Original Article

Contribution of Biodiversity Spatial Patterns on Development of Ecotourism Outcomes in Akagera National Park, Rwanda

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ABSTRACT

The rapid decrease in biodiversity has become an urgent issue for ecosystems worldwide, with over one million species currently at risk of extinction due to human activities such as habitat loss, pollution, resource overexploitation, and climate change impacts. Although the relationship between biodiversity and ecotourism is established, little is known about how spatial patterns of biodiversity affect ecotourism outcomes in Akagera National Park, indicating a gap in research regarding the impact of these spatial patterns. This article aimed to assess the effects of biodiversity distribution, habitat quality, wildlife presence, and ecotourism services on developing ecotourism outcomes in Akagera National Park, Rwanda. The study utilized primary quantitative data collected through a structured survey questionnaire involving 133 respondents from a targeted sample size of 134, from RDB, REMA, Kayonza District, Akagera Hotel, and beneficiaries reached through a stratified sampling technique. The quantitative analysis employed the Statistical Package for Social Science version 25.0, applying descriptive statistical analysis to determine the mean and standard deviation, as well as inferential statistical analysis using the analysis of variance test to analyze correlation, significance levels, and regression between study variables. The multiple regression model was used, and findings indicated a positive correlation and significant effects of biodiversity distribution, habitat quality, wildlife presence, and ecotourism services on developing ecotourism outcomes in Akagera National Park. The overall correlation coefficients, R=0.844, and $R^2 = 0.712$, indicate that the independent variables contributed 71.2% to the dependent variable. The findings revealed a general positive view of biodiversity well distributed in Akagera National Park, though there is a gap in the diversity of beautiful flora categories to attract tourism revenues, with habitat quality being fully available and wildlife presence activities being correctly managed, with inadequate management of wild animals and human conflict resulting from protecting the park to prevent wild animals conflicting nearby homes. Finally, there was a general positive view of the ecotourism services available in Akagera National Park, which attract tourists and contribute to the development of ecotourism outcomes, yet a gap in the availability of water springs in Akagera Park was identified, which would enhance its attractiveness. The study concluded that there is a generally positive perception that spatial patterns of biodiversity have significantly contributed to the development of ecotourism outcomes in Akagera

National Park, Rwanda. The MoE, RDB, and their partners were recommended to add diverse flora in Akagera National Park, to manage human-wildlife conflict by erecting fences around the park to prevent animals from entering nearby homes, to create water bodies, to increase biodiversity to boost tourism revenue, and to enhance the park's appearance. Researchers were recommended to explore unstudied factors influencing ecotourism outcomes, contributing 28.8% to its development.

INTRODUCTION

The rapid decrease in global biodiversity has become a critical concern, with over one million species currently at risk of extinction due to human-induced factors such as habitat loss, pollution, overexploitation of resources, and the impacts of climate change (Raven & Wagner, 2021). These pressures threaten the integrity of ecosystems, disrupt biodiversity distribution, and undermine essential ecological services that support life on Earth. As biodiversity loss continues, it poses a direct threat to the quality of habitats and the presence of wildlife that many natural systems and economies depend on.

In Africa, biodiversity hotspots face even more acute challenges. The continent is home to rich and unique ecosystems, yet these areas are increasingly threatened by rapid population growth, land-use changes, and climate-related disasters such as droughts and floods (Mwongera et al., 2019). These disturbances degrade habitat quality and reduce species richness, directly impacting the development of ecotourism outcomes across the continent. Ecotourism, which relies heavily on the visibility and presence of iconic wildlife species, is particularly sensitive to fluctuations in biodiversity patterns.

In Rwanda, Akagera National Park, one of Rwanda's main conservation zones, is a biodiversity-rich environment that supports a diverse range of vegetation and wildlife. The park is critical in promoting ecotourism, which is an essential part of Rwanda's economy (Umuziranenge & Muhurwa, 2017). However, the park confronts serious risks such as habitat fragmentation, climatic unpredictability, and invasive species, all of which damage biodiversity and undermine its value as a tourist destination (Pörtner et al., 2023)

Despite Rwanda's major efforts to promote biodiversity protection, such as the establishment of protected areas and the implementation of conservation programs, there is still a fundamental gap in knowing how biodiversity patterns affect ecotourism potential (Guerrero-Moreno & Oliveira-Junior, 2024). This absence of data reduces the efficiency of management initiatives aimed at maximizing Akagera National

Park's economic and ecological advantages. For example, research in comparable ecosystems have shown that decreases in essential species can result in lower tourist profits, emphasizing the need for biodiversity conservation in sustaining visitor interest and income production (Pörtner et al., 2023). Given the growing effects of climate change on ecosystems, understanding biodiversity patterns is more important than ever. This research helps to preserve the natural health of Akagera National Park while also promoting sustainable ecotourism. By closing the information void, will help policymakers and stakeholders maximize the park's economic contributions to local people while also assuring long-term biodiversity protection.

