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Adapting Environmental Conditions for Sustainable Ecotourism Development: Evidence from the Dong Nai Culture and Nature Reserve, Vietnam

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Abstract

Sustainable ecotourism represents a vital strategy for harmonizing biodiversity conservation with socio-economic development, particularly within nature-based destinations in developing countries. This study explores the impact of environmental conditions on sustainable ecotourism development in the Dong Nai Culture and Nature Reserve, Vietnam. Using a combination of exploratory factor analysis (EFA), logistic regression, and SWOT analysis, the research identifies key environmental factors that influence tourists' revisit intentions and long-term sustainability. The EFA results highlight three main dimensions: environmental management, environmental quality, and biodiversity and landscape integrity. Environmental management emerged as the most influential factor. The measurement model demonstrated satisfactory reliability and validity (KMO = 0.749; cumulative explained variance = 58.492%; Cronbach's α = 0.64–0.79). The logistic regression confirmed that environmental management (β = 1.536, p-value = 0.029) has the strongest impact on revisit intention, followed by environmental quality (β = 1.024, p-value = 0.039) and biodiversity (β = 0.425, p-value = 0.342). Building upon these findings, the SWOT analysis translated the statistical evidence into strategic priorities for adaptive ecotourism governance, emphasizing improvements in environmental quality, biodiversity interpretation, climate resilience, visitor-flow management, and stakeholder collaboration. The study underscores the importance of adaptive management strategies that address climate change, pollution, and visitor overcrowding to enhance sustainability. This research offers a framework for improving adaptive capacity in ecotourism management and ensuring the long-term resilience of the reserve.

Keywords: *adaptive sustainable development, ecotourism, environmental management, logistic regression, SWOT analysis*

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Introduction

Sustainable ecotourism has emerged as a crucial pathway toward achieving the dual objectives of environmental conservation and community well-being, particularly in biodiversity-rich developing countries like Vietnam (Baloch et al., 2023; Dang, 2023). As tourism expands into ecologically sensitive areas, the challenge lies in ensuring that economic benefits do not come at the cost of environmental degradation (Mai et al., 2020; Sianipar et al., 2022). To address this, the concept of adaptive sustainable development emphasizing flexibility, feedback, and learning within management systems has gained increasing attention in both theory and practice (Holling, 1978; Biggs et al., 2015). Adaptive approaches to ecotourism are especially relevant in tropical ecosystems, where human pressures and climate variability interact to create complex, dynamic environments that require continuous monitoring and policy adjustment (Holling, 1978).

Globally, ecotourism has been promoted as a mechanism for balancing conservation with livelihood improvement (Stronza et al., 2019). However, achieving sustainability depends not only on protecting natural assets but also on understanding how tourists perceive and respond to environmental conditions (Chiu et al., 2014a; Suryawan et al., 2025a). Tourists' perceptions of environmental quality, biodiversity integrity, and management performance can serve as critical feedback indicators of a destination's adaptive capacity (Chiu et al., 2014a; Wang et al., 2025). When environmental degradation or weak management is perceived, tourist satisfaction and revisit intention tend to decline, thereby threatening both economic stability and conservation goals (Lee & Jan, 2015; Wang et al., 2021). Conversely, effective management that adapts to emerging environmental and social challenges can enhance visitors' trust, encourage environmentally responsible behavior, and reinforce long-term destination resilience.

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In Vietnam, ecotourism has grown rapidly over the past two decades, yet many destinations still face challenges related to waste management, biodiversity conservation, and visitor carrying capacity (Khuu et al., 2023; Huynh et al., 2025). The Dong Nai Culture and Nature Reserve (DNCNR) represents an ideal case for studying these issues within an adaptive framework. As part of the UNESCO Dong Nai Biosphere Reserve, the area embodies both rich ecological diversity and complex management dynamics (Nguyen et al., 2022; 2023). It integrates forest ecosystems, wetland habitats, and cultural landscapes that support community-based ecotourism initiatives (Dong Nai Provincial People's Committee & Dong Nai Biosphere Reserve Management Board, 2021; Nguyen et al., 2023). However, rising visitation has introduced new environmental pressures, including localized pollution, habitat disturbance, and uneven biodiversity visibility (Dong Nai Provincial People's Committee & Dong Nai Biosphere Reserve Management Board, 2021). These conditions necessitate an adaptive management approach that can respond to changing tourist behavior, ecological feedback, and institutional capacity.

To understand the relationship between environmental conditions and sustainable tourism outcomes, this study examines how environmental quality, biodiversity and landscape integrity, and environmental management affect tourists' behavioral intentions, particularly their willingness to revisit. Without empirical evidence on how environmental conditions shape tourists' behavior, management authorities would continue to rely primarily on general conservation indicators or qualitative assessments when allocating budgets, designing visitor management strategies, and prioritizing environmental interventions. Such a knowledge gap could weaken long-term revenue streams for conservation financing and undermine community-based ecotourism initiatives that depend heavily on visitor loyalty. In a rapidly urbanizing region adjacent to Ho Chi Minh City, such as Dong Nai Province, the absence of behavioral evidence also risks leading to inefficient infrastructure investments, misaligned conservation messaging, and reactive rather than adaptive responses to emerging pressures, including overcrowding, pollution inflows, and climate-related disturbances. For the DNCNR, it occupies a distinctive governance and ecological position within Vietnam. As part of the UNESCO Dong Nai Biosphere Reserve, the site combines high biodiversity value, rising visitation pressure, community-based tourism programs, and cross-sectoral management involving provincial authorities and biosphere reserve institutions. Without site-specific empirical insights, decision-makers may struggle to justify trade-offs among biodiversity protection, infrastructure development, and visitor access, potentially leading to an overemphasis on visible facilities while neglecting ecological restoration or, conversely, to overly restrictive controls that undermine tourism viability. Unlike conventional studies that assess sustainability from a static perspective, this research adopts a dynamic and adaptive viewpoint, conceptualizing environmental management as a living system that evolves through learning, stakeholder participation, and empirical feedback (Holling, 2001). The study employs a mixed-methods design integrating exploratory factor analysis (EFA), logistic regression, and SWOT analysis. The EFA identifies the underlying dimensions of tourists' environmental perceptions; the logistic model quantifies the influence of these dimensions on revisit intention; and the SWOT synthesis translates statistical insights into strategic implications for adaptive ecotourism governance.

