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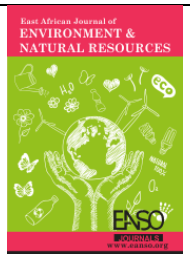

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Original Article

Effect of Green Economy Practices on Flood Risk Reduction in the City of Kigali

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Keywords:

Green Economy Practices, Flood Risk Reduction, Wetland Restoration, E-Mobility, Green Urban Planning, Green City Kigali, Kigali.

ABSTRACT

Climate change remains a pressing global challenge, exacerbated by unsustainable economic activities, rapid urbanization, and resource depletion. This study explores the effect of green economy practices on flood risk reduction in the City of Kigali, Rwanda. Recognizing the global urgency of climate change and environmental degradation, the research focuses on sustainable practices such as electric mobility, green urban planning, plastic recycling, and wetland conservation. Using a mixed-methods approach, both qualitative and quantitative data were collected from 210 respondents, including green economy practitioners and policymakers. Descriptive statistics revealed strong public support for green practices, particularly the adoption of electric vehicles, restoration of wetlands, implementation of green infrastructure, and circular economy efforts like plastic recycling. Regression analysis showed a strong positive relationship between green economy practices and flood risk reduction with correlation coefficients (R = 0.875, R2 = 0.786), indicating that 78.6% of the variance in flood risk reduction could be explained by these practices. Regression analysis further identifies wetland conservation (B = 0.804, $p < 0.001$) as the strongest contributor, followed by green urban planning (B = 0.713, $p < 0.001$). Plastic recycling (B = 0.521, p = 0.002) also shows a significant positive effect, while e-mobility (B = 0.278, p = 0.028 contributed positively, though to a slightly lesser degree. The findings emphasize the necessity of integrated, sustainable urban planning strategies to enhance climate resilience. The study draws a conclusion that scaling up green economy practices is vital for Kigali's climate adaptation strategy and recommends stronger policy support, public awareness, and investment in green technologies to further strengthen urban resilience against climate-induced flood disasters.

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INTRODUCTION

A green economy promotes human well-being and social equity while reducing environmental risks and conserving resources for future generations (UN, 2011). Although the concept gained traction after the 2008–2009 global financial crisis and Rio+20, interest has waned despite its critical role in achieving sustainable development goals (Lucien et al., 2017; Davies, 2013). Global frameworks like the Sustainable Development Goals (SDGs) have reignited the need to align economic growth with environmental sustainability.

Rwanda has embraced this paradigm through its Vision 2050, which aspires to transform the country into an upper-middle-income economy by 2035 and a high-income economy by 2050. In line with this, the National Green Growth and Climate Resilience Strategy (GGCRS) focuses on climate-resilient and low-carbon development (Mujawamariya, 2022). The country's industrial targets—24% of GDP by 2035 and 33% by 2050—necessitate sustainable infrastructure, green energy, and conservation-oriented economic models (Ministry of Environment, 2022).

However, the traditional linear economy model, which emphasizes "take-make-use-dispose," has contributed to environmental degradation, resource over-extraction, and misdirected investments away from critical green sectors such as renewable energy and ecosystem services (Alfonso & Paolo, 2016; UNEP, 2011)- leading to significant waste generation, which at the same time adversely impacts the environment (Cezarina, et al., 2024)

Statement of the Problem

Nowadays, due to unsustainable economic patterns, the world is experiencing unchecked environmental degradation, exacerbated climate change, and unsustainable resource exploitation, resulting in severe economic, ecological, and social consequences (Ranjit & Kushwaha, 2022; Helen 2015).

Despite Rwanda's efforts to pursue green growth, unsustainable urbanization and economic practices continue to strain natural ecosystems, especially in the City of Kigali. Rapid urban expansion, population growth, and industrialization are driving up air pollution, increasing urban heat island effects, and threatening wetlands through encroachment and degradation resulting in the loss of their ecological services (Muvunangabo, 2022; Nizeyimana, 2021, Pepe, et al., 2021).

Moreover, the frequency and intensity of climate-related disasters —including floods, soil erosion, and biodiversity loss—have surged, with Gasabo District showing the highest exposure to flood risks (Hakuzimana et al., 2023). These challenges are exacerbated by continued reliance on conventional economic models that prioritize short-term financial gains over long-term environmental sustainability. There is an urgent need to reassess development

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models and enhance the integration of green economy principles to mitigate environmental degradation, improve resilience, and promote sustainable livelihoods in urban centres like Kigali.