Although the relationship between biodiversity and ecotourism has been established, little is known about how spatial patterns of biodiversity influence ecotourism outcomes in Akagera National Park. This knowledge gap highlights the need for further research on the impact of biodiversity distribution on ecotourism. Few studies have looked at how biodiversity distribution affects these visiting patterns, despite studies showing that some parts of the park get more visitors than others (Mugisha et al., 2021). This research aimed to assess the contribution of biodiversity spatial patterns to the development of ecotourism outcomes in Akagera National Park. Specifically, it has assessed the contribution of Biodiversity Distribution, Habitat Quality, wildlife presence, and the contribution of Ecosystem services on the Development of Ecotourism Outcomes in Akagera National Park, Rwanda.The baseline theories and previous empirical studies in the same field were reviewed to draw attention to the gaps in the field's knowledge and comprehension of the need for research contributions.

Ecosystem Service Valuation Theory: According to Viteritto, (2024), the theory posited a systematic method for measuring and confirming the advantages that ecosystems provide from supplying, regulating, supporting, and cultural services, and promoting the inclusion of ecosystem services in policy and decision-making to strengthen conservation initiatives and sustainable resource management by highlighting their intrinsic and economic worth (Bremer et al., 2023). From a scientific standpoint, the quality and sustainability of ecosystem services are influenced by spatial patterns of biodiversity, such as the distribution of important plant species and habitat variety. Furthermore, the presence of wildlife, including local and endangered species, benefits from healthy ecosystem services, which increases Akagera's appeal to ecotourists and visitors who prioritize conservation (Akani, 2023). Considering these advantages, there is little information about the ecosystem services' whole economic contribution to the growth of ecotourism in Akagera National Park due to the lack of valuation studies on these services.

Metacommunity Dynamics Theory: By considering how species interact across various habitat patches within a landscape, the Metacommunity Dynamics Theory offers an essential viewpoint on the distribution of biodiversity. The four main concepts identified by this theory, species sorting, population effects, patch dynamics, and neutral dynamics, all have an impact on the distribution of species according to factors including competition, habitat quality, and dispersion constraints. Since various species in Akagera National Park adapt to certain environmental circumstances, including marshes, savannas, and forests, species sorting is important in this situation. Since seasonal changes in water availability promote species migrations, mass effects where species movement across habitats impacts population dynamics are also significant in Akagera Park. The park's diverse ecological zones, from its lakes and marshlands to acacia woodlands, create a mosaic of habitats that support different levels of species richness, influencing ecotourism potential.

Sustainable Tourism Development Theory: According to Boley & Green (2016), the theory offers a framework for finding a balance between the economic, environmental, and social components of tourism. This idea permits economic gains from tourism while emphasizing the value of resource protection (Boley & Green,

2016). Since Akagera Park is a popular tourist destination as well as a conservation area, sustainable tourism is essential there. The park has seen a rise in both visitors and revenue since its restoration efforts, which included the reintroduction of rhinos in 2017 and lions in 2015 (REMA, 2021). To avoid wildlife disturbances, biodiversity loss, and habitat damage, this expansion must be carefully controlled. Over-tourism might jeopardize the park's biological balance in the absence of sustainable measures, lowering its long-term target without sustainable policies, over-tourism could threaten the park's ecological balance and reduce its long-term viability as an ecotourism destination (Cheng, 2019). Local communities are important to conservation efforts and should benefit from ecotourism through revenue-sharing schemes, employment opportunities, and cultural tourism activities. Additionally, implementing eco-friendly initiatives like regulated safari routes, waste management systems, and habitat restoration programs can help minimize the environmental footprint of tourism. Empirical studies shed light on the regional patterns of biodiversity and their impact on ecotourism. Pedroso & Kung'u,(2019) conducted a study in East Africa to assess visitors' willingness to pay (WTP) for biodiversity protection. According to their findings, 68% of questioned tourists were prepared to give an additional 10% of their admission prices to help conserve biodiversity hotspots. This suggests a significant economic incentive to engage in biodiversity protection as part of ecotourism efforts. Akagera National Park, with its various ecosystems and famous animal species, offers a comparable potential for using biodiversity protection to boost tourist revenue.

Steven, (2021) conducted a study on the Analysis of The Effect of human-wildlife conflict On the Conservation of Flora and Fauna in Akagera National Park, Rwanda, and indicated that there are various effects of the human and wildlife conflicts on wildlife conservation in Akagera National Park Effective information dissemination, high costs charged to tourists, and lack of skilled staff are the challenges affecting the humans of conflicts on conservation. Sharing conservation-related benefits and involving local people in decision-making for resource management can increase the positive attitudes of local people towards wildlife, protected areas, and conservation practices (Steven, 2021).

