National Perspectives, Problem statement, Research Objectives, Scope of the Study and Organization of the Study.

### ***1.1. Background of the study***

Environmental security, defined as the maintenance of environmental quality and natural resource availability for human well-being [1] is intrinsically linked to sustainable development aims to strike a balance between social justice, environmental preservation, and economic prosperity. Environmental security and sustainable development are critical issues in Africa and East Africa, where the continent faces unique challenges and opportunities [2]. Rapid population growth, urbanization, and industrialization in many African countries have increased pressure on natural resources and ecosystems, leading to environmental degradation, biodiversity loss, and climate change impacts [3]. From an African perspective, achieving environmental security involves safeguarding the continent's rich biodiversity, ecosystems, and natural resources, which are crucial for supporting livelihoods, food security, and economic development [4]. The necessity for integrated approaches to sustainable development is emphasized by the region's countries, who acknowledge the connections between social stability, economic progress, environmental security, and regional collaboration [2]. Kigali, the capital city of Rwanda, is no exception, experiencing rapid urban expansion and industrialization, leading to complex environmental issues which also calls for integrated approach to ensure sustainable development [5].

This research project aimed to deepen our understanding of environmental security practices and sustainable development of Kigali City in Rwanda. Specifically, the study assessed the current state of environmental security policies and practices, analyzed its implications for sustainable development outcomes, identified key drivers and barriers to progress, and proposed strategies for enhancing resilience and promoting inclusive growth [6]. Through illuminating the intricate relationships between environmental security practices and sustainable development of Kigali City in Rwanda, this study will advance scholarly understanding, support evidence-based planning and policy decisions, and offer useful perspectives for promoting urban sustainability in Kigali and other urban Cities.

### ***1.2. Problem Statement***

Environmental security, defined as the safeguarding of ecosystems and natural resources to prevent conflicts and ensure human well-being, is becoming more and more acknowledged as being essential to urban stability [3]. In a similar vein, sustainable development aims to strike a balance between social justice, economic expansion, and environmental preservation so that urbanization may satisfy current demands without endangering future generations [7]. However, much of the existing research tends to focus on isolated aspects, such as environmental management or socio-economic development, without fully examining the interconnectedness of these two concepts. This fragmented approach overlooks the complex and integrated challenges that urban areas face, where issues like environmental degradation and socio-economic disparities are deeply intertwined [8]. As a result, there is still a big vacuum in the research on the complex interactions between environmental security practices and sustainable development in urban settings. Urban regions continue to face environmental degradation and socio-economic disparities, despite a rising worldwide understanding of these concerns. This calls for a more integrated and comprehensive response.

Rwanda's capital city Kigali, faces a unique set of environmental security issues, such as increasing urbanization, deforestation, and irresponsible resource use [6]. Due to these problems, the area is now more vulnerable to the effects of climate change, such as flooding and soil erosion, which endangers the ecosystem and the socioeconomic stability of the community [9]. However, the relationship between these environmental challenges and Kigali's sustainable development efforts remains underexplored in the current literature, highlighting a critical gap in understanding how to effectively integrate environmental security into urban planning [6]. A thorough strategy that takes into account the intricate relationships between environmental security practices and sustainable development is needed to address these problems. By offering a thorough examination of Kigali's environmental security practices dynamics and their implications for the city's sustainable development trajectories, this research aimed to close this gap.

### ***1.3. Objectives of the Study***

This research project examined environmental security practices on sustainable development of Kigali City in Rwanda with the following specific objectives:

- a) To assess the environmental security policies and how they affect sustainable development in Kigali City
- b) To evaluate environmental security compliance on the sustainable development of Kigali City
- c) To investigate environmental security technologies and how they enhance sustainable development in Kigali City

## II. METHODOLOGY

### 1. Research Design

This research study employed a mixed-methods approach, combining qualitative and quantitative methodologies, to assess environmental security practices and sustainable development of Kigali City in Rwanda. For data collection instrument the researcher used questionnaires, interviews and google forms to collect data.