Study Objectives

The general objective of this study is to assess the effect of green economy practices on climate change resilience in the City of Kigali with the specific objective of examining whether there is a significant relationship between green economy practices and climate change resilience in the city of Kigali

LITERATURE

Urbanization is a major factor that amplifies the frequency and severity of urban flooding hazards. The rapid expansion of cities leads to the loss of green spaces and a rise in impervious surfaces, such as roads and buildings, which worsens flooding by limiting water absorption and increasing surface runoff (Kabila et al., 2020). Urban green spaces, such as parks, road trees, and vegetated areas, significantly lower flooding probability by enhancing water infiltration and reducing surface runoff, thereby improving urban flood resilience (Hyomin et al., 2016; Tian et al., 2018).

Wetland conservation and restoration also play a critical role in urban ecological resilience. These natural ecosystems reduce air pollution, mitigate urban flood risks, and support biodiversity and water filtration, while also offering nature-based recreational and educational opportunities (Niyontezeho et al., 2022). Healthy ecosystems act as natural buffers against disasters like floods, storm surges, and landslides (UNEP, 2020).

Based on ecological economics theory, overpopulation, rising inequality, resource-depleting technologies, and habitat destruction are considered to be major threats to the planet's long-term sustainability. These interconnected challenges suggest that human demands are exceeding Earth's carrying capacity, putting both environmental systems and future generations at risk. In response, ecological economics emphasizes the need for sustainable strategies (green economy) that prioritize the efficient use of resources, the preservation of natural capital, and equitable distribution to ensure social and intergenerational justice (Costanza et al., 2015).

Furthermore, green urban planning practices—such as the implementation of structural, non-structural, and functional measures—have been shown to enhance disaster-resilient public and private investments. This includes the adoption of green building practices, retrofitting, green roofs, and permeable pavements, all of which reduce the urban flood footprint and promote climate adaptation (UNDRR, 2015).

In addition to these, contemporary literature highlights the significance of electric mobility and plastic recycling as key components of broader green economy practices, contributing to reduced carbon emissions, enhanced air quality, and sustainable urban resource management. For instance, electric vehicles reduce fossil fuel dependency, (Rafael, et al., 2022, Mandana, et al., 2021) while plastic recycling supports the circular economy (Elias, et al., 2023) and reduces environmental pollution in urban spaces. (Osama, 2021)

These green economy practices—electric mobility, wetland conservation, green urban planning, and plastic recycling—have been widely documented as strategic interventions for promoting flood risk reduction and enhancing environmental resilience in urban areas. This review is grounded in the Triple Bottom Line (TBL) framework, which emphasizes the integration of environmental sustainability, social well-being, and economic viability (Elkington,1998). The TBL framework provides a holistic lens for analyzing how green economy practices not only address flood risks but also contribute to long-term sustainable urban development.