Richard & Singh, (2020) conducted a study on Biodiversity Business Innovations: A Case Study of Akagera National Park, Rwanda, and revealed that all biodiversity businesses conducted at Akagera National Park depend on the biodiversity environment and therefore, business owners have to institute sustainability plans to ensure that they operate their business sustainably. He insisted that various biodiversity products provide employment and income generation through car rentals, accommodation, reservations, camping sites, and tour guiding. The community around the park benefits from the support and sensitization offered by the private entrepreneurs and responds to the mutual relationship between business and conservation by promoting the value of conservation through decreased incidences of poaching. The study also recommended that the Akagera Park needs to encourage more private enterprises, such as the establishment of campsites outside the park, to boost income-generating and employment opportunities among the residents. Secondly, annual refresher courses are suggested to improve the capacity of businesses, to enable them to participate fully in building public discourse on the biodiversity business and its sustainability.

MATERIALS AND METHODS

This section outlines various methods and techniques that were used by the researcher during the gathering of relevant data, addresses research design techniques, targeted population, sampling techniques and sample size, methods and tools of data collection and analysis in a defined study area.

Study Area

Akagera National Park is Rwanda's only savanna park and the biggest protected wetland in Central Africa, with 1,122 Km^2 in size, located in Eastern

Rwanda, bordering Tanzania(Zajadacz & Uwamahoro, 2020). The park was created in 1934, and took its name from the Akagera River, running along its eastern edge and draining into Lake Ihema and several smaller lakes. With rolling hills, vast savannas, river forests, lakes, and wetlands, the park's geography forms a mosaic of landscapes that sustain a variety of ecosystems. Its hydrology is characterized by the Akagera River, which forms the Eastern border and runs from Burundi and Uganda into Rwanda before emptying into Lake Victoria, and with ten lakes found in the park, including Lake Ihema, the biggest covering over 90 km2. Its climate is tropical savanna, with distinct dry and wet seasons. While the dry seasons go from June to September and January to February, the wet seasons run from March to May and October to December, with an average annual temperature between 20°C and 30°C.

Figure 1: Map of Akagera National Park

Source: Researcher, 2025.

Research Design

The researcher applied a quantitative research method through both Descriptive and Inferential approaches to analyze the numerical data. The researcher used a stratified sampling technique chosen to ensure that a sample accurately reflects the population it is drawn from, reduces sampling variability, leads to more precise estimates, and helps avoid bias by ensuring the inclusiveness of the strata to reach the targeted population of two hundred (200) people from the different institutions, including RDB, REMA, Akagera Hotel, and Residents of the areas as beneficiaries of the Akagera National Park outcome. The sample size was 134 staff and beneficiaries of the Akagera National Park who responded to the face-to-face and online surveys, using structured survey questionnaires, prepared under a Likert scale ranging from 1=Strongly Disagree (SD), 2=Disagree(D), 3=Neutral (N), 4=Agree(A), and 5=Strongly Agree (SA).

Table 1: Aggregated Population and Sample Size

Respondents	Population	Sample Size
Staff from RDB	25	*17*
Staff from REMA	30	*20*
Staff from Akagera Hotel	25	*17*
KAYONZA District staff	*30*	***20***
Project Beneficiaries	*90*	***60***
Total	**200**	**134**

Source: *Researcher, 2024-2025.*

The quantitative method of analysis was applied to analyze the primary numerical data through both descriptive and inferential statistical analysis. The descriptive statistical analysis was performed by calculating the Mean and standard deviations (Std Dev.) of the respondents' views on each specific objective to ensure an easy understanding and decisions on the respondents' agreement or disagreement of the fact of how biodiversity spatial patterns contributed to Development of Ecotourism Outcomes in Akagera National Park, Rwanda. The following equidistant mean (μ), and standard deviation (Std) of $1.0 \leq \mu \leq 1.8$: Very low mean: the fact is not apparent. $1.9 \leq \mu \leq 2.6$: Low mean: the fact appears less. $2.7 \leq \mu \leq 3.4$: Neutrality. $3.5 \leq \mu \leq 4.2$: High mean: the fact appears more. $4.3 \leq \mu \leq 5.0$: Very high mean: Strong evidence of the existence of the fact. Std ≤ 0.5: homogeneity of responses and closeness to the mean, and Std >0.5: heterogeneity of responses & dispersion from the mean, was considered to interpret the Mean & standard deviations for decision making.

The inferential statistical analysis was applied to analyze the correlation, significance, and regression characteristics of the variables and the regression model of the study using an ANOVA Test, decided due to the normal distribution of data proven by a test of Normality. The multiple linear regression model of the form $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$ was elaborated to investigate how independent variables affect the dependent variable, with Y = Development of Ecotourism outcomes, X_1: Biodiversity Distribution, X_2: Habitat Quality, X_3: Wildlife Presence; X_4: Ecosystem Services, and β_0, to β_4: Coefficients of estimates, and ε = error term.

Ethically, confidentiality, consent, safety, integrity, truthfulness, plagiarism, and copying were applied by the researcher, to seek consent from all sources of data and the research process by requesting appointments and audience in written letters to collect data from the respondents, keeping the confidentiality of the source of information, and acknowledging the authors quoted in this study through citations and referencing to avoid plagiarism.

RESULTS

The descriptive Analysis was performed to study the characteristics of the study variables from the respondents' views and perceptions about the biodiversity spatial patterns' contribution and availability in the Ecotourism Project in Akagera National Park.