### 2. Target Population

The target population of this study is 9,660 comprising the entire population of Gisozi and Rutunga sector of Gasabo District in Kigali City, as reported by the National Institute of Statistics of Rwanda in its 5th Rwanda Population and Housing Census [10]. The Researcher also included 12 environmental experts and representatives of the local government from Kigali City, Gasabo District.

### 3. Sample Size

The sample size was calculated using Yamens formula as follow:

$$n = \frac{N}{1 + N \times e^2}$$

Where N is the size of the target population, n is the sample size, and e is the margin of error (fixed at 10% or 0.1). By using these parameters:  $n = 9660 / [1 + 9660 \times (0.10)^2] = 9660 / 97.69660 \approx 99$ . Hence, for this study the sample size is approximately 99 Respondents (General Respondents).

**Table 1. Sample Size**

Category	Population	Sample size
Environmental experts	8	4
Environmental and natural resources managers	4	2
Gasabo District Residents	9,660	99
<b>Total</b>	<b>9,672</b>	<b>105</b>

Source: Researcher (2024)

## III. RESEARCH FINDINGS AND DISCUSSION

### 1. Introduction

This chapter deals with the presentation, analysis and interpretation of the results from the data collected from the field. Data presentation, Analysis and interpretation follows the major theme and objectives of the study. It is composed of tables illustrating the results of the study.

### 2. Demographic Characteristics of Respondents

#### A. Age Distribution of the Respondents

**Table 2. Age Distribution of the Despondence**

Age	Number of Respondents	Percentage
18- 35 Years	21	23.6%
36 – 50 Years	43	48.3%
51 - 65 Years	19	21.3%
More than 65 Years	6	6.7%
<b>Total</b>	<b>89</b>	<b>100%</b>

Source: Primary Data (2024)

Table2 illustrates the age distribution of respondents across four categories: 18–35 years, 36–50 years, 51–65 years, and over 65 years.

**B. Response Rate from the Respondents****Table 3. Response Rate**

Category	Number of Questionnaires Distributed	Number of Responses Received	Response Rate (%)
Residents	99	89	90
Environmental Experts	6	5	83
<b>Total</b>	<b>105</b>	<b>95</b>	<b>90%</b>

**Source: Primary Data (2024)**

From the table 3 above, the overall response rate of 90% is considered adequate for the purposes of this research. It ensured a representative sample, providing a solid foundation for analysing the environmental security practices and their impact on sustainable development in Kigali City.

**3. Presentation of Findings****A. Environmental Security Policies and their Effect to Sustainable Development of Kigali City in Rwanda****Table 4. The Effect of Environmental Security Policies to Sustainable Development of Kigali: General Respondents (General Community) Perspectives**

Effect of Environmental Security Policies	SD	D	N	A	SA	M	S.D
The current environmental security policies (e.g. Rwanda's Environment and Climate Change Policy) are effective in addressing environmental issues in Kigali City.	0	10	3	60	16	3.92	.815
The environmental security policies (Like Kigali City Air Quality Management Strategy) have contributed to significant improvements in air quality in Kigali City.	0	7	2	65	15	3.99	0.715
The environmental security policies (e.g. National Policy for Climate Change and Green Growth) contribute significantly to sustainable resource management (e.g., water, land) in Kigali City.	0	2	1	39	47	4.47	0.641
The environmental security policies support the achievement of sustainable development goals in Kigali City.	2	3	3	36	48	4.46	0.675

**Note:** SD= Strongly Disagree; D= Disagree; N= Neutral; A= Agree; SA= Strongly Agree; M= Mean and S.D= Standard Deviation

**Source: Primary Data, 2024**

The frequency table 9 above, shows the analysis on the effect of environmental security policies on sustainable development in Kigali City reveals a generally positive perception among the general community respondents. The statement regarding the effectiveness of current policies, such as the Rwanda Environment and Climate Change Policy, received a mean score of 3.92, with 60 respondents agreeing and 16 strongly agreeing, indicating substantial recognition of the policies' impact on addressing environmental issues. Furthermore, the National Policy for Climate Change and Green Growth garnered an even higher mean score of 4.47, with 39 agreeing and 47 strongly agreeing that it significantly contributes to sustainable resource management. Similarly, the perception that environmental security policies support the achievement of sustainable development goals scored 4.46, reflecting strong community endorsement.