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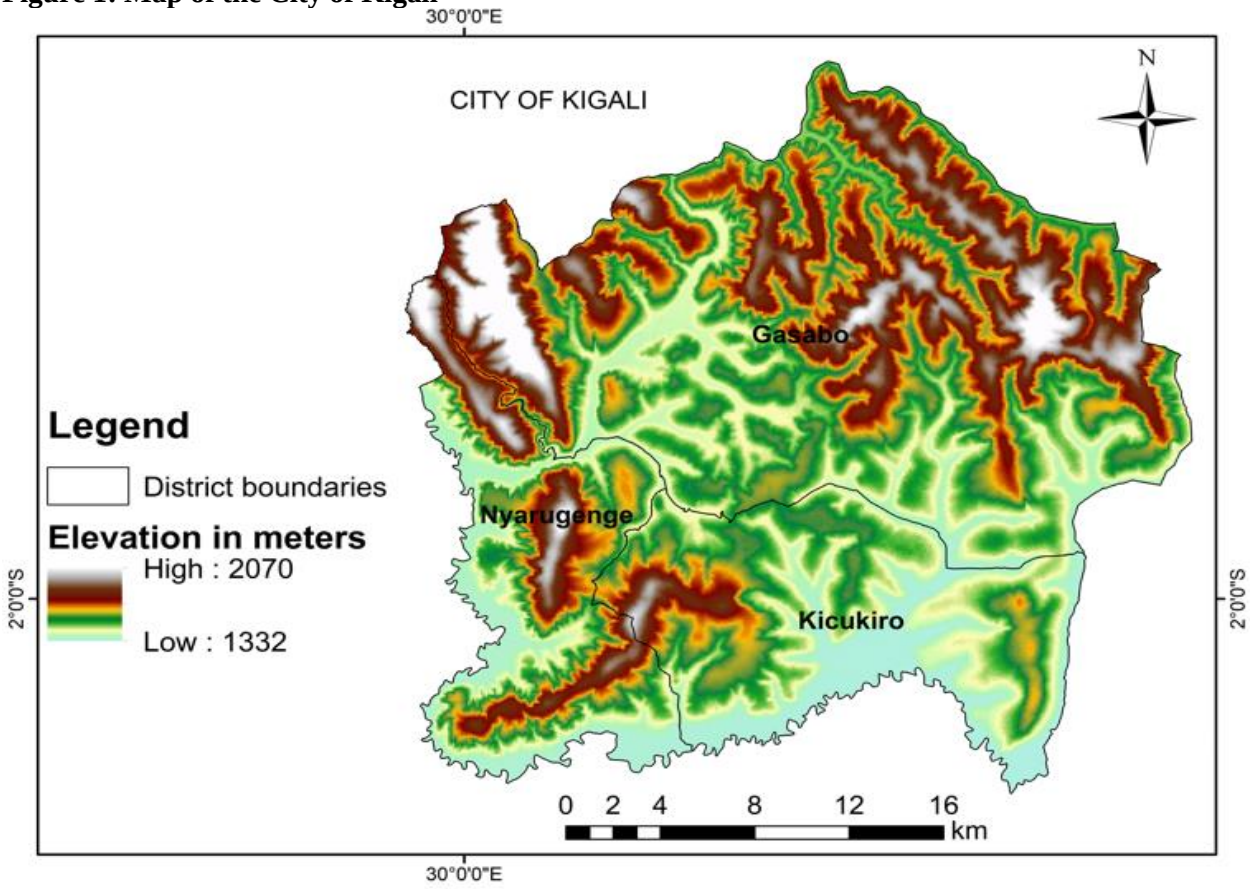
MATERIALS AND METHODS

Study Area Description

The City of Kigali is one of the five provinces of Rwanda, situated in the central part of Rwanda between 29°43'0''E and 29°44'0''E of longitude and 2°35'0''S and 2°37'0''S of latitude. The elevation in the lower areas is approximately 1400 meters, while the surrounding hills rise above 1845 meters above sea level. The tallest of these is Mount Kigali, which reaches an altitude of 1850 meters. (Nduwayezu, et al., 2016) The capital city of Rwanda is located at the geographical centre of the country. Spanning an area of 730 km^2. Wetlands represent one of Kigali's significant hydrological characteristics, primarily situated within different valleys and occupy approximately 12.5% of the city's total land area (Manirakiza, et al., 2019). Kigali has a tropical climate and receives 950 mm of total rainfall per year, with the wettest month of April and a minimum rainfall from June to August, when it almost never rains (Niyotwizera, 2022). The city is organized into three districts: Gasabo, Kicukiro, and Nyarugenge which are further subdivided into 35 administrative sectors and the latter then divided into 161 cells (CoK, 2018). As reported by the Fifth Rwanda Population and Housing Census (RPHC5), Kigali has a population of 1,745,555 with a population density of 2,401 inhabitants/km^2 (NISR, 2023)

Figure 1: Map of the City of Kigali



Map of Kigali (Author, 2025)

The study examines four key green initiatives in Kigali*: CFAO Mobility, Nyandungu Eco-Park, Green City Kigali, and We Can Recycle Ltd*, along with input from policymakers in the *City of Kigali*. *CFAO Mobility* launched East Africa's first BYD electric vehicle dealership in Kigali, offering EVs and full e-mobility services including charging,

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maintenance, and solar solutions; *Nyandungu Eco-Park* is a restored 121.8-hectare wetland featuring indigenous trees, recreational spaces, bike lanes, and eco-tourism attractions; *Green City Kigali* aims to create a sustainable, climate-resilient urban community on Kinyinya Hill, delivering affordable housing and eco-friendly transport infrastructure; *We Can Recycle Ltd*, based in the Kigali Special Economic Zone, promotes circular economy by recycling various plastics into usable materials and raw materials for other plastic products.