Response Rate

The response rate was determined from the targeted sample size and the current respondents who returned their questionnaires. The total targeted sample size was 134 people in different categories, and the total number of respondents who truly returned their questionnaires was 133, equivalent to 99.25% of the targeted sample size.

Table 2: Response Rate

Participants' category	Frequency	Response Rate (%)
Respondents to the questionnaires	133	99.25
Non-respondents	1	.75
Total	**134**	**100.00**

Source*: Field Data, 2024-2025.*

The researcher distributed questionnaires to 134 people, but only 133 people, equivalent to 99.25%, responded and returned the questionnaires. One (1) non-respondent was not available due to unavoidable circumstances. The researcher realized that the response rate of 99.25% was enough to continue the study, and 0.75% did not have a significant effect on the study results.

Biodiversity Distribution

Table 3: Respondents 'Views on Biodiversity Distribution

Biodiversity Distribution	N	Mean	Std
Akagera National Park is rich in various biodiversity Species that attract tourists.	133	4.16	0.73
Diverse habitats are available in Akagera National Park	133	4.20	0.72
There are beautiful Flora categories to attract tourism revenues in Akagera National Park.	133	2.53	1.06
Biodiversity is distributed in all corners of the park to attract tourists	133	4.47	0.54
Overall statistics	**133**	**3.93**	**0.72**

Source: Field Data, 2024/2025.

Table 3 confirmed that Akagera National Park is rich in various biodiversity species that attract tourists. The park contains diverse habitats, and biodiversity is distributed across all areas, as evidenced by high mean scores of 4.16, 4.20, and 4.47, with standard deviations between 0.54 and 0.73. This indicates some variation in respondents' views but a general agreement on biodiversity distribution. However, the presence of beautiful flora categories to attract tourism revenue was rated low, with a mean of 2.53 and a standard deviation of 1.06, showing greater variability in respondents' opinions. The overall results showed an aggregated high mean score of 3.93 and a standard deviation of 0.72, confirming that biodiversity is well distributed in Akagera National Park and contributes significantly to ecotourism development under RDB.

Habitat Quality

Table 4: Respondents 'Views on Habitat Quality

Habitat Quality	N	Mean	Std
Water bodies are forming a quality of habitat in the Akagera National Park to increase tourism events.	133	4.21	0.66
There was vegetation covering the Akagera National Park and creating a gallery of tourism	133	4.37	0.69
Soil contained healthy animals, attracting tourists to the park.	133	4.28	0.81
Akagera National Park's Habitat is quality and increases the revenues of the country.	133	4.26	0.62
Overall statistics	**133**	**4.28**	**0.69**

Source: Field data, 2024/2025.

Table 4 strongly confirms the presence of water bodies that enhance habitat quality in Akagera National Park, contributing to increased tourism activities. The park is covered with vegetation, creating a scenic environment for tourism, and its soil supports healthy wildlife, attracting more visitors. The habitat quality of Akagera National Park was found to significantly contribute to ecotourism development, with high to very high mean scores of 4.21, 4.37, 4.28, and 4.26. Standard deviations ranged from 0.62 to 0.81, indicating some variation in respondents' views but a consensus on habitat quality.

The overall results showed an aggregated very high mean score of 4.28 and a standard deviation of 0.69, confirming that habitat quality is well established in Akagera National Park. Respondents generally agreed that habitat quality plays a crucial role in the park's ecotourism development, supported by RDB and partner institutions.

Wildlife Presence

Table 5: Respondents 'Views on Wildlife Presence

Wildlife Presence	N	Mean	Std
Akagera National Park possesses native species, making it a competitive advantage in tourism events.	133	4.29	0.54
Due to its safety, invasive species from other countries are available in Akagera National Park	133	4.66	0.86
Endangered species are available in the Akagera National Park to attract tourists.	133	4.35	0.72
The park's wildlife is safe and protected against Human conflict.	133	2.01	1.08
Overall statistics	**133**	**3.83**	**0.80**

Source: Field data, 2024/2025.

Table 5 confirmed that Akagera National Park hosts native species, providing a competitive advantage for tourism. Due to its safety, invasive species from other countries are also present, along with endangered species that attract tourists. The strong agreement on wildlife presence was reflected in very high mean scores of 4.29, 4.66, and 4.35, with standard deviations ranging from 0.54 to 0.86, indicating some variability in respondents' views but overall support for the presence of wildlife.

However, the results indicated that wildlife safety and protection against human conflict were lacking, with a low mean score of 2.01. This suggests that wildlife is not adequately protected from human activities, as evidenced by a standard deviation of 1.08, showing diverse opinions among respondents. The overall findings presented an aggregated high mean score of 3.83 and a standard deviation of 0.80, confirming a generally positive perception that wildlife presence activities in Akagera National Park contribute to ecotourism development.