The significance of these findings lies in showing that environmental policies are well-integrated into the city's development framework and are critical to achieving sustainability outcomes. In an interview with Environmental Expert he said '*Environmental policies in Rwanda are key drivers of a sustainable environment and must be considered in all development activities. These policies outline the necessary actions to ensure that the environment is properly conserved which in turn affect Rwanda's development in social, economic and technological aspect of development.*' This interview

response highlights the importance of environmental policies, and it is encouraging that the analysis shows a strong familiarity with these policies. This familiarity can be leveraged to preserve the environment and promote sustainable development in our country.

### B. Evaluation of Environmental Security Compliance on the Sustainable Development of Kigali City

**Table 5. Environmental Security Practices Compliance and Sustainable Development in Kigali City: General Respondents' Perspectives**

Environmental Security Compliance Practices	SD	D	N	A	SA	M	S.D
The current environmental security practices (e.g., Waste Management and Recycling; Green Areas Management; Community Clean-up Campaigns) in Kigali City are effectively implemented and followed.	0	1	0	69	10	3.89	0.745
The current air quality management practices (e.g., Urban Green Spaces, Tree Planting, and control of industrial emissions) in Kigali City are effective at improving air quality.	1	4	3	58	23	4.10	0.754
The implementation of Integrated Water Resources Management (IWRM) practices significantly contributes to improving water quality in Kigali City.	0	5	0	71	13	4.03	0.611
The current waste management system (e.g., Segregation and collection of waste, landfill management) in Kigali City is effective at reducing environmental pollution.	0	6	3	65	15	4.00	0.691
Improvements in environmental security practices (e.g., Tree plantation, waste collection, public awareness campaigns) support the overall sustainable development of Kigali City.	0	0	1	35	53	4.58	0.518

**Note:** SD= Strongly Disagree; D= Disagree; N= Neutral; A= Agree; SA= Strongly Agree; M= Mean and S.D= Standard Deviation

#### Source: Primary Data (2024)

The frequency analysis results for environmental security practices compliance and sustainable development in Kigali City, based on general respondents' perspectives, from table 12 above, show a largely positive perception of the city's environmental practices. The mean scores for each practice indicate a positive evaluation, with values ranging from 3.89 to 4.58. The highest-rated item, "Improvements in environmental security practices (e.g., Tree plantation, waste collection, public awareness campaigns) support the overall sustainable development of Kigali City," has a mean of 4.58 and a low standard deviation (S.D) of 0.518, indicating strong consensus. Similarly, air quality management practices score a mean of 4.10 with an S.D of 0.754, reflecting respondents' recognition of its effectiveness in improving air quality.

**Table 6. Descriptive Statistics for Environmental Security Practices Compliance and Their Impact on Sustainable Development in Kigali City: Key Respondents Perspectives**

Environmental Security Practices Compliance	N	Min	Max	M	S.D	Var
The current environmental security practices (e.g., Waste Management and Recycling; Green Areas Management; Community Clean-up Campaigns) in Kigali City are effectively implemented and followed.	5	4	5	4.20	0.447	0.200
The current air quality management practices (e.g., Urban Green Spaces, Tree Planting, and control of industrial emissions) in Kigali City are effective at improving air quality.	5	4	5	4.20	0.447	0.200
The implementation of Integrated Water Resources Management (IWRM) practices significantly contributes to improving water quality in Kigali City.	5	3	5	4.00	0.707	0.500

The current waste management system (e.g., Segregation and collection of waste, landfill management) in Kigali City is effective at reducing environmental pollution.	3	4	3.80	0.447	0.200
Improvements in environmental security practices (e.g., Tree plantation, waste collection, public awareness campaigns) support the overall sustainable development of Kigali City.	4	5	4.40	0.548	0.300
Valid N (listwise)	5				

**Note:** N=89, Min= Minimum, Max= Maximum, M= Mean, SD= Standard Deviation; Var = Variance

#### Source: Primary Data (2024)

Table 7 above, indicate the descriptive statistics of environmental security practices compliance and their relationship to sustainable development in Kigali City and reveal a generally positive perspective among the key respondents. The highest mean score (4.40) reflects a consensus that enhancements in these practices are significantly supporting the overall sustainable development of the city.