Research Design

This study used a mixed-method approach combining quantitative and qualitative research methods and descriptive statistics was utilized for data analysis. The primary and secondary data were used in this study where primary data were gathered through a questionnaire-based survey and interviews from businesses in the green economy including We Can Recycle ltd-a company, CFAO mobility company, green city Kigali, Nyandungu Eco-Park as well as insights from policymakers in the City of Kigali. The total target population was 441 respondents from which a sample size of 210 respondents was drawn using Slovin's formula as follows:

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

Equation (1) is Slovin's equation for sample size determination. n is sample size, N is total population and e is confidence level equal to 5%

During the study, stratified and purposive sampling techniques were used to obtain an accurate representation of the results without bias as the target population was not homogeneous. On the other hand, the secondary data was collected from various sources such as books, journals, reports, and other reliable documents.

The researcher upheld ethics by ensuring privacy, confidentiality, honesty, and transparency throughout the study. Participants' identities were protected, and data was handled with integrity, free from bias or manipulation. Intellectual property rights were respected, and care was taken to prevent any physical or emotional harm.

Data Analysis

The collected data was analyzed systematically in accordance with the study's objectives, focusing on the effect of green economy practices on flood risk reduction in the City of Kigali. The SPSS version 16 software was used to process and analyze the data, with results presented in tabular format for clarity. Descriptive statistics, including the mean and standard deviation, were employed to measure the general trend and variability of responses among respondents. In addition, multiple regression analysis was performed in order to explore the relationship between green economy practices namely—e-mobility, green urban planning, plastic recycling, and wetland conservation— against flood risk reduction. The regression model helped quantify how much each indicator of green economy practices contributed to changes in flood risk reduction, offering insights into the predictive strength and significance of each practice. This combination of descriptive and inferential statistical methods ensured a comprehensive evaluation of the research data. In addition, the thematic analysis was used to analyze the collected qualitative data from various key respondents.

RESULTS DISCUSSION

Descriptive Results

The descriptive results revealed a strong agreement among respondents, regarding the critical effect of green economy practices on flood risk reduction.

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Table 1: Green Economy Practices versus Flood Risk Reduction Statements

Reduced disaster risk	Mean	SD	Comment
Wetlands absorb and store excess rainwater, reducing the risk of flooding in nearby areas. They act as natural sponges, slowing down water flow and releasing it gradually.	4.78	.418	Very high mean Homogeneity
Green spaces can act as buffers during extreme weather events, such as floods and storms, reducing damage to urban infrastructure. They also filter pollutants from stormwater, improving water quality.	4.50	.507	Very high mean Moderate
Plastic recycling helps reduce litter and clogged drainage systems, lowering the risk of flood.	3.90	.761	High mean Heterogeneity
E-mobility reduces greenhouse gas emissions, playing a key role in climate change mitigation and the long-term stabilization of extreme weather conditions such as heavy rainfall and flooding.	3.68	.732	High mean Heterogeneity
Overall mean	**4.21**		

Table 1 shows that wetlands, green spaces, plastic recycling, and e-mobility all contribute to reducing flood risks, with wetlands and green spaces having very high mean scores. Overall, the initiatives demonstrate a strong positive impact, with an overall mean of 4.21

Regression Analysis

The inferential statistics conducted in the city of Kigali provided a perception of the deep effect of green economy practices on flood risk reduction. Through regression analysis, the significant associations between green economy practices including —e-mobility, wetland conservation, green urban planning and plastic recycling— and flood risk reduction have been observed.

Table 2: Model Summary of Green Economy Practices and Flood Risk Reduction in the City of Kigali

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.875[a]	.786	.721	.324

a. Predictors: (Constant), Wetland conservation, Green urban planning, e-mobility, Plastic recycling
Source: *Field data, 2025*

Table 2 of the model summary demonstrates a very strong relationship between green economy practices and flood risk reduction with ($R^2 = 0.786$) indicating that 78.6% of the variance in flood risk reduction is explained by four key predictors namely wetland conservation, green urban planning, electric mobility, and plastic recycling. The adjusted R^2 of 0.721 and low standard error (0.324) confirm the model's robustness and reliability in predicting the dependent variable

Table 3: Analysis of Variance (ANOVA) for Green Economy Practices and Flood Risk Reduction in the City of Kigali

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	118.654	4	29.663	33.405	.000[a]
Residual	168.783	190	.888		
Total	237.437	195			

a. Predictors: (Constant), Wetland conservation, Green urban planning, e-mobility, Plastic recycling
b. Dependent Variable: Flood risk reduction
Source: *Field data, 2025*

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Table 3 of analysis of variance (ANOVA) for green economy practices and flood risk reduction in the City of Kigali shows the statistical significance of the model supported by the F-statistic ($F = 16.513$, $p < 0.001$) demonstrating that the four predictors collectively have a significant influence on flood risk reduction. Although a considerable portion of the variance is explained ($SS_{exp} = 118.654$), the presence of residual variance ($SS_{res} = 168.783$) suggests the presence of other influencing factors beyond those included in the model.

Table 4: Regression Coefficients of Green Economy Practices Flood Risk Reduction in the City of Kigali

	Unstandardized Coefficients		Standardized Coefficients		
Model	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	.747	.258		7.012	.005
e-mobility	.278	.284	.374	.232	.028
Green urban planning	.713	.083	.672	17.385	.000
Plastic recycling	.521	.274	.408	.522	.002
Wetland conservation	.804	.102	.765	43.107	.000

Dependent Variable: Flood risk reduction

Source: *Field data, 2025*

Table 4 of regression coefficients for green economy practices on flood risk reduction in the City of Kigali offers valuable perspectives. The wetland conservation ($B = 0.804$, $p < 0.001$) has the strongest positive effect on flood risk reduction, followed by green urban planning ($B = 0.713$, $p < 0.001$). Plastic recycling ($B = 0.521$, $p = 0.002$) also contributes significantly, while e-mobility ($B = 0.278$, $p = 0.028$) has a smaller but still significant influence. The finding suggests that investing in these green economy practices mostly improves the ability to withstand floods in the city of Kigali. The corresponding regression equation is as follows:

$$Y = 0.747+0.278X_1+0.713X_2+0.521X_3+0.804X_4+\epsilon \quad (2)$$

Equation (2) is the regression equation showing the relation between green economy practices and flood risk reduction. Y is flood risk reduction, X_1 is e-mobility, X_2 is green urban planning, X_3 is plastic recycling and X_4 is wetland restoration.

The data from interviews was thematically analyzed and expressed the evidence that various green economy practices collectively contribute to flood risk reduction. E-mobility reduces greenhouse gas emissions, playing a key role in climate change mitigation and the long-term stabilization of extreme weather conditions such as heavy rainfall and flooding. Plastic recycling enhances urban cleanliness by minimizing litter and preventing drainage blockages, thereby lowering the risk of floods and waterborne diseases. Additionally, restored wetlands serve as natural buffers, absorbing excess stormwater and reducing flood severity in urban areas. Green City Kigali promotes affordable, eco-friendly housing supported by climate-resilient infrastructure.

Sustainable urban planning plays a key role in managing and preventing rain-induced flooding. Well-planned drainage networks, vegetated areas, and rain gardens help slow down rainwater flow and effectively reduce the risk of floods—properties located near green infrastructure, experienced an increase in value—indicating a lower perceived flood risk—while traditional grey infrastructure had no notable effect on property values. (Seung et al., 2020, Jiang et al., 2024)). The global role of the

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green economy promotes sustainable development and resource efficiency, emphasizing areas like sustainable construction, renewable energy, infrastructure, water management, waste reduction, and biodiversity preservation for climate resilience. (Mikhno et al. 2021). Similarly to these studies, the current study confirms that green economy practices help mitigate and build resilience to climate change-induced flood disaster

CONCLUSION

The study revealed that green economy practices such as plastic recycling, electric mobility, wetland conservation, and green urban planning significantly enhance flood risk reduction in the City of Kigali. Investing in green economy practices, particularly wetland conservation and sustainable urban planning plays a critical role in enhancing flood resilience in the city of Kigali. These practices are essential components of a comprehensive strategy to reduce disaster risks and promote environmental sustainability in urban areas. The study concentrated on four specific green economy practices (e-mobility, wetland conservation, plastic recycling, and green urban planning), leaving out other potentially relevant practices that could influence flood risk reduction. In addition to this, the study focused only on the City of Kigali, which may limit the generalizability of the findings to other regions of Rwanda.

As a recommendation, the City of Kigali should increase green investments in renewable energy, electric mobility, and the circular economy, backed by strong policy enforcement to boost green development and climate resilience. Expanding eco-friendly urban planning and infrastructure, along with accelerating wetland restoration and protection, will further support sustainable growth and flood resilient city. Further studies are needed to evaluate the role of government policies in the implementation of green economy initiatives to know what the government can do or improve to bolster such green economy initiatives.

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