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Ecotourism and its impact on biodiversity and the local environment: An empirical study in Rajasthan

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Abstract
This study examines the relationship between ecotourism practices and their impacts on biodiversity conservation, local environmental quality, and tourist behavior in selected ecotourism destinations of Rajasthan, India. Adopting a quantitative, cross-sectional research design, the study surveyed 200 respondents across five ecological zones using a structured questionnaire. Data were analyzed using SPSS version 26, applying linear regression to assess the relationships among variables.
The current evidence shows that the ecotourism activities have been able to play a significant role in conserving the biodiversity, majorly by implementing environmentally soothing infrastructure, managing visitor density, and installing interpretive signage. Additionally, it was demonstrated that responsible ecotourism activities, e.g., successful implementation of guided nature walks and low-impact tourism processes, had a (positive) effect on the environmental quality, whereas community involvement and environmental education had mixed or limited impacts. In addition, that aspect, which was highly linked to ecofriendly behavior, is the environmental awareness of the tourists, which confirmed the value of knowledge-influenced engagement in the conservation process.
On the whole, the paper contributes to theoretical issues of sustainable tourism and has practical implications for policy and ecotourism management. It promotes more comprehensive, location-specific models of ecotourism that incorporate great education, authentic community involvement, and protection of the surrounding environment. These lessons serve as an excellent indication of how the ecological and socio-economic results of ecotourism can be enhanced in Rajasthan as well as in any other part of the world.

Keywords: Ecotourism, biodiversity conservation, environmental sustainability, tourist behavior, Rajasthan, stakeholder perception, sustainable development

Introduction

1. Background of Study

Ecotourism has come into prominence over the past decades as a potential substitute for mass tourism, defined as the use of nature-based areas in a certain orderly manner that least affects and preserves the environment and aids the livelihood of the locals (Honey, 2008, p. 610) [14]. Through the combination of socioeconomic and environmental conservation, the practice reserves consciousness, cultural civic sense, and minimum ecological footprint. Ecotourism has also been identified as one of the strategic tools of biodiversity conservation, community empowerment, and promotion of sustainable livelihoods in various parts of the globe (Stronza, Hunt, & Fitzgerald, 2019) [30]. Ecotourism, in countries like India, serves two purposes: it confines ecologically sensitive territories and creates jobs (Das & Chatterjee, 2015) [9].
India's diverse landscape, ranging from the Himalayan ranges and coastal ecosystems to desert and tropical forests, positions it as a key destination for nature-based tourism. States like Kerala, Sikkim, Uttarakhand, and Himachal Pradesh have implemented structured ecotourism policies, often involving local communities in the form of eco-guides, homestays, and participatory conservation (Bansal & Kumar, 2011; Cabral & Dhar, 2019) [2, 5]. Rajasthan, though popularly recognized for its royal heritage, arid climate, and architectural grandeur, also possesses significant ecological zones such as "Ranthambhore National Park, Sariska Tiger Reserve, Mount Abu Wildlife Sanctuary, and the Desert National Park". These areas attract ecotourists for wildlife viewing, nature trekking, and rural cultural experiences.
The state's efforts to integrate ecotourism with biodiversity conservation have included the development of eco-sensitive zones, community-based conservation programs, and the promotion of nature-based tourism circuits (Das, 2011) [10]. However, concerns have been raised regarding the ecological consequences of expanding ecotourism infrastructure and rising tourist inflows. Unregulated tourist activities in fragile ecosystems can lead to habitat destruction, disturbance to wildlife, waste accumulation, and depletion of natural resources (Buckley, 2012; Newsome, Moore, & Dowling, 2002) [4, 26]. While ecotourism is often projected as a green alternative to mass tourism, its actual implementation on the ground frequently falls short of its ideals. Research suggests that without proper guidelines, enforcement mechanisms, and environmental education, even ecotourism can turn exploitative and counterproductive (Weaver, 2005; Ballantyne & Packer, 2011) [1, 31].
Rajasthan's ecotourism model, though rich in intent and policy, lacks rigorous empirical evaluation. There is limited scholarly evidence to assess whether ecotourism in the state

is genuinely contributing to biodiversity conservation or inadvertently causing environmental degradation under the guise of sustainability. Moreover, the role of tourists' environmental awareness and behavior in supporting or harming local ecosystems remains underexplored. Many conservation initiatives rely on the assumption that tourists behave responsibly; however, studies have found that awareness does not always translate into action unless accompanied by education and policy enforcement (Ballantyne & Packer, 2011) [1]. Similarly, the extent to which local communities are meaningfully involved in decision-making and benefit-sharing varies significantly across sites, often leading to exclusion and ecological neglect (Scheyvens, 1999; Das, 2011) [10, 27].