### C. Investigation of Environmental Security Technologies and How They Enhance Sustainable Development in Kigali City

**Table 7. Environmental Security Technologies and Sustainable Development in Kigali City: General Respondents' Perspectives**

Statements	D	SD	NA	SA	M	S.D
Waste-to-energy technologies can enhance sustainable development by reducing waste and generating energy in Kigali City.	0	2	1 23	63	4.65	.623
The adoption of green building technologies (e.g., energy-efficient materials, sustainable construction practices) will contribute to sustainable development in Kigali City.	0	1	0 34	54	4.58	.560
Air purification technologies (e.g., tree planting & green spaces) are effective in improving air quality and contributing to sustainable development in Kigali City.	1	17	6 54	11	3.64	.968
Implementing water recycling systems (e.g., rainwater harvesting) can support sustainable development by conserving water resources in Kigali City.	1	1	0 20	67	4.70	.647
The increased use of renewable energy technologies (e.g., solar panels) is effective in promoting sustainable development in Kigali City.	1	11	6 58	12	3.78	.877

**Note:** SD= Strongly Disagree; D= Disagree; N= Neutral; A= Agree; SA= Strongly Agree; M= Mean and S.D= Standard Deviation

#### Source: Primary Data (2024)

The table 8 above, presents the general respondents' perspectives on the effectiveness of various environmental security technologies in promoting sustainable development in Kigali City. The results show that respondents overwhelmingly agree on the potential of these technologies to support environmental sustainability. For waste-to-energy technologies, the majority of respondents (63 strongly agreed and 23 agreed) believe that these technologies can significantly enhance sustainable development by reducing waste and generating energy, with a mean score of 4.65 and a standard deviation of 0.623. This indicates a very high level of agreement. Regarding green building technologies, such as energy-efficient materials and sustainable construction practices, respondents also express strong support, with 54 strongly agreeing and 34 agreeing. The mean score of 4.58 and a low standard deviation of 0.560 indicate a consensus that these technologies will contribute positively to sustainable development.

**Table 8. Correlation Analysis of Environmental Policies, Compliance, and Environmental Technologies with Sustainable Development of Kigali City: General Respondents Perspectives****Correlations**

			IV1	IV2	IV3	DV
Spearman's rho	IV1	Correlation Coefficient	1.000	.757**	.685**	.370**
		Sig. (2-tailed)	.	<.001	<.001	<.001
		N	89	89	89	89
IV2		Correlation Coefficient	.757**	1.000	.610**	.303**
		Sig. (2-tailed)	<.001	.	<.001	.004
		N	89	89	89	89
IV3		Correlation Coefficient	.685**	.610**	1.000	.303**
		Sig. (2-tailed)	<.001	<.001	.	.004
		N	89	89	89	89
DV		Correlation Coefficient	.370**	.303**	.303**	1.000
		Sig. (2-tailed)	<.001	.004	.004	.
		N	89	89	89	89

\*\* . Correlation is significant at the 0.01 level (2-tailed)

**Note:** IV1= Independent Variable 1, IV2: Independent Variable 2; IV3= Independent Variable 3 and DV= Dependent Variable

**Source: Primary Data (2024)**

The analysis from table 18 above, reveals that Independent Variable- VI (Environmental Policies) shows a significant positive correlation with Dependent Variable- DV (Sustainable Development), with a correlation coefficient of 0.370 ( $p < .001$ ). This indicates a moderate positive relationship, suggesting that as familiarity with or the effectiveness of environmental policies increases, sustainable development in Kigali City tends to improve. Additionally, Environmental Policies exhibits strong positive correlations with Independent Variable- IV2 (Compliance with Policies) and Independent Variable- IV3 (Environmental Technologies), with coefficients of 0.757 and 0.685, respectively. These correlations indicate that a greater focus on environmental policies is associated with better compliance and the adoption of environmental technologies.