Ecotourism Services

Table 6: Respondents' views on Ecotourism Services

Ecotourism Services	N		Mean	Std
There is water springing in Akagera Park, making it attractive		133	2.54	0.99
Carbon is sequestered in the park to lessen the impact of park warming and help tourists stay healthy.		133	4.29	0.54
There is fresh air with quality, attracting tourism events		133	4.19	0.71
The park's ecotourism services are well-delivered and attract many tourists and increase revenues.		133	4.16	0.76
Overall statistics	**133**		**3.79**	**0.75**

Source: Field data, 2024/2025.

Table 6 confirms that carbon sequestration in Akagera National Park helps mitigate the warming effects and supports tourist health. The park also provides fresh air of high quality, attracting tourism activities, and offers well-delivered ecotourism services that increase revenue. These findings were supported by high mean scores of 4.29, 4.19, and 4.16, with standard deviations ranging from 0.54 to 0.76, indicating some variability in respondents' views but general agreement on the availability and effectiveness of ecotourism services. However, the results negated the presence of water springs in the park as a tourism attraction, with a low mean score of 2.54. This suggests that water springs are not a significant feature in Akagera National Park, as reflected by a standard deviation of 0.99, indicating diverse opinions among respondents. The overall findings presented an aggregated high mean score of 3.79 and a standard deviation of 0.75, confirming a general positive perception of ecotourism services as a key contributor to tourism development in the park.

Development of Ecotourism Outcomes

Table 7: Respondents' Views on Development of Ecotourism Outcomes.

Development of Ecotourism Outcomes	N	Mean	Std
Akagera National Park increases ecotourism revenues in Rwanda.	133	4.80	.45
The community and surrounding Residents benefit more from the outcomes of the Akagera National Park.	133	3.83	1.00
The number of Tourists is increasing due to the Park's Biodiversity attractions.	133	4.53	.50
Park's Ecotourism outcomes have been developed more quickly.	133	3.89	.98
Overall statistics	133	4.26	0.73

Source: Field Data, 2024/2025.

Table 7 strongly confirms that Akagera National Park significantly contributes to ecotourism revenue growth in Rwanda. The surrounding community benefits from the park's outcomes, and the increasing number of tourists is driven by the park's rich biodiversity attractions. These findings were supported by very high to high mean scores of 4.80, 3.83, 4.53, and 3.89, indicating strong agreement that ecotourism outcomes have improved in terms of revenue, community benefits, and park attractions. The overall results showed an aggregated very high mean score of 4.26, confirming a general positive perception among respondents that the development of ecotourism outcomes in Akagera National Park has been successfully achieved.

Correlation Analysis

Table 8: Pearson Correlation Analysis

Correlations		X_1	X_2	X_3	X_4	Y
Biodiversity Distribution (X_1)	Pearson Correlation	1	0.451**	0.371**	0.397**	**0.509****
	Sig. (2-tailed)		0.000	0.000	0.000	0.000
	N	133	133	133	133	133
Habitat Quality (X_2)	Pearson Correlation	0.451**	1	0.821**	.537**	**0.675****
	Sig. (2-tailed)	0.000		0.000	0.000	0.000
	N	133	133	133	133	133
Wildlife presence (X_3)	Pearson Correlation	0.371**	0.821**	1	0.644**	**0.572****
	Sig. (2-tailed)	0.000	0.000		0.000	0.000
	N	133	133	133	133	133
Ecotourism Services (X_4)	Pearson Correlation	0.397**	0.537**	0.644**	1	**0.749****
	Sig. (2-tailed)	0.000	0.000	0.000		0.000
	N	133	133	133	133	133
Development of Ecotourism Outcomes(Y)	Pearson Correlation	**0.509****	**0.675****	**0.572****	**0.749****	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	
	N	133	133	133	133	133

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

The researcher had the purpose of finding if there is a relationship between Biodiversity Distribution, Habitat Quality, Wildlife Presence, Ecotourism Services and Development of Ecotourism Outcomes in AKAGERA National Park where the statistical/numeric data allows the researcher to highlight the direct individual correlation between independent variables and the

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dependent variable as shown in table 8, above indicated that there was a moderate positive correlation Coefficient, R=0.509, between Biodiversity distribution and Development of Ecotourism Outcomes. A moderate positive correlation, R=0.675, between Habitat Quality and Development of Ecotourism Outcomes. A moderate positive Correlation Coefficient, R=0.572, between Wildlife Presence and Development of Ecotourism Outcomes, and a Strong positive correlation Coefficient, R=0.749, between ecotourism Services and Development of Ecotourism Outcomes. The individual Pearson correlation coefficients (R) explain the correlation between independent (X) and dependent (Y) variables. The correlation coefficients vary between -1 and +1, with R=-1 (Negative correlation), R=0 (Zero correlation), and R=+1 (Positive correlation).

Regression Analysis

A multiple regression analysis was performed to identify how the predictors (independent variables) contributed to the dependent variable. It aimed to determine the prediction of a single dependent variable from a group of independent variables, using regression coefficients and significance levels.

Table 9: Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.844	0.712	0.703	0.931

a. Predictors: (Constant), Biodiversity Distribution, Habitat Quality, Wildlife Presence, Ecotourism Services.