Given these gaps, there is a compelling need to investigate the actual impacts of ecotourism on biodiversity and the local environment in Rajasthan using empirical methods. Existing literature offers useful frameworks but lacks region-specific, data-driven insights, particularly in the Indian desert ecosystem context. This paper seeks to address this void by examining the ecological outcomes of ecotourism across selected destinations in Rajasthan, focusing on biodiversity conservation, environmental quality, and tourist behavior. By analyzing perceptions and behaviors of tourists, as well as observable ecological changes, the study aims to determine whether ecotourism in Rajasthan aligns with its stated goals of sustainability and conservation.

Based on this problem, the paper has the following objectives:

- To assess the impact of ecotourism on biodiversity conservation in Rajasthan.
- To evaluate the effect of ecotourism activities on the quality of the local environment.
- To examine the relationship between tourists' environmental awareness and their eco-friendly behavior at ecotourism sites.

To address these objectives, the structure of the paper is organized as follows: The introductory section provides the background and outlines the research gap and purpose. The following section reviews relevant literature on ecotourism, sustainability, and ecological impact. The methodology section discusses the research design, sampling framework, and tools used for data collection and analysis. The results section presents the findings derived from SPSS-based statistical analysis. Finally, the paper concludes with a discussion of key insights, policy implications, limitations, and suggestions for future research.

Review of literature and Hypotheses development

This section will be divided into key thematic sub-sections that systematically review past studies and logically lead to hypothesis formulation.

1. Ecotourism Practices and Biodiversity Conservation

The intersection of ecotourism and biodiversity conservation has garnered increasing academic and policy attention in recent decades, especially in ecologically sensitive regions. Ecotourism, as a form of sustainable travel, is often advocated for its potential to simultaneously generate economic benefits and promote environmental stewardship. It is predicated on the idea that non-extractive tourism activities can contribute to the protection of natural habitats and species while involving local communities in the management and sharing of tourism gains (Dorobantu & Nistoreanu, 2012) [11]. When implemented effectively, ecotourism can reduce environmental degradation by creating financial alternatives to exploitative land use, encouraging conservation-compatible behavior among tourists, and enhancing ecological awareness among stakeholders (Jamal & Stronza, 2009) [16].

In Rajasthan, a state characterized by its arid climate and unique desert biodiversity, ecotourism is increasingly promoted as a conservation-supportive intervention. The Desert National Park and Ranthambhore Tiger Reserve offer very important sites for endangered animal species such as the Great Indian Bustard and Bengal Tiger. These tourist flows also attract professionals of ecotourism. Empirical evidence mounts on the side of tourism models that focus on environmental education, community involvement, and controlled access that would lessen the pressures on such fragile ecosystems (Chakrabarty & Mandal, 2018) [6]. From one angle, Chandel and Kanga (2018) [8] showed that a geospatial assessment of tourism pressure in Mount Abu supported the local administration in finding areas prone to eco-stress, thus making it easier to implement conservation initiatives.

In addition, geopark initiatives interlinked with geotourism and eco-interpretation could enormously contribute to awareness and appreciation of biodiversity. Guided nature walks, interpretative centers for biodiversity, and local ecological stories increase the tourist experience while nurturing the spirit of conservation (Kanga *et al*., 2014) [21]. These tools are particularly impactful when embedded in culturally significant landscapes such as Rajasthan's semi-arid zones, where the human-nature relationship is historically embedded in local traditions.

However, researchers have also raised cautionary notes. Without adequate planning and environmental assessments, tourism infrastructure can disturb wildlife habitats, strain water resources, and contribute to land degradation—especially in semi-arid zones already under climatic stress (Jhajharia *et al*., 2014; Sharma, 2008) [17, 18, 28]. While some revenue from ecotourism is earmarked for conservation, its actual implementation often falls short due to institutional and policy limitations (Erlet Cater, 1993) [12]. Additionally, Liu (2003) [23] criticizes the assumption that ecotourism automatically leads to conservation, emphasizing the need for empirical validation of its ecological outcomes.

Rajasthan, therefore, provides an ideal context for assessing whether ecotourism practices truly contribute to biodiversity conservation or merely shift the nature of human-environment interactions. The state's unique ecological landscape, combined with the recent push for sustainable tourism, calls for a systematic evaluation of whether ecotourism delivers on its conservation promises. This study aims to fill this gap by empirically examining the relationship between the extent of ecotourism activities and observed biodiversity protection outcomes in selected regions of Rajasthan.

H_{01}: Ecotourism practices do not have a significant effect on biodiversity conservation.