Furthermore, Compliance with policies is significantly positively correlated with DV (Sustainable Development), presenting a correlation coefficient of 0.303 ( $p = .004$ ), which implies that improved compliance with environmental security practices enhances sustainable development in Kigali City. IV3 (Environmental Technologies) also shows a significant correlation with sustainable development, with a coefficient of 0.303 ( $p = .004$ ), indicating that the adoption of environmental technologies positively impacts sustainable development. Overall, the results demonstrate that environmental policies, compliance, and technologies all significantly positively relate to sustainable development. Stronger environmental policies, along with better compliance and technology adoption, contribute positively to sustainable development of Kigali City, with environmental policies emerging as the most significant factor, strongly linked to compliance and technology usage.

#### IV. CONCLUSION AND RECOMMENDATIONS

##### A. Conclusion

The findings of this study answer the key research questions, demonstrating that environmental security policies, compliance practices, and technologies are all critical to achieving sustainable development in Kigali City. Key environmental security policies, such as Rwanda's Environment and Climate Change Policy and the National Policy for Climate Change and Green Growth, have a significant impact on sustainable development. The study's findings show a high level of familiarity with these policies, and both general and key respondents agree on their importance in fostering sustainability. However, the slightly lower awareness and perceived effectiveness of the Kigali City Air Quality

Management Strategy suggest that this policy requires more robust communication and enforcement to optimize its impact.

Compliance with environmental security regulations, particularly in areas such as waste management, air quality control, and public awareness campaigns, plays a pivotal role in sustainable development. Both general and key respondents view compliance positively, though key respondents indicated a slightly more critical perspective. This highlights the need for increased community engagement and government oversight. Environmental security technologies, such as waste-to-energy systems and green building technologies, were rated highly, but key respondents suggested there is room for improvement, especially in renewable energy and air purification. In terms of participant demographics, general respondents included both male and female participants, with the majority being between the ages of 26-45. This diversity reflects a broad representation of opinions and experiences, enhancing the reliability of the conclusions drawn.

### **B. Recommendations**

Based on the findings and conclusions, the following recommendations are proposed to enhance the impact of environmental security practices on sustainable development in Kigali City:

- 1. Strengthen Public Awareness Campaigns:** There is a need to improve awareness of policies like the Kigali City Air Quality Management Strategy to ensure their full implementation and effectiveness.
- 2. Enhance Waste Management Practices:** Both general and key respondents indicated that waste management practices, while effective, could be improved. The government should invest in scaling up waste-to-energy technologies and improve community waste segregation systems.
- 3. Increase Investment in Environmental Technologies:** Kigali City should continue investing in advanced technologies such as waste-to-energy technology; renewable energy systems and green building practices. More funding should be allocated to expand these technologies' availability and accessibility.
- 4. Focus on Compliance and Enforcement:** Strengthening the enforcement of environmental security regulations and increasing compliance, particularly in water resource management and air quality control, will be crucial for sustainable development.

### **C. Suggestions for Further Study**

This study has highlighted areas for future research that could expand on the findings:

- 1. Impact of Gender on Environmental Policy Perception:** Further studies could explore how gender influences the awareness and implementation of environmental security policies in Kigali City.
- 2. Longitudinal Study on Environmental Security Technologies:** A long-term study examining the effects of emerging environmental technologies on sustainability outcomes could provide valuable insights into their effectiveness over time.
- 3. Youth Engagement in Environmental Security Practices:** As the study showed lower participation from younger respondents, future research could focus on the role of youth in environmental security practices and how to increase their engagement in sustainability efforts.

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