By applying this integrative framework, the study seeks to fill several research gaps. First, it contributes to the limited empirical literature on adaptive environmental management in ecotourism contexts in Vietnam. Second, it provides evidence of how tourists' perceptions can function as a feedback mechanism within adaptive systems, linking environmental conditions to behavioral outcomes. Third, it offers a practical decision-support tool for managers to design strategies that enhance both ecological resilience and visitor satisfaction. The DNCNR thus serves as a microcosm for exploring how adaptive capacity, defined as the ability to learn, reorganize, and adjust to change, can guide the transformation of ecotourism from a resource-dependent model toward a resilience-based sustainable system. Ultimately, this research aligns with the broader goals of the sustainable development goals (SDGs), particularly SDG 13 (Climate action) and SDG 15 (Life on land), by emphasizing that sustainable tourism development must be adaptive, participatory, and evidence-based. Through integrating behavioral insights, quantitative modeling, and strategic analysis, this study contributes to both the theoretical advancement of adaptive sustainable tourism and the practical design of resilient management systems for Vietnam's protected areas.

Conceptual framework and research hypotheses. Theoretical foundation Sustainable ecotourism development is widely recognized as a multidimensional construct integrating environmental, social, and behavioral dimensions (Jieyao et al., 2025). The present study is grounded in the theory of planned behavior (TPB) (Ajzen, 1991) and the ecological systems perspective (Gössling, 2017), both of which emphasize that human behavior and sustainability outcomes are shaped by environmental conditions and management systems. According to TPB, attitudes toward the environment, subjective norms, and perceived behavioral control influence the intention to engage in environmentally responsible behavior (Ajzen, 1991; Jieyao et al., 2025). When applied to ecotourism, tourists' perceptions of environmental quality, biodiversity integrity, and effective management directly affect their behavioral intentions toward sustainable actions such as revisiting, recommending, or supporting conservation initiatives (Chiu et al., 2014b; Wang et al., 2021). From an ecological systems perspective, tourism activities are embedded within broader natural systems, implying that the quality of the environment both constrains and enables sustainable development outcomes (Raisi et al., 2024; Suryawan et al., 2025a). Accordingly, environmental conditions represented here by environmental quality, biodiversity and landscape integrity, and environmental management constitute the foundational inputs for sustainable ecotourism (Chiu et al., 2014a; Jieyao et al., 2025). These environmental inputs interact to influence the sustainability of tourism performance, including tourist

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satisfaction, community livelihood, and conservation effectiveness (Lea et al., 2018; Suryawan et al., 2025b). Integrating these theoretical views, this research conceptualizes sustainable ecotourism development as the behavioral and outcome-oriented response to varying environmental conditions within protected areas.

Development of hypotheses Integrated within the theoretical lens of the TPB (Ajzen, 1991) and the ecological systems perspective, this study emphasizes the interplay between individual behavioral intentions and multi-level environmental contexts that shape sustainable tourism outcomes. Building upon the conceptual framework, this study posits that sustainable ecotourism development in the DNCNR is shaped by three interrelated environmental dimensions: environmental quality (Chatterjee & Datta, 2024), biodiversity and landscape integrity (Vejsiu & Stafasani, 2017), and environmental management (Baloch et al., 2023) (Table 1). These constructs represent the core environmental components that collectively determine the ecological sustainability and experiential quality of the destination. Sustainable ecotourism development is operationalized as a composite outcome reflecting visitor satisfaction, revisit intention, and support for environmental conservation (Jieyao et al., 2025).

Table 1 Indicators for environmental condition constructs

Construct	Code	Measurement item	Description	Source
Environmental quality (EQ)	EQ1	The air in the reserve is clean and free from pollution.	Reflects perceived air quality, a key environmental perception affecting tourist satisfaction.	Chiu et al. (2014a); Wang et al. (2025)
	EQ2	The water in lakes and rivers within the reserve is clean and safe.	Water quality strongly influences destination image and visitors' environmental comfort.	Gössling (2017); Jieyao et al. (2025)
	EQ3	The reserve is quiet and free from excessive noise.	Noise reduction enhances the sense of tranquility and authenticity of ecotourism.	Dang (2023); Raisi et al. (2024)
	EQ4	The natural landscape is visually attractive and well preserved.	Landscape aesthetics affect the overall tourism experience and revisit intention.	Vejsiu and Stafasani (2017)
	EQ5	The environment is clean, and there is minimal visible waste.	Cleanliness is a direct indicator of environmental quality and management effectiveness.	Chatterjee and Datta (2024)
Biodiversity & landscape integrity (BL)	BL1	The reserve has a high diversity of flora and fauna.	Biodiversity richness enhances ecological and educational value of ecotourism.	Das and Chatterjee (2015); Lee and Jan (2019)
	BL2	Native species can be observed easily in their natural habitats.	Wildlife visibility contributes to perceived natural authenticity and visitor engagement.	Lea et al. (2018)
	BL3	Forests and ecosystems are healthy and show minimal human disturbance.	Ecological integrity is central to sustainable tourism and conservation outcomes.	Gössling (2017)
	BL4	The landscape remains natural and has not been excessively modified.	Retention of naturalness reflects effective conservation and scenic quality.	Baloch et al. (2023); Bui et al. (2021)
	BL5	The ecosystem demonstrates resilience and vitality (e.g., reforestation, natural regeneration).	Ecological resilience ensures long-term sustainability of tourism and biodiversity.	Wang et al. (2021)
Environmental management (EM)	EM1	Waste collection and treatment systems in the reserve are well managed.	Reflects the practical implementation of environmental management measures.	Chiu et al. (2014a); Lee and Jan (2015)
	EM2	Environmental protection rules are clearly established and enforced.	Legal enforcement and governance are critical for ecotourism sustainability.	Gössling (2017)
	EM3	Information and education on environmental protection are available to visitors.	Environmental interpretation increases awareness and promotes responsible behavior.	Huynh et al. (2025); Raisi et al. (2024)
	EM4	Tourism activities are planned to minimize negative environmental impacts.	Low-impact tourism planning supports ecological balance and visitor satisfaction.	Vejsiu and Stafasani (2017); Wang et al. (2021)
	EM5	The management authority regularly monitors and evaluates environmental conditions.	Continuous monitoring ensures adaptive management and sustainable practices.	Chatterjee and Datta, (2024); Stronza et al. (2019)