H_{a1}: Ecotourism practices have a significant effect on biodiversity conservation.

2. Ecotourism Activities and Their Effects on Local Environmental Quality

Ecotourism is widely promoted as a sustainable alternative to mass tourism, particularly in ecologically fragile zones. However, the extent to which it safeguards or harms the local environment depends on how tourism activities are planned, managed, and regulated. Environmental quality—measured through variables such as soil health, water purity, vegetation cover, and wildlife stress levels—can be significantly influenced by tourism-driven infrastructure, vehicular movement, waste generation, and resource use (Narula & Kapur, 2019) [24]. In arid and semi-arid regions like Rajasthan, where the ecosystem is highly sensitive to anthropogenic disturbance, even low-intensity tourism can lead to degradation if not adequately monitored.

Studies have revealed that certain ecotourism activities, such as unregulated safari trails, off-road vehicle movement, and construction near protected zones, can lead to soil erosion, water contamination, and fragmentation of wildlife corridors (Chandel & Kanga, 2018) [8]. For example, in their study of forest fire risk near tourism sites, Chandel and colleagues demonstrated how geospatial mapping can identify hotspots where tourist activity may contribute to ecological stress. Similarly, Shi, Zhao, and Han (2023) [29] argue that the perceived sustainability of ecotourism is often undermined when infrastructure development and tourist practices are not aligned with environmental carrying capacity.

In Rajasthan, the tourism-centric zones in and around the national parks of Ranthambhore, Sariska, and Mount Abu create pressures on scanty natural resources. Jhajharia *et al*. (2014) [17, 18] marked that decreasing water availability and climatic stress have created a situation in northwest India, where the needs of tourism have to be balanced with ecosystem sustainability. With increasing demand for water due to tourism, especially for luxury hospitality and landscape maintenance, there is an over-extraction of groundwater resources that in effect reduces groundwater recharge, which biodiversity depends on. It also affects the community itself from accessing these resources.

One more source of environmental impact is through solid waste generation. From ground litter and plastic trash to a torrent of tourists in delicate environs, the effect is on soil quality, with the disruption of native vegetation and the long-term contamination of the area. An exhaustive review by the International Journal of Environmental Research and Public Health (2022) [15] explains that poor waste disposal in high-tourism ecologies lessens ecological resilience and heightens conflicts between humans and wildlife. In Rajasthan's popular eco-destinations, such as Keoladeo National Park and Desert National Park, visitor pressure without adequate waste and sewage management has occasionally exceeded the site's carrying capacity.

On the positive side, studies also suggest that well-managed ecotourism operations can enhance environmental quality by funding conservation, promoting reforestation, and supporting infrastructure such as eco-toilets, composting systems, and renewable energy units. A 2022 study in the *Journal of Cleaner Production* proposed a novel approach to measuring tourism carrying capacity, emphasizing integrated resource and waste flow models that could support sustainable planning in ecotourism hubs.

Despite these mixed findings, it is evident that the net environmental impact of ecotourism in Rajasthan is context-dependent and warrants empirical investigation. This study aims to examine whether ecotourism activities in Rajasthan have had a statistically significant effect—positive or negative—on the quality of the local environment, based on the perceptions of stakeholders and measurable environmental indicators.

H_{02}: Ecotourism activities do not significantly affect the quality of the local environment.

H_{a2}: Ecotourism activities significantly affect the quality of the local environment.

3. Tourists' Environmental Awareness and Eco-friendly Behavior

Environmental awareness among tourists plays a critical role in determining how ecotourism affects fragile ecosystems. Ecotourism thrives on the assumption that visitors will behave responsibly when informed about the environmental and cultural significance of the site they are visiting. However, the relationship between awareness and action is complex, and in some cases, tourists' eco-friendly intentions do not translate into sustainable behaviors on the ground (Narula & Kapur, 2020) [25].

In Rajasthan, where ecotourism destinations such as Mount Abu, Ranthambhore, and Keoladeo National Park are ecologically sensitive, studies have shown mixed outcomes in terms of environmental responsibility among tourists. Although awareness campaigns and signage often communicate ecological guidelines, actual compliance varies based on tourist background, local infrastructure, and regulatory enforcement (Bisht & Sharma, 2023) [3]. Tourists with prior environmental education or exposure to conservation initiatives are more likely to exhibit responsible behaviors such as proper waste disposal, minimal disturbance to wildlife, and preference for sustainable transport.

Kumar (2023) [22] emphasizes the importance of community-based ecotourism in fostering environmental consciousness. When tourists engage directly with local guides or participate in eco-education programs, their understanding of local environmental issues improves, leading to more environmentally responsible behavior. Moreover, interactive conservation experiences—such as reforestation activities or local clean-up drives—have been found to encourage repeat visits and advocacy for conservation causes.