Table 9 indicated an overall multiple correlation coefficient R = 0.844, explaining that there was a strong positive correlation between the independent and dependent variables in the model. The values, R2 and Adjusted R2 (coefficients of multiple determination) were also presented to describe the goodness of fit or the amount of variance explained by a given set of predictor variables in the study. The R2= 0.712 or 71.2%, showed that there was a good fitness of the model to the data(R2>50%), meaning that all independent variables of this study contributed 71.2% in the Development of Ecotourism Outcomes, hence 28.8% was accounted for, by other factors that contributed to the Development of Ecotourism Outcomes. The Adjusted R2 =0.703 or 70.3%, showed that by keeping other factors constant, a 70.3% change in the Development of Ecotourism Outcomes could be explained by the effectiveness of Biodiversity spatial patterns considered in this study.

Table 10: Analysis of Variance (ANOVA)

ANOVAᵃ						
Model		Sum of Squares	Df	Mean Square	F	p-value Sig.
1	Regression	274.480	4	68.620	79.146	0.000
	Residual	110.963	128	0.867		
	Total	385.443	132			

a. Dependent Variable: Development of Ecotourism Outcomes.
b. Predictors: (Constant), Biodiversity Distribution, Habitat Quality, Wildlife Presence, and Ecotourism Services

Table 10 indicated that the F-statistic calculated at a 5% significance level was 79.146 and the Mean square (F_critical) value of 68.620, with a significance(sig.) value of 0.000. Since sig. (p-value) =0.000≤0.05, confirmed by F-statistic =79.146 ≥ 68.620 (Mean Square), which justified that the model was statistically significant and that the model fits the predicted study variables.

Table 11: Regression coefficients
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	p-value
1	(Constant)	0.192	0.188		-1.021	0.310
	Biodiversity Distribution	0.162	0.063	0.140	2.571	0.012
	Habitat Quality	0.571	0.090	0.551	6.344	.000
	Wildlife presence	0.340	0.098	0.321	3.469	.001
	Ecotourism Services	0.583	0.061	0.605	9.557	.000

a. Dependent Variable: Development of Ecotourism Outcomes

Table 11 gave the unstandardized Coefficients (B), from which the multiple linear regression model of the form $Y=-0.192+0.162X_1 + 0.571X_2 + 0.340X_3 + 0.583X_4+\varepsilon$, was developed, with Y= Development of Ecotourism Outcomes and X1 to X4 representing respectively the independent variables of the study.

The coefficient of estimates B=0.162 for Biodiversity Distribution, B=0.571 for Habitat Quality, B=0.340 for Wildlife Presence, B=0.583 for Ecotourism Services, and Constant α=-0.192. These coefficients of estimates mean that when all independent variables are fixed to zero, the value of Y is constant and equals -0.192. Increasing biodiversity distribution by one unit generates an increase of 0.162 in the Development of Ecotourism Outcomes; Increasing Habitat Quality by one unit generates an increase of 0.571 in the Development of Ecotourism Outcomes; Increasing Wildlife Presence by one unit generates an increase of 0.340 in the Development of Ecotourism Outcomes, and Increasing Ecotourism Services by one unit generates an increase of 0.583 in the Development of Ecotourism Outcomes.

Table 12: Hypothesis Testing Results

Research Hypotheses	Beta	t	p-value	Decision
Ho1: There is no significant effect of Biodiversity Distribution on the Development of Ecotourism Outcomes.	.140	2.571	0.012	Ho1, rejected p-value≤0.05
Ho2: There is no significant effect of Habitat Quality on the Development of Ecotourism Outcomes.	.551	6.344	0.000	Ho2, rejected p-value≤0.05
Ho3: There is no significant effect of Wildlife Presence on the Development of Ecotourism Outcomes.	.321	3.469	0.001	Ho3, rejected p-value≤0.05
Ho4: There is no significant effect of Ecotourism Services on the development of Ecotourism Outcomes.	.605	9.557	0.000	Ho4, rejected p-value≤0.05

The null hypothesis one (Ho1), was rejected, since p-value=0.012≤0.05, with β1=0.140, and t=2.571, leading the researcher to confirm that there is a significant effect of Biodiversity Distribution on the development of Ecotourism Outcomes; hence, Biodiversity Distribution kept the fourth position in contribution to the development of ecotourism outcomes since β1 = 0.140, and t=2.571.

The second null hypothesis (Ho2) was rejected since p-value=0.000 ≤0.05, with β2=0.551, and t=6.344, leading the researcher to confirm that there is a significant effect of Habitat Quality on the development of Ecotourism Outcomes. Hence, Habitat Quality kept the second position in contribution to the development of ecotourism outcomes since β2 = 0.551, and t=6.344.

The third null hypothesis (Ho3) was rejected since p-value=0.001≤0.05, with β3=0.321, and t=3.469, leading the researcher to confirm that there is a significant effect of Wildlife Presence on the

Development of Ecotourism Outcomes. Hence, Habitat Quality kept third position in contribution to the development of ecotourism outcomes since β3=0.321, and t=3.469.

The fourth null hypothesis (Ho4) was rejected, since the p-value=0.000≤0.05, with β4=0.605, and t=9.557, leading the researcher to confirm that there is a significant effect of Ecotourism Services on the Development of Ecotourism Outcomes. Hence, Ecotourism services kept the first position in contribution to the development of ecotourism outcomes since β4 = 0.605, and t = 9.557.4.6.

DISCUSSION

The first objective of this study was to assess the effect of biodiversity distribution on the development of ecotourism outcomes in Akagera National Park, Rwanda. The findings from Table 3, showed that biodiversity was well distributed across the park. Proper biodiversity distribution plays a vital role in maintaining ecosystem balance, enhancing ecosystem resilience, and supporting habitat health. From an ecological perspective, it contributes to improved ecosystem functioning, balanced predator-prey dynamics, and overall environmental stability. For humans, well-distributed biodiversity fosters increased tourism and recreation, provides educational and research opportunities, and enhances ecosystem services, ultimately improving human well-being. These findings align with (Umuziranenge & Muhurwa, 2017), who emphasized the economic significance of biodiversity in sustainable tourism, particularly in Rwanda's Nyungwe National Park, where ecotourism earnings accounted for 40% of the park's revenue. This reinforces the importance of biodiversity distribution in promoting conservation and sustainable ecotourism strategies.

The second objective of this study was to assess the effect of habitat quality on the development of ecotourism outcomes in Akagera National Park. The findings from Table 4, confirmed that habitat quality was well maintained in the park, significantly contributing to ecotourism outcomes. High-quality habitats provide essential resources such as food, water, and shelter for wildlife, ensuring biodiversity support and species survival. Ecologically, habitat quality fosters ecosystem stability, balanced predator-prey relationships, efficient nutrient cycling, and resilience to disturbances. Additionally, ecological connectivity within the park allows species to move freely, promoting genetic diversity and enhancing their long-term survival. (Halls, 1997) similarly found that biodiversity hotspots in vulnerable ecosystems, such as wetlands, attract significant numbers of tourists, highlighting the link between habitat quality, conservation, and ecotourism demand. These findings further emphasize that maintaining habitat quality is essential for sustaining ecotourism and promoting long-term conservation efforts.

The third objective of this study assessed the effect of wildlife presence on the development of ecotourism outcomes in Akagera National Park. The findings from Table 5, confirmed that wildlife presence activities were correctly managed, demonstrating the park's commitment to conservation. Wildlife presence enhances ecological balance by maintaining a functional ecosystem with interconnected food webs, ultimately supporting biodiversity. It also has significant socio-economic benefits, as wildlife-related tourism attracts visitors, generating revenue and conservation funding. However, the study also highlighted challenges related to human-wildlife conflict, emphasizing the need for effective management strategies to mitigate risks and ensure coexistence. Ouko & Kamau (2020) found that 68% of surveyed tourists were willing to pay an additional 10% of admission fees to support biodiversity conservation, illustrating a strong economic incentive for maintaining wildlife presence. Moreover, (Obradović, Stojanović, & Milić, 2023) emphasized that sharing conservation benefits with local communities can foster positive attitudes toward wildlife protection and conservation initiatives, further strengthening ecotourism outcomes.

The fourth objective examined the effect of ecotourism services on developing ecotourism outcomes in Akagera National Park. The findings

from Table 6 indicated that ecotourism services in the park significantly contribute to attracting tourists and generating revenue. Ecotourism services provide multiple benefits, including conservation funding, economic opportunities for local communities, and increased environmental education and awareness. Sustainable tourism initiatives promote conservation incentives and encourage responsible tourist behaviour, ultimately benefiting both the environment and local economies. Biodiversity-related businesses in Akagera National Park, such as accommodations, car rentals, and guided tours, not only provide income but also reduce poaching and promote biodiversity conservation (Turamwishimiye, 2015). These findings reinforce the notion that ecotourism services play a critical role in ensuring long-term park sustainability and enhancing conservation efforts.

Overall, the study findings underscore the interconnectedness between biodiversity distribution, habitat quality, wildlife presence, and ecotourism services in contributing to the development of ecotourism outcomes in Akagera National Park. The increasing number of tourists due to the park's rich biodiversity, well-maintained habitats, and diverse wildlife highlights the park's significance in Rwanda's ecotourism sector. However, addressing challenges such as human-wildlife conflict and ensuring equitable conservation benefits remain crucial for sustaining ecotourism. By integrating conservation policies, community engagement, and ecotourism development, Akagera National Park can continue to serve as a model for sustainable tourism and biodiversity conservation.

CONCLUSION

The researcher was interested in assessing the effect of Biodiversity spatial patterns on the Development of Ecotourism Outcomes in Akagera National Park, Rwanda, focusing on the effect of Biodiversity Distribution, Habitat Quality, Wildlife Presence, and Ecotourism Services on the Development of Ecotourism Outcomes. All the specific objectives were achieved, and the researcher generally concludes

that all Biodiversity spatial patterns studied in this study had a significant effect on the development of ecotourism outcomes in terms of revenues, community benefits, and tourism attractions in the Akagera National Park, Rwanda.

The researcher concluded that Biodiversity Distribution in terms of species richness, habitat diversity, and flora categories had a moderate positive correlation and significant effect on the Development of Ecotourism Outcomes in Akagera National Park, Rwanda. The overall results showed a positive view of Biodiversity Distribution in the fact that biodiversity was well distributed in Akagera National Park, and left a gap in that there were no beautiful Flora categories to attract tourism revenues in Akagera National Park. This gap was not negligible and could have a big impact on tourist attractions, which ultimately affects the development of ecotourism outcomes. These results are supported by (Udahogora, 2024) who argued that natural and human influences impacted spatial patterns of biodiversity in Rwanda's Nyungwe National Park, with ecotourism earnings accounting for 40% of the park's overall income, highlighting the economic value of biodiversity in sustainable tourism and demonstrating the value of spatial biodiversity studies in influencing conservation and tourist policies.

The study thus concluded and signified that the Habitat Quality in terms of water bodies, vegetation cover, and soil health had a moderate positive correlation and significant effect on the Development of Ecotourism Outcomes in Akagera National Park, Rwanda. The overall results indicated a general positive response that there was a lot of Habitat quality in Akagera National Park, attracting tourists and contributing more to the development of ecotourism outcomes. The researcher learned that Habitat Quality is the key in ecotourism projects to attract revenues and translate plans into tangible outcomes. The results are supported by (Alikhani, Nummi, & Ojala, 2021) who discovered that 65% of biodiversity hotspots were in ecologically vulnerable regions like wetlands, the regions attracting 70% of park visitors, demonstrating an effective link between

biodiversity richness and ecotourism demand where emphasize was on the importance of spatial mapping and the maintenance of biodiversity hotspots as habitat quality in promoting sustainable tourism and ecosystem preservation.

The study concluded that wildlife presence in terms of native, invasive, and endangered species had a moderate positive correlation and significant effect on the Development of Ecotourism Outcomes in Akagera National Park, Rwanda. The overall results showed a positive view of Wildlife Presence activities practised in Akagera National Park and left a gap of failure to manage wild animals and human conflict by protecting the park to prevent wild animals from penetrating the prone zone homes. This gap is a very serious issue that can cause conflict and loss of health to the residents of the prone areas. The results are also supported by (Steven, 2021), who indicated various effects of the human and wildlife conflicts on wildlife conservation in the Akagera National Park. Current information dissemination, high costs charged to tourists, and a lack of skilled staff are the challenges affecting the humans of conflicts in conservation. Sharing conservation-related benefits and involving local people in decision-making for resource management can increase the positive attitudes of local people towards wildlife, protected areas, and conservation practices.

The researcher concluded and signified that Ecotourism Services in terms of water springs, Carbon sequestration, air quality, park guiding, etc, had a strong positive correlation and a significant effect on the Development of Ecotourism Outcomes in Akagera National Park, Rwanda.

The overall results indicated a general positive respondents' view of Ecotourism services available in Akagera National Park, attracting tourists to contribute to the development of Ecotourism Outcomes, but leaving a gap due to a lack of water springs in the Akagera Park to make it more attractive. This gap remained a serious issue to handle as water springs in the park form a

pattern attracting ecotourism events as well as revenues.

The results are supported by (Richard & Singh, 2020), who revealed that all biodiversity businesses conducted at Akagera National Park depend on the biodiversity environment and insisted that various biodiversity products provide employment and income generation through car rentals, accommodation, reservations, camping sites, and tour guiding and the community around the park benefits from the support and sensitization offered by the private entrepreneurs and responds to the mutual relationship between business and conservation by promoting the value of conservation through decreased incidences of poaching.

RECOMMENDATIONS

Paving on the findings of this study, the researcher has recommended that the Rwanda Development Board (RDB) and Partner institutions in Ecotourism projects should plan and include beautiful Flora categories to attract tourism revenues and bridge the gap found in Akagera National Park. RDB and its partner institutions should encourage tourism in Akagera National Park to attract more revenues, as there is a lot of Habitat quality in place. RDB, Park guides, and their partner institutions should manage wild animals and human conflict by protecting the park through fencing activities to prevent wild animals from penetrating prone zone homes and provide safety and security to the surrounding areas. The government of Rwanda, MoE, REMA and RDB to create water bodies and increase the biodiversity patterns in the Akagera National Park to make it more attractive. Academicians, students, and future Researchers to use this study's findings to explore how Ecotourism outcomes have contributed to the development of Tourism in Rwanda. The researcher didn't work on the points that the researcher didn't work on due to timeline and budget constraints, so, she recommended future research on the study of factors other than Biodiversity distribution, Habitat Quality, Wildlife presence and Ecotourism Services, which contributed 28.8% in

the development of Ecotourism outcomes of Akagera National Park, Rwanda, Effect of human-wildlife conflict on performance of tourism projects in National parks of Rwanda, case of Akagera National Park, and Challenges to sustainable tourism and ecosystem in Rwandan National Parks.

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