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Environmental quality (EQ) refers to visitors' perceptions of air and water purity, cleanliness, noise control, and landscape aesthetics (Chatterjee & Datta, 2024). High environmental quality enhances visitors' sensory and emotional experiences, leading to greater satisfaction and stronger pro-environmental attitudes (Chiu et al., 2014b; Wang et al., 2025). Empirical studies have shown that well-preserved environmental conditions improve destination image and behavioral intentions, whereas environmental degradation diminishes perceived sustainability (Chiu et al., 2014a; Bui et al., 2021). Accordingly, it is hypothesized that H1: Environmental quality has a positive and significant effect on sustainable ecotourism development.

Biodiversity and landscape integrity (BL) represent the richness of flora and fauna, ecological health, and the degree of naturalness or minimal human disturbance (Vejsiu & Stafasani, 2017). Ecological diversity and scenic authenticity are fundamental to the ecotourism experience, providing educational and aesthetic value that attracts environmentally conscious visitors (Lee & Jan, 2015; Vejsiu & Stafasani, 2017). When tourists perceive a destination as biologically diverse and ecologically intact, they are more likely to develop strong pro-conservation attitudes and intentions to revisit (Jieyao et al., 2025; Suryawan et al., 2025b). Therefore, the following hypothesis is proposed, H2: Biodiversity and landscape integrity have a positive and significant effect on sustainable ecotourism development.

Environmental management (EM) encompasses the visible practices of waste management, enforcement of conservation rules, and environmental education provided to visitors (Baloch et al., 2023). Effective management enhances visitors' trust and confidence in the destination's sustainability practices, thereby increasing satisfaction and loyalty (Lea et al., 2018; Chatterjee & Datta, 2024). Conversely, inadequate or inconsistent management can lead to resource degradation and negative perceptions of sustainability. Hence, the third hypothesis is formulated as H3: Environmental management has a positive and significant effect on sustainable ecotourism development.

Method

Study area The DNCNR, located in Dong Nai Province, southern Vietnam (Figure 1), was selected as the study site due to its ecological richness, cultural diversity, and increasing importance as a model for sustainable ecotourism. Covering over 100,000 hectares and forming part of the UNESCO Dong Nai Biosphere Reserve since 2011, the area represents one of Vietnam's largest inland protected ecosystems (Dong Nai Provincial People's Committee & Dong Nai Biosphere Reserve Management Board, 2021; Nguyen et al., 2022). It encompasses a mosaic of evergreen forests, wetlands, and grasslands, hosting more than 1,400 plant species and 1,000 animal species, including several endangered species such as the gaur (Bos gaurus) and black-shanked douc langur (*Pygathrix nigripes*) (Dong Nai Provincial People's Committee & Dong Nai Biosphere Reserve Management Board, 2021). This ecological diversity, combined with its proximity to major urban centers like Ho Chi Minh City, provides ideal conditions for ecotourism activities such as forest trekking, birdwatching, and environmental education. The DNCNR is also home to ethnic communities such as the Ma, Stieng, and Kinh, whose traditional livelihoods and cultural heritage add unique social value to the area (Nguyen et al., 2022). In recent years, local authorities have integrated community-based ecotourism into the reserve's management strategy to promote conservation awareness and local participation (Nguyen et al., 2023). However, the increasing number of visitors has also raised concerns regarding environmental degradation, waste management, and uneven biodiversity visibility. This study focuses on the DNCNR because it exemplifies the interaction between environmental quality, management performance, and sustainable tourism behavior in a rapidly developing region. By analyzing tourists' perceptions of environmental conditions and management effectiveness, the research provides evidence-based insights into how adaptive strategies can balance ecological protection with tourism growth.

Figure 1

Sample and data collection The research data for this study were collected through a process of face-to-face interviews, employing a systematic random sampling approach, a well-established and reliable method commonly utilized in quantitative behavioral and ecotourism studies (Hair, 2009; Phan et al., 2025; Widiastutie et al., 2025). The sample size was initially determined using Yamane's formula as shown in Equation *[1]* (Yamane, 1973).

$$n = \frac{N}{1+N(e^2)} \qquad [1]$$

note: n is the required sample size, N represents the total population of visitors to the DNCNR, and e is the allowable error (precision level). Based on the annual visitor statistics provided by the Dong Nai Forest Protection Department (2024), approximately 6,500 tourists visited the reserve in 2024. With an allowable error of 7%, the sample size was calculated as 197.

Accordingly, the final sample size was set at 220 tourists to ensure sufficient representation and reliability for multivariate statistical analysis, including exploratory factor analysis (EFA) and logistic regression.