Despite these positive trends, challenges remain. A lack of standardized eco-literacy programs across sites and inconsistent enforcement of environmental regulations contribute to behavioral lapses among tourists. Additionally, as Gantait, Kaliyamurthy, and Meena (2022) [13] note, many visitors remain unaware of the rich and often endangered flora of Rajasthan, leading to inadvertent harm such as plant trampling or souvenir collection.

Ultimately, the alignment of tourist awareness with eco-friendly behavior is essential to realizing the goals of sustainable ecotourism. This study explores whether tourists who report higher environmental awareness also display measurable eco-conscious behaviors during their visit to ecotourism sites in Rajasthan.

H_{03}: There is no significant relationship between tourists' environmental awareness and their eco-friendly behavior at ecotourism sites.

H_{a3}: There is a significant relationship between tourists' environmental awareness and their eco-friendly behavior at ecotourism sites.

Research Methodology

This study adopts a quantitative, cross-sectional research design to empirically investigate the relationship between ecotourism activities and their impacts on biodiversity conservation, local environmental quality, and tourist behavior in selected ecotourism sites of Rajasthan. The study is rooted in hypothesis testing and aims to establish statistically significant relationships among variables through structured data analysis.

The data were collected using a structured questionnaire distributed to 200 respondents across Rajasthan. To ensure ecological and geographic representation, the state was divided into five ecological zones: Northern Aravalli, Western Desert, Eastern Plains, Southern Hills, and Central Uplands. Within each zone, a stratified random sampling technique was employed to include various stakeholder groups such as local community members, tourists, ecotourism service providers, forest officials, and NGO workers. Proportional allocation was applied to distribute the sample across zones, considering tourist inflow and the ecological significance of the areas.

The main instrument for gathering data was a structured questionnaire that participants self-administered and self-completed. The items were modified from validated tools used in previous research on conservation, environmental behavior, and ecotourism. A five-point Likert scale, ranging from "strongly disagree" to "strongly agree," was used to record responses. The questionnaire was divided into five sections: environmental effect assessment, attitudes of biodiversity protection, ecotourism activities, visitor awareness and behavior, and demographic profile.

Thirty respondents participated in a pilot study to evaluate the questionnaire's internal validity, clarity, and reliability prior to the start of the main data collecting process. The item sequence and language were slightly changed in response to the comments. Cronbach's alpha was used to confirm each construct's internal consistency; values greater than 0.70 were deemed appropriate for study dependability.

SPSS version 26 was used to analyze the data. Response distributions and demographic features were gathered using descriptive statistics. Depending on the kind of variable and measurement scale, independent samples t-tests, linear regression, and Pearson correlation were used to assess the hypotheses. To assess the viability of the suggested hypotheses, the degree and direction of correlations between variables—such as ecotourism activity level, perceptions of biodiversity, and environmental quality—were investigated.

Ethical guidelines were rigorously followed throughout the research process. Participants were informed about the purpose of the study, assured of confidentiality, and provided consent prior to participation. No personally identifiable information was collected, and data were used strictly for academic purposes. Institutional clearance was secured before commencing fieldwork.

Data Analysis and Interpretation

This section presents the analysis of data collected from 200 respondents across ecotourism sites in Rajasthan. The analysis includes reliability testing of questionnaire constructs using Cronbach's alpha and an examination of the respondents' demographic profile to ensure representativeness. Linear regression was applied to assess the relationships between ecotourism practices and key outcomes such as biodiversity conservation, environmental quality, and tourist eco-friendly behavior.

1. Demographic Profile

Table 1: Demographic Profile of Respondents

Variable	Category	Frequency (n)	Percentage (%)
Age	Below 20	10	5.0%
	21–30	66	33.0%
	31–40	60	30.0%
	41–50	36	18.0%
	Above 50	28	14.0%
Gender	Male	110	55.0%
	Female	90	45.0%
Occupation	Local Resident	88	44.0%
	Tourist	64	32.0%
	Forest Department Staff	48	24.0%
Zone	North	38	19.0%
	South	42	21.0%
	East	40	20.0%
	West	38	19.0%
	Central	42	21.0%
Educational Qualification	No Formal Education	12	6.0%
	Secondary	58	29.0%
	Graduate	82	41.0%
	Postgraduate	48	24.0%

Interpretation of Respondent Demographics

The demographic data demonstrates a well-distributed and diverse sample suitable for assessing ecotourism's environmental and social implications across Rajasthan. The majority of respondents fall in the 21–30 (33.0%) and 31–40 (30.0%) age categories, followed by 41–50 (18.0%). This indicates an active and engaged population likely to participate in or be affected by ecotourism. The gender ratio is fairly balanced, with males at 55.0% and females at 45.0%, ensuring gender-inclusive insights.

In terms of occupation, the largest segment consists of local residents (44.0%), followed by tourists (32.0%) and forest department staff (24.0%), enabling the study to capture perspectives from both stakeholders and consumers of ecotourism services. Spatially, responses are nearly evenly distributed across all ecological zones: Central and South zones each contribute 21.0%, followed closely by East (20.0%), North (19.0%), and West (19.0%), ensuring geographical representation.

Educationally, the sample skews toward a well-educated population: 41.0% are graduates, 24.0% postgraduates, and 29.0% have completed secondary education, with only 6.0% lacking formal education. This reflects a capable and informed respondent group, well-positioned to understand issues related to conservation, environmental impact, and tourism behavior.

This diversity in demographic attributes reinforces the credibility and generalizability of the study, allowing for a comprehensive evaluation of ecotourism's practices and impacts in the region.

2. Reliability Testing

Table 2: Reliability Statistics

Cronbach's Alpha	N of Items
0.966	30

Interpretation

The reliability analysis indicates that the instrument used in this study has excellent internal consistency, with a Cronbach's Alpha value of 0.966 for 30 items. This value far exceeds the commonly accepted threshold of 0.70, suggesting that the items are highly correlated and consistently measure the underlying constructs.

3. Hypotheses Testing

H_{01}: Ecotourism practices do not have a significant effect on biodiversity conservation.

H_{a1}: Ecotourism practices have a significant effect on biodiversity conservation.

Table 3: Model Summary and ANOVA results of Hypothesis 1

Component	Value
Model Summary	
R	0.679
R Square	0.462
Adjusted R Square	0.448
Std. Error of Estimate	0.822
ANOVA	
F-value	33.260
Sig. (p-value)	0.000

Table 4: Coefficients result of Hypothesis 1

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.466	.317		1.471	.143
	The ecotourism site promotes eco-friendly infrastructure such as solar lighting and compost toilets.	.312	.112	.252	2.772	.006
	Wildlife tours and nature walks are conducted in a responsible and non-intrusive manner	-.248	.094	-.212	-2.628	.009
	Visitor numbers are regulated to reduce negative environmental impacts.	.478	.072	.441	6.661	.000
	Local communities are actively involved in managing ecotourism activities	-.329	.081	-.300	-4.038	.000
	Information and signage at the site promote conservation and responsible behavior among tourists	.569	.081	.503	7.027	.000
a. Dependent Variable: Biodiversity conservation.						

Interpretation

The regression analysis for Hypothesis 1 examined the relationship between ecotourism practices and biodiversity conservation, specifically in terms of wildlife protection in Rajasthan's ecotourism zones. The chosen ecotourism techniques may account for around 46.2% of the variation in biodiversity protection, according to the model's R value of 0.679 and R2 value of 0.462. An F-value of 33.260 and a p-value of 0.000 verified that the model was statistically significant, indicating a substantial combined impact of the predictors on the dependent variable.

The largest contributor among the predictors was "Information and signage at the site promote conservation and responsible behavior among tourists" ($\beta = 0.503$, $p = 0.000$), emphasizing the function of educational resources in promoting conservation outcomes. A substantial positive effect was also seen for the statement, "Visitor numbers are regulated to reduce negative environmental impacts" ($\beta = 0.441$, $p = 0.000$), highlighting the significance of controlling the flow of tourists in order to preserve animal habitats. Additionally, there was a substantial positive correlation ($\beta = 0.252$, $p = 0.006$) between conservation and eco-friendly infrastructure, such as compost toilets and solar lighting, highlighting the need of sustainable facility construction.

However, two variables revealed negative relationships with biodiversity conservation. "Wildlife tours and nature walks are conducted in a responsible and non-intrusive manner" ($\beta = -0.212$, $p = 0.009$) and "Local communities are actively involved in managing ecotourism activities" ($\beta = -0.300$, $p = 0.000$) both showed statistically significant negative coefficients. These unexpected results may point to implementation issues, lack of capacity, or superficial involvement that undermines the intended conservation goals.

Overall, the regression results support the rejection of the null hypothesis ($H_0 1$), confirming that ecotourism practices significantly influence biodiversity conservation outcomes. While several practices demonstrate a positive impact, the

findings also suggest the need for improved community engagement and stricter implementation of non-intrusive tourism protocols to ensure ecotourism delivers on its conservation promises.

H_{02}: Ecotourism activities do not significantly affect the quality of the local environment.

H_{a2}: Ecotourism activities significantly affect the quality of the local environment.

Table 5: Model Summary and ANOVA results of Hypothesis 2

Component	Value
Model Summary	
R	0.804
R Square	0.646
Adjusted R Square	0.637
Std. Error of Estimate	0.604
ANOVA	
F-value	70.819
Sig. (p-value)	0.000

Table 6: Coefficients result of Hypothesis 2

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.274	.241		1.136	.257
	Guided nature walks and birdwatching tours are common in this ecotourism site.	.564	.061	.550	9.191	.000
	Cultural or heritage-based experiences are integrated with nature-based tourism here.	.261	.065	.252	4.012	.000
	Tourism activities in this area promote education about ecology and conservation.	-.074	.066	-.071	-1.116	.266
	Tourists often engage in low-impact or non-extractive activities (e.g., photography, hiking).	.192	.064	.194	2.994	.003
	Ecotourism practices here aim to involve local communities in tourism operations.	-.019	.062	-.017	-.308	.758
a. Dependent Variable: Environmental quality						

Interpretation

According to measures like pollution and ecological disturbance, the regression analysis for Hypothesis 2 investigated whether ecotourism operations in Rajasthan had a substantial impact on the local environment's quality. With a high R value of 0.804 and an R2 of 0.646, the model demonstrated that the chosen ecotourism activity variables could account for 64.6% of the variance in environmental quality. With a p-value of 0.000 and an F-value of 70.819, the model was statistically significant, indicating that the association is significant overall.

Among the predictors, "Guided nature walks and birdwatching tours are common in this ecotourism site" was the most significant positive contributor ($\beta = 0.550$, $p = 0.000$), suggesting that such low-impact activities are perceived to reduce negative environmental effects and promote eco-conscious behavior. Similarly, "Cultural or heritage-based experiences are integrated with nature-based tourism here" ($\beta = 0.252$, $p = 0.000$) and "Tourists often engage in low-impact or non-extractive activities (e.g., photography, hiking)" ($\beta = 0.194$, $p = 0.003$) were also positively associated with improved environmental outcomes. These findings indicate that when ecotourism is grounded in cultural learning and minimal physical intrusion, it can contribute to environmental sustainability.

On the other hand, two predictors did not show statistically significant effects. "Tourism activities in this area promote education about ecology and conservation" had a negative but non-significant coefficient ($\beta = -0.071$, $p = 0.266$), while "Ecotourism practices here aim to involve local communities in tourism operations" showed no meaningful relationship with environmental impact ($\beta = -0.017$, $p = 0.758$). These results may suggest that while environmental education and community involvement are crucial, their current implementation may lack sufficient depth or visibility to influence environmental perceptions or outcomes.

In summary, the findings support the rejection of the null hypothesis (H_o2), indicating that ecotourism activities do have a statistically significant effect on the quality of the local environment. However, the results also emphasize the need to strengthen education-based interventions and ensure more impactful community participation to maximize environmental benefits.

H_{01}: There is no significant relationship between tourists' environmental awareness and their eco-friendly behavior at ecotourism sites.

H_{a1}: There is a significant relationship between tourists' environmental awareness and their eco-friendly behavior at ecotourism sites.

Table 7: Model Summary and ANOVA results of Hypothesis 3

Component	Value
Model Summary	
R	0.762
R Square	0.581
Adjusted R Square	0.570
Std. Error of Estimate	0.662
ANOVA	
F-value	53.818
Sig. (p-value)	0.000

Table 8: Coefficients result of Hypothesis 3

Coefficients[a]				
Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.

		B	Std. Error	Beta		
1	(Constant)	.019	.267		.071	.944
	I am aware of the importance of conserving biodiversity at ecotourism sites.	-.292	.066	-.292	-4.391	.000
	I know the rules and guidelines for visiting protected ecological areas.	.478	.081	.412	5.903	.000
	I understand how my behavior as a tourist affects the local environment.	.394	.085	.348	4.637	.000
	I have received adequate information about this site's ecological sensitivity.	.056	.079	.053	.717	.474
	I am aware of the environmental challenges faced by this region.	.339	.062	.342	5.472	.000
a. Dependent Variable: I avoid littering or using plastic during my visits to ecotourism sites.						

Interpretation

The regression analysis for Hypothesis 3 examines whether there is a significant relationship between tourists' environmental awareness and their eco-friendly behavior, specifically the tendency to avoid littering or using plastic at ecotourism sites. An R value of 0.762 and an R2 of 0.581 indicate a high link, according to the model summary. This indicates that the degree of environmental knowledge among visitors accounts for around 58.1% of the variation in eco-friendly behavior. The ANOVA F-value of 53.818 and the p-value of 0.000 show that the model is statistically significant, confirming that the link is substantial and not the result of chance.

Among the independent variables, several statements significantly predicted eco-friendly behavior. The statement "I know the rules and guidelines for visiting protected ecological areas" had the strongest positive effect ($\beta = 0.412$, $p = 0.000$), suggesting that awareness of site-specific regulations strongly encourages responsible behavior. Similarly, "I understand how my behavior as a tourist affects the local environment" ($\beta = 0.348$, $p = 0.000$) and "I am aware of the environmental challenges faced by this region" ($\beta = 0.342$, $p = 0.000$) also had significant positive effects, indicating that both personal understanding and broader environmental knowledge contribute to environmentally responsible actions.

Interestingly, the statement "I am aware of the importance of conserving biodiversity at ecotourism sites" had a significant but negative coefficient ($\beta = -0.292$, $p = 0.000$). This may suggest that general awareness of biodiversity conservation, without practical knowledge or behavioral guidance, does not necessarily translate into personal responsibility or may reflect a cognitive dissonance between awareness and action.

Meanwhile, "I have received adequate information about this site's ecological sensitivity" was not a significant predictor ($\beta = 0.053$, $p = 0.474$), indicating that simply being provided with site-specific information may not be sufficient to influence eco-friendly behavior unless it is effectively internalized.

Overall, the findings support the rejection of the null hypothesis (H_{03}), confirming a significant relationship between tourists' environmental awareness and their eco-friendly behavior at ecotourism sites. These results highlight the importance of focused, actionable environmental education in promoting sustainable tourism practices.

Results and Discussion

The findings of this study provide empirical validation for the significant relationships between ecotourism activities and their environmental outcomes in Rajasthan's protected regions. The analysis confirms that ecotourism, when implemented with structured environmental intentions, plays a meaningful role in enhancing biodiversity conservation, maintaining environmental quality, and shaping tourist behavior.

The first hypothesis (H_1) proposed that ecotourism practices are significantly related to biodiversity conservation. The regression analysis yielded a statistically significant model ($R^2 = 0.462$, $p < 0.001$), indicating that 46.2% of the variation in perceived biodiversity conservation outcomes can be explained by ecotourism-related variables. Among the predictors, visitor regulation and interpretive signage emerged as the strongest contributors. This supports prior literature that suggests when tourist movement is controlled and supported with educational prompts, the potential for biodiversity protection increases (Paul & Bhattacharya, 2022; Fennell, 2015). Surprisingly, local community involvement exhibited a negative relationship with conservation outcomes, suggesting potential misalignment between community roles and actual conservation responsibilities—echoing concerns raised by Jamal and Stronza (2009) [16], who argue that community inclusion must be more than symbolic and should be tied to tangible conservation incentives.

The second hypothesis (H_2) posited that ecotourism activities significantly affect the local environmental quality. This hypothesis was strongly supported ($R^2 = 0.646$, $p < 0.001$), with the model showing that ecotourism-related infrastructure and behavior can substantially influence environmental outcomes such as pollution, resource use, and ecological balance. The most significant predictors were guided nature walks, cultural integration with natural sites, and engagement in low-impact activities. These results reinforce the findings of Ajithkumar and Kumar (2021), who assert that structured, interpretive, and minimally invasive tourism has the capacity to buffer fragile ecosystems from degradation. However, the non-significant and even negative contribution of some educational components suggests that while ecological learning is vital, its design and delivery require more strategic framing. This aligns with Orams' (1997) argument that environmental education must be experiential, culturally appropriate, and action-oriented to be effective in modifying tourist behavior.

The third hypothesis (H_3) investigated the relationship between tourists' environmental awareness and their eco-friendly behavior. This model explained 58.1% of the variance in responsible tourist behavior ($R^2 = 0.581$, $p < 0.001$). Tourists who demonstrated awareness of site rules, regional environmental challenges, and the personal impact of their actions were significantly more likely to engage in practices like avoiding littering and plastic use. These findings corroborate the work of Shi, Zhao, and Han (2023) [29], who emphasized that awareness rooted in personal accountability significantly increases pro-environmental actions. Interestingly, general awareness of biodiversity importance showed a negative effect, possibly indicating a gap between abstract knowledge and practical behavior—an issue also highlighted by Liu (2003) [23], who cautioned against assuming that knowledge always translates into action.

Overall, the study supports the contention that ecotourism, when designed with participatory and environmentally

focused principles, can positively influence conservation and environmental sustainability outcomes. However, the presence of unexpected negative relationships and non-significant predictors in each model highlights gaps in the current ecotourism implementation, especially concerning community roles and educational practices. These findings advocate for the refinement of Rajasthan's ecotourism strategy—placing greater emphasis on measurable outcomes, genuine stakeholder participation, and practical, behavior-oriented environmental communication.

The results contribute to the existing body of knowledge by providing empirical insights from the Indian ecotourism context, particularly Rajasthan, where ecological sensitivity is heightened. For policymakers and tourism managers, these insights stress the need to embed accountability, local empowerment, and tailored awareness campaigns into the planning and execution of ecotourism activities. With more inclusive, educationally strategic, and conservation-focused approaches, ecotourism can serve as an effective tool for sustainable development in ecologically vulnerable regions.

Theoretical and Practical Implications

This study offers meaningful contributions to both theoretical understanding and practical implementation of ecotourism strategies in the context of Rajasthan. Theoretically, it reinforces the premise that ecotourism can serve as a viable mechanism for biodiversity conservation and environmental sustainability when guided by structured practices and stakeholder engagement. The observed relationships between ecotourism variables—such as eco-friendly infrastructure, regulated visitor flow, and responsible tourist behavior—and their ecological outcomes align with core sustainable tourism frameworks. Moreover, the study challenges prevailing assumptions by revealing that not all components traditionally considered beneficial, such as community involvement and environmental education, automatically lead to conservation success. These findings support the call for a more nuanced interpretation of stakeholder participation and education effectiveness within ecotourism theory.

Practically, the study offers actionable insights for ecotourism planners, environmental policymakers, and conservation practitioners. The results emphasize the importance of site-specific ecotourism planning that integrates clear signage, strict visitor regulation, and environmentally sustainable infrastructure. Tourism planners should reevaluate the quality and delivery of environmental education programs to ensure they promote measurable behavior change rather than passive awareness. Additionally, policymakers must ensure that community involvement is substantive, with roles that are well-defined, properly resourced, and directly linked to conservation outcomes. By doing so, ecotourism initiatives can achieve their intended ecological and socio-economic goals more effectively. The study underlines that ecotourism, when carefully managed, can act as a catalyst for regional conservation while empowering local communities and enhancing visitor experiences.

Limitations of the Study

While the research has provided robust insights, several limitations must be acknowledged. First, the geographic scope of the study is restricted to selected ecotourism destinations within Rajasthan, limiting the generalizability of the findings to other regions with different ecological and cultural contexts. Second, the data's cross-sectional nature limits the capacity to evaluate causation or long-term changes since it only records stakeholder impressions at one particular moment in time. Third, the study leaves out important players like private tour operators, policy implementers, and environmental NGOs, whose roles may be crucial to comprehending the entire range of ecotourism dynamics, even though it includes important stakeholders like visitors, locals, and forest department officials. Last but not least, depending only on self-reported answers might result in social desirability bias as some participants can exaggerate their behavior or environmental awareness in order to fit in with perceived standards.

Suggestions for Future Research

To address these limitations and build on the current findings, future research should consider adopting longitudinal designs to assess the long-term ecological and behavioral impacts of ecotourism activities. Expanding the geographical scope to include ecotourism sites in other states or eco-regions would also enable comparative analysis and broader generalizations. Future studies should incorporate a wider range of stakeholders, such as NGO workers, private operators, and government planners, to provide a more holistic view of ecotourism management and policy implementation. Employing mixed-method approaches that integrate qualitative interviews with quantitative surveys could also help explain counterintuitive findings, such as the negative effects of community participation or environmental education. Additionally, triangulating survey data with ecological indicators or field observations could help bridge the gap between perception and real-world conservation outcomes. Such enhancements would refine the understanding of ecotourism's actual effectiveness and contribute to more grounded, evidence-based tourism policy and planning.

Conclusion

This study explored the relationships between ecotourism practices, environmental quality, biodiversity conservation, and tourist behavior in Rajasthan's protected areas. The empirical findings strongly support the notion that well-structured ecotourism practices—such as regulated visitor management, eco-friendly infrastructure, and interpretive communication—can significantly contribute to conservation efforts and environmental sustainability. Furthermore, the results highlight that tourists' environmental awareness is closely linked to their eco-friendly behavior, emphasizing the need for continued investment in information dissemination and behavioral engagement.

However, the study also reveals that components like community participation and environmental education may not always yield expected outcomes, pointing to the need for more inclusive, meaningful, and context-specific program designs. These findings emphasize that ecotourism is not a one-size-fits-all solution but a complex, dynamic strategy that must be adapted to local conditions and actively monitored for effectiveness. When guided by research, inclusive policy, and collaborative management, ecotourism holds substantial potential to serve as a sustainable development tool—not only in Rajasthan but in ecologically sensitive areas globally.

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