Subsequently, face-to-face interviews were conducted directly with tourists within the DNCNR's main ecotourism zones, between May and July 2025. This approach offered several advantages. Firstly, it allowed for a more nuanced and comprehensive understanding of respondents' perceptions, as participants could seek clarification from surveyors when needed. Secondly, the method fostered rapport and trust between enumerators and respondents, thereby enhancing data reliability and response quality. To ensure ethical standards were upheld, all interviewers were trained in research ethics and professional conduct before data collection. Each respondent was informed about the study's objectives, the voluntary nature of participation, and the confidentiality of their responses. Only those who willingly agreed to participate were included in the sample. The survey targeted tourists aged 18 and above, encompassing both domestic and international visitors to ensure diversity in

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experience and perception. In total, 220 questionnaires were distributed, and 200 valid responses were obtained, resulting in an impressive response rate of 90.9%. The exclusion rate was minimal, with approximately 9.1% of responses omitted due to incompleteness or inconsistencies. The questionnaire comprised three sections: (i) demographic characteristics of respondents, (ii) perceptions of environmental conditions, and (iii) behavioral intentions related to sustainable ecotourism. The structure of the study is shown in Figure 2.

Data analysis Data collected from the 200 respondents were coded and analyzed using SPSS version 26.0, following a systematic sequence that integrated reliability testing, EFA, and logistic regression modeling. The analytical process was designed to ensure both statistical robustness and theoretical coherence with the proposed conceptual framework.

Initially, data screening was conducted to identify missing values, outliers, and inconsistencies. All variables were checked for normality and coding accuracy, while descriptive statistics were generated to summarize respondents' socio-demographic characteristics and the overall distribution of responses. To evaluate internal consistency, Cronbach's alpha coefficients were computed for each construct. Items with corrected item–total correlations below 0.3 were removed to improve scale reliability. Constructs with α values greater than 0.60 were considered acceptable for further analysis, ensuring that the indicators were homogenous and reliably represented their latent constructs. Consequently, no indicators were removed at this stage, and all originally proposed items were retained for subsequent exploratory factor analysis and regression modeling.

Following the reliability assessment, an EFA was conducted to identify the underlying structure of environmental condition variables. The analysis used the principal component analysis extraction method combined with Varimax orthogonal rotation to maximize interpretability of factors. The suitability of the data for factor analysis was confirmed through the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity, with thresholds of KMO ≥ 0.6 and p-value < 0.05, respectively. Factors with eigenvalues greater than 1 were retained, and variables with factor loadings below 0.50 or exhibiting cross-loadings above 0.40 were excluded to maintain discriminant validity.

Once the factor structure was established, binary logistic regression was applied to test the hypothesized relationships between environmental conditions and tourists' sustainable behavioral intention. In this step, the dependent variable intention to revisit was transformed into a binary outcome, where respondents who scored 4 or 5 on the Likert scale (agree or strongly agree) were coded as 1, indicating a high level of revisit intention, while those who scored 3 or below were coded as 0. The logistic model estimated the log-odds of revisit intention as a linear function of the three environmental factors, formulated as shown in Equation *[2]*.

$$ln\left(\frac{P(Y=1)}{1-P(Y-1)}\right) = \beta_0 + \beta_1 EQF + \beta_2 ELF + \beta_3 EMF + \varepsilon \quad [2]$$

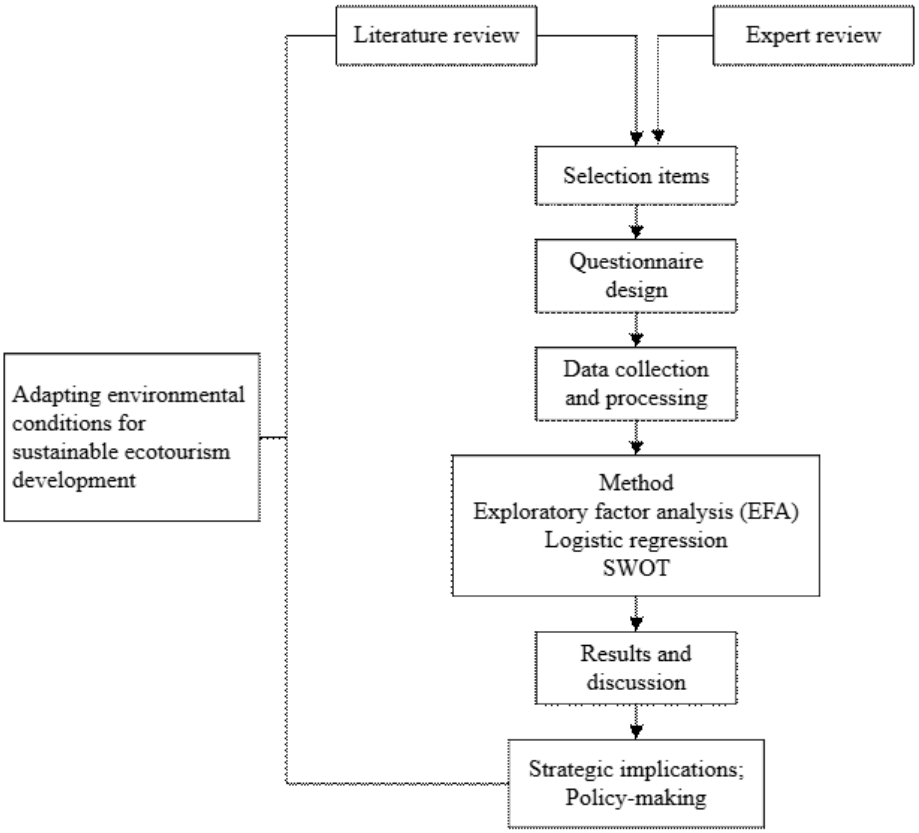

Table 1 Indicators for environmental condition constructs.

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note: P(Y = 1) denotes the probability that a tourist intends to revisit the reserve, and βi represents the coefficients measuring the strength and direction of influence of each environmental factor (EQF, BLF, EMF).

The logistic model's overall goodness of fit was examined through several diagnostic tests. The Hosmer–Lemeshow test was employed to verify model calibration, with a non-significant *p*-value (> 0.05) indicating an adequate fit between observed and predicted probabilities. The Nagelkerke R^2 value was reported to measure explanatory power. Coefficients were interpreted in terms of odds ratios (Exp(β)), where values greater than 1 suggested that higher perceptions of environmental conditions increase the likelihood of tourists' sustainable behavior.

After completing the quantitative modeling, the results were synthesized through SWOT analysis to derive strategic insights for environmental management. This interpretive stage involved identifying internal and external factors that could enhance or hinder sustainable ecotourism in the DNCNR. Specifically, factors with high mean scores and statistically significant positive effects in the logistic model were categorized as Strengths, whereas those with low scores or non-significant impacts were labeled as Weaknesses. Opportunities and Threats were determined based on external environmental, socio-economic, and policy contexts. The integration of statistical evidence with strategic evaluation ensured analytical rigor and provided a practical basis for formulating recommendations that could guide future management decisions toward sustainability.

Results

Demographic profile of respondents As shown in Table 2, the demographic information of respondents provides a clear representation of the overall sample structure. Among the participants, 52.5% were female and 47.5% were male, suggesting a relatively balanced gender composition. Regarding age, the largest group (approximately 38%) fell within the 30–39 age range, followed by those aged 40–49 (27%), 18–29 (18%), and a smaller share above 50 years old (17%). This distribution highlights that the majority of ecotourists in the reserve are young to middle-aged adults, consistent with previous studies indicating that younger generations are more engaged in environmentally responsible tourism (Lea et al., 2018). In terms of education level, most respondents possessed a university degree (56%), while 27% had completed college or vocational education, and 17% held postgraduate qualifications. This relatively high level of educational attainment reflects the intellectual awareness typical of ecotourists who value environmental learning and conservation ethics during travel. Regarding residence, approximately 61% of respondents were domestic visitors from within Dong Nai and neighboring provinces, whereas 32% came from other regions of Vietnam, and 7% were international tourists. This indicates that the DNCNR primarily serves regional and national ecotourism demand but also attracts a small yet meaningful international segment, suggesting potential for cross-border marketing initiatives. In terms of visitation frequency, 68% of participants reported that this was their first visit, while 32% indicated repeat visitation, demonstrating a promising level of tourist loyalty and revisit potential. Moreover, the majority (74%) traveled in small groups of friends or family, reflecting the social and experiential nature of ecotourism activities in the reserve.

EFA findings analysis The results of the EFA conducted on the five items related to environmental quality, biodiversity and landscape integrity, and environmental management are presented in Table 3. The KMO measure of sampling adequacy was calculated to be 0.749, which is above the commonly accepted threshold of 0.6 (Hair, 2009), suggesting that the sample is suitable for factor analysis. Furthermore, the Bartlett's test of sphericity produced a highly significant result (*p*-value < 0.0001), further confirming that the data are appropriate for EFA and that the variables are sufficiently correlated. Principal component analysis with Varimax

Table 2 Demographic profile of respondents

Variable	Category	Frequency (n)	Proportion (%)
Gender	Male	95	47.5
	Female	105	52.5
Age group (years)	18–29	36	18
	30–39	76	38
	40–49	54	27
	≥ 50	34	17
Education level	Secondary/High school	0	0
	College/Vocational	54	27
	Bachelor's degree	112	56
	Postgraduate	34	17
Place of residence	Within Dong Nai Province	61	30.5
	Other provinces in Vietnam	103	51.5
	International	14	7
Visitation frequency	First-time visitor	136	68
	Repeat visitor	64	32
Travel group composition	Alone	18	9
	With family	84	42
	With friends	64	32
	Organized tour group	34	17

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rotation identified three main factors, which were labeled as follows: Factor 1: Environmental quality, Factor 2: Biodiversity and landscape integrity, and Factor 3: Environmental management. The results revealed that EQ explained 22.901% of the variance, with factor loadings ranging from 0.678 to 0.760. These loadings indicate that the five items related to EQ have a strong correlation with the environmental quality factor, highlighting the significant role of water and air quality, cleanliness, noise control, and landscape aesthetics in shaping tourists' perceptions. In addition, BL explained 19.877% of the variance, with item loadings between 0.616 and 0.745, reflecting the relevance of flora and fauna richness and the ecological health of the destination. Moreover, EM accounted for 15.731% of the variance, with item loadings ranging from 0.586 to 0.684, indicating that environmental management practices such as waste control and the enforcement of conservation rules play an important role in shaping visitors' perceptions of sustainability. Collectively, these three factors explained 58.492% of the total variance, which is above the acceptable threshold of 50%, confirming that a substantial portion of the variability in the data is accounted for by these factors. Furthermore, all item loadings exceeded the 0.5 threshold, ensuring that the observed variables are strongly associated with their respective factors, providing evidence for the robustness of the factor structure. The Cronbach's alpha values for the three factors were found to be 0.73 for EQ, 0.785 for BL, and 0.64 for EM. These values exceed the threshold of 0.6, indicating that the factors have adequate internal consistency and are reliable for further analysis.

Environmental drivers of revisit intention The regression analysis results presented in Table 4 reveal the impact of environmental factors on tourists' intention to revisit the DNCNR. Environmental management emerged as the most significant predictor of revisit intention, with a positive and statistically significant coefficient (β = 1.536, p-value = 0.029) and an odds ratio (Exp(β)) of 4.646. This suggests that higher perceptions of environmental management effectiveness significantly increase the likelihood of tourists intending to revisit the reserve. In contrast, EQ is also positively related to revisit intention, with a significant coefficient (β = 1.024, p-value = 0.039) and an odds ratio of 2.783, indicating that better perceived environmental quality, such as air and water cleanliness, enhances the likelihood of revisiting. However, BL did not show a significant impact on revisit intention, with a non-significant p-value (0.342) and a relatively low odds ratio (Exp(β) = 1.529). This suggests that,

Table 3 EFA findings

Factors	Loading	Percent (%) of variance explained	Cronbach's alpha
Factor 1: Environmental quality		22.901	0.730
EQ1	0.760		
EQ2	0.750		
EQ3	0.739		
EQ4	0.713		
EQ5	0.678		
Factor 2: Biodiversity and landscape integrity		19.877	0.785
BL1	0.745		
BL2	0.720		
BL3	0.716		
BL4	0.644		
BL5	0.616		
Factor 3: Environmental management		15.731	0.640
EM1	0.684		
EM2	0.679		
EM3	0.640		
EM4	0.602		
EM5	0.586		

KMO = 0.749, Bartlett: p-value < 0.000, Cumulative % = 58.492

Table 4 Results of the regression analysis on environmental drivers of revisit intention

Variable	β	S.E.	p-value	Exp(β)
Environmental quality	1.024	0.496	0.039	2.783
Biodiversity and landscape integrity	0.425	0.447	0.342	1.529
Environmental management	1.536	0.703	0.029	4.646
Constant	-6.470	3.058	0.034	0.002
-2LL	101.566 (χ^2 = 7.792, df = 8, p-value < 0.001)			
Cox & Snell R Square	0.048			
Nagelkerke R^2	0.113			
Hosmer & Lemeshow test	p-value = 0.454			
Classification accuracy	92.0%			

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while biodiversity and landscape quality contribute to overall satisfaction, they may not be the primary drivers for tourists' revisit decisions compared to other factors like management and environmental quality. Additionally, the model fit statistics provide useful insights. The Nagelkerke R^2 value of 0.113 suggests that about 11.3% of the variance in revisit intention can be explained by the environmental factors included in the model. Although this value is relatively modest, it indicates that the environmental factors do have a notable influence. Furthermore, the Hosmer & Lemeshow test yielded a p-value of 0.454, indicating that the model fits the data well and that there is no significant discrepancy between observed and predicted values. Lastly, the classification accuracy of 92.0% confirms that the model does a highly accurate job of predicting revisit intentions, which supports the robustness and reliability of the results. Despite the moderate Nagelkerke R^2, the high classification accuracy suggests that the model successfully differentiates between tourists who intend to revisit and those who do not.

SWOT synthesis and strategic implications Based on the EFA and logistic regression results, a comprehensive SWOT analysis was conducted to identify key strengths, weaknesses, opportunities, and threats influencing the sustainable development of ecotourism at the DNCNR. This synthesis combines the empirical findings with strategic implications for effective management and development (Figure 3).

Strengths (S–high priority): The environmental management factor emerged as the strongest driver of revisit intention, as shown by the logistic regression results (β = 1.536, p-value = 0.029). The high ratings for waste management, regulation enforcement, and visitor education confirm that effective management enhances the likelihood of visitors returning. This is reinforced by the EFA results, where environmental management indicators (EM1–EM5) showed the highest factor loadings (≥ 0.60). Consequently, the reserve should continue to highlight its strong management practices in promotional activities and expand visitor education programs.

Figure 3 SWOT matrix diagram.

Weaknesses (W–moderate to high priority): Despite the strength of management, the analysis revealed several weaknesses in environmental quality and biodiversity and landscape integrity. The EFA results indicated that environmental quality (EQ1–EQ5) and biodiversity and landscape integrity (BL1–BL5) were moderately rated (mean ≈ 3.2), suggesting room for improvement. The logistic regression results confirmed that environmental quality (β = 1.024, p-value = 0.039) significantly influences revisit intention, though it is less impactful than environmental management. Similarly, biodiversity and landscape integrity (β = 0.425, p-value = 0.342) had a weaker influence on revisit decisions. To address these weaknesses, the reserve should prioritize improvements in water quality, noise control, and biodiversity visibility. Enhancing wildlife observation opportunities and eco-friendly signage could strengthen visitors' connection to nature.

Opportunities (O–high priority): The reserve has several opportunities to capitalize on. The ASEAN Heritage Park status and the government's green tourism policies offer significant branding potential. As eco-tourism demand grows globally and public environmental awareness rises, the reserve can tap into a broader, eco-conscious market. The logistic regression analysis, which shows a 92% classification accuracy, further suggests that improving environmental management can increase visitors' intentions to return and their loyalty. The reserve should leverage this opportunity by collaborating with national programs for enhanced funding and visibility and developing eco-tourism packages that focus on sustainable travel experiences.

Threats (T–high priority): However, the reserve faces several external threats. Pollution inflows from surrounding areas, along with climate change impacts (e.g., flooding, droughts), threaten both biodiversity and visitor satisfaction. These threats are reflected in the logistic regression, which indicates that environmental quality plays a significant role in visitor satisfaction. Moreover, overcrowding during peak seasons exacerbates the strain on the reserve's natural resources. To mitigate these threats, the reserve should implement climate resilience measures, seasonal visitor caps, and early warning systems to address environmental fluctuations. Collaborating with local authorities to control pollution and establish eco-friendly infrastructure will also help sustain the reserve's appeal.

Drawing on the SWOT analysis results, we identify five priority actions for the DNCNR: 1) invest in biodiversity interpretation and visibility, including guided wildlife tours, monitoring dashboards, and immersive education programs; 2) upgrade environmental quality infrastructure, particularly for water treatment, waste management, and noise mitigation; 3) introduce adaptive visitor-flow management, combining zoning, reservation systems, and seasonal caps; 4) strengthen inter-agency collaboration for pollution control and climate adaptation; and 5) leverage international branding and funding mechanisms linked to ASEAN and UNESCO conservation frameworks.

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Discussion

The findings of this study highlight the critical role of environmental conditions in shaping sustainable ecotourism behavior within the DNCNR and offer insights into how adaptive management can support long-term sustainability. The EFA revealed that tourists' perceptions of the reserve's environment are structured around three interrelated dimensions: environmental quality, biodiversity and landscape integrity, and environmental management. This multidimensional perception aligns with earlier research emphasizing that ecotourists evaluate destinations not only by their natural assets but also by the effectiveness of environmental governance and maintenance systems (Chiu et al., 2014b; Raisi et al., 2024; Jieyao et al., 2025). The high internal reliability (Cronbach's $\alpha > 0.6$) and clear factor loadings validate the robustness of the measurement model, confirming that visitors differentiate between what they see (e.g., cleanliness, landscape aesthetics), what they value (biodiversity and ecological integrity), and what they trust (management and regulatory effectiveness). Such differentiation reflects an increasing maturity among visitors who recognize that sustainability depends on both ecological and managerial quality (Lee & Jan, 2015; Chatterjee and Datta, 2024). From an adaptive management perspective, these insights suggest that the sustainability of ecotourism hinges on the capacity of destination managers to balance natural preservation with responsive governance practices that evolve alongside environmental changes and visitor expectations (Biggs et al., 2015; Stronza et al., 2019; Suryawan et al., 2025c). Furthermore, the logistic regression analysis provides quantitative evidence that perceived environmental conditions significantly influence tourists' intention to revisit, a key indicator of behavioral sustainability. Among the three dimensions, EM exerts the most substantial impact ($\beta = 1.536$, p-value < 0.029), followed by EQ ($\beta = 1.024$, p-value < 0.039) and BL ($\beta = 0.425$, p-value < 0.342). These results are consistent with the TPB (Ajzen, 1991), which posits that perceived control and trust in management enhance behavioral intention. They also corroborate recent empirical findings in sustainable tourism suggesting that visitors' loyalty and willingness to pay are shaped more by tangible management performance such as waste control, signage, and visible monitoring than by abstract ecological attributes (Chiu et al., 2014b; Bui et al., 2021; Rahman et al., 2025; Wang et al., 2025). The relatively weaker role of biodiversity perception implies that, while ecological integrity remains the foundation of sustainability, it is not always directly perceived or valued by visitors unless it is communicated through interpretation, education, and on-site experience design (Jieyao et al., 2025; Suryawan et al., 2025b). In such settings, visitors may implicitly expect high levels of biodiversity and ecosystem integrity, treating them as minimum requirements rather than salient attributes that differentiate their experience or motivate repeat visitation. Previous studies have similarly noted that ecological qualities often influence behavioral outcomes in-directly—through mediating constructs such as destination image, environmental awareness, satisfaction, or emotional attachment to nature—rather than exerting strong direct effects in statistical models (Chiu et al., 2014a; Lee & Jan, 2015; Abbasi et al., 2021; Jieyao et al., 2025). Therefore, effective communication of conservation actions and participatory visitor management can transform ecological awareness into behavioral commitment, reinforcing the adaptive capacity of the reserve to maintain ecological resilience while ensuring visitor satisfaction.

The relatively modest explanatory power of the logistic model (Nagelkerke $R^2 = 0.113$) suggests that visitors' decisions to return to the DNCNR are shaped by a broader constellation of factors beyond ecological attributes and management performance, such as perceived value for money, accessibility, cultural attractions, safety, crowding, electronic word-of-mouth transmitted through social media and online travel reviews, and overall experiential satisfaction (Abbasi et al., 2021; Lin, 2024; Lee-Anant, 2025). The apparent discrepancy between the high classification accuracy (92%) and the relatively low pseudo-R^2 therefore deserves careful interpretation. In binary logistic models, classification performance can be inflated when outcome categories are unevenly distributed or when predicted probabilities cluster around dominant response patterns, even though substantial variance in behavioral processes remains unexplained. Thus, while the present model demonstrates that environmental conditions are meaningful predictors of revisit intention, it does not claim theoretical completeness. Rather, the results highlight the partial yet policy-relevant role of environmental drivers within a more complex decision-making system.

Integrating the quantitative outcomes with the SWOT analysis further illustrates how the DNCNR can strategically adapt to sustain its ecological and social systems. The Strengths identified, particularly effective environmental management and waste control, represent the reserve's institutional adaptive capacity, which allows it to respond flexibly to changing environmental pressures (Biggs et al., 2015). However, the Weaknesses, including uneven environmental quality and limited biodiversity visibility, highlight the need for targeted interventions in low-performing areas. The Opportunities stemming from supportive national policies, ASEAN heritage branding, and a growing eco-conscious market offer a favorable context for implementing adaptive strategies that integrate environmental monitoring, digital communication, and participatory conservation (Nguyen et al., 2023). Meanwhile, the Threats such as climate variability, external pollution, and visitor congestion underline the importance of adaptive planning tools like carrying capacity limits, early-warning systems, and climate-resilient infrastructure (Huynh et al., 2025; Jieyao et al., 2025).

This study confirms that sustainable ecotourism development cannot rely solely on conservation efforts; rather, it must involve continuous learning, feedback, and adjustment, hallmarks of adaptive management (Holling, 1978; 2001; Gössling, 2017). The empirical evidence indicates that management effectiveness and environmental quality are not only determinants of immediate tourist satisfaction but also critical levers for building long-term sustainability through adaptive feedback systems. As environmental conditions and visitor profiles evolve under the pressures of urbanization and climate change, adaptive strategies such as community-based monitoring, dynamic zoning, and data-driven decision-making will become

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essential to maintain both ecological resilience and social acceptance. Hence, the reserve's future sustainability lies in its ability to transform scientific understanding of environmental drivers into flexible, inclusive, and evidence-based management practices that continuously align with the principles of adaptive sustainable development.

Despite the contributions of this study, several limitations should be acknowledged, and they provide important avenues for future research. First, the research employed a cross-sectional survey design, which captures tourists' perceptions and behavioral intentions at a single point. While this approach is appropriate for exploratory and explanatory purposes, it limits the ability to infer causal relationships or to observe how perceptions and intentions evolve in response to environmental change, management interventions, or seasonal variation. Longitudinal designs or repeated surveys across different visitation periods would allow future studies to examine dynamic feedback loops between environmental conditions, management actions, and tourist behavior, which are central to adaptive management frameworks. Second, the analysis relied primarily on self-reported perceptions and stated intentions, which may be subject to common method variance and social desirability bias, particularly when surveys are administered on-site within protected areas where pro-environmental norms are salient. Although anonymity was emphasized and enumerators were trained to remain neutral, future research could triangulate perceptual data with objective environmental indicators (e.g., water quality measurements, biodiversity monitoring records), behavioral data (e.g., actual revisit records, length of stay, spending patterns), or experimental designs that manipulate information provision to test causal mechanisms more rigorously. Third, the study focused on a single case site—the DNCNR, a UNESCO Biosphere Reserve—selected for its ecological complexity and management relevance. While this context provides rich insights into adaptive ecotourism governance under rapid urbanization pressure, the single-site design limits the generalizability of the findings to other protected areas with different ecological, institutional, or socio-economic characteristics. Comparative multi-site studies across biosphere reserves, national parks, or community-managed forests in Vietnam and Southeast Asia would enable testing whether the identified environmental drivers operate similarly across contexts or whether institutional arrangements and market conditions moderate these relationships. Fourth, although detailed information on age, education level, and prior visitation experience was collected, these variables were not incorporated as covariates in the final specification, which focused primarily on perceived environmental conditions. As a result, some degree of unobserved heterogeneity or confounding may remain, given that more educated visitors may evaluate environmental quality differently and repeat visitors may possess distinct motivations for revisiting compared with first-time tourists. Future research should therefore employ hierarchical modeling strategies that introduce demographic variables in successive steps to examine their incremental explanatory power and to test whether they moderate the effects of environmental perceptions on revisit intention. Fifth, in the present survey, 68% of respondents were first-time visitors, whereas only 32% had previously visited the DNCNR. For first-time visitors, stated intentions to return are necessarily hypothetical and may reflect novelty effects or momentary enthusiasm rather than durable satisfaction or long-term loyalty. Consequently, the estimated relationships between perceived environmental conditions and revisit intention may be somewhat optimistic and should be interpreted with caution when extrapolating to sustained visitation behavior. Longitudinal studies tracking actual return visits, or subgroup analyses separating first-time and repeat visitors, would strengthen future inference. Finally, although the study is grounded in the Theory of Planned Behavior and the ecological systems perspective, its theoretical contribution is not limited to merely validating existing frameworks. By integrating these theories with an adaptive management lens and empirically operationalizing environmental management as a central mechanism linking ecological conditions to revisit intention, the study advances current understanding of how adaptive capacity functions in ecotourism systems. Nevertheless, future research could further extend theory by incorporating mediating and moderating pathways—such as destination image, environmental interpretation, satisfaction, trust in authorities, perceived crowding, or seasonal dynamics—within structural equation models. Such extensions would allow scholars to move beyond direct-effect models and to examine how environmental attributes translate into behavioral outcomes through psychological and institutional processes.

Conclusion

This study contributes to the growing body of knowledge on adaptive sustainable ecotourism management by empirically examining how environmental conditions shape tourists' sustainable behavior and revisit intentions within the DNCNR. Through the integration of EFA, logistic regression, and SWOT analysis, three environmental dimensions—environmental quality; biodiversity and landscape integrity; and environmental management—were identified as the key determinants of sustainable ecotourism development. Among these, environmental management and quality emerged as the most influential factors, highlighting the decisive role of governance, enforcement, and environmental maintenance in shaping visitor satisfaction, loyalty, and conservation support, while biodiversity contributed indirectly by fostering environmental awareness and emotional connection to nature. The findings emphasize that sustainable ecotourism outcomes depend not only on ecological attributes but also on adaptive management mechanisms that ensure environmental resilience under changing conditions. Moreover, the SWOT synthesis revealed both internal strengths (effective management, eco-awareness programs) and external challenges (pollution inflows, visitor congestion, climate variability), underscoring the need for adaptive environmental governance that links monitoring, community participation, and policy coordination. From a theoretical perspective, this study extends the integration of the Theory of Planned Behavior and the ecological systems perspective by demonstrating how adaptive environmental management functions as a practical mechanism linking environmental

conditions with tourists' behavioral intentions. The proposed analytical framework provides an evidence-based approach that can support sustainable ecotourism planning and adaptive governance in protected areas facing increasing environmental and tourism pressures.

Recommendations

Based on the empirical findings, several recommendations are proposed to strengthen the long-term sustainability of ecotourism in the DNCNR. First, reserve managers should prioritize improvements in environmental management by strengthening waste collection systems, enforcing conservation regulations, expanding environmental education programs, and implementing regular ecological monitoring. Given that environmental management exerts the strongest influence on revisit intention, investments in these areas are likely to generate both conservation and tourism benefits.

Second, greater attention should be given to improving environmental quality through enhanced water quality management, pollution control, noise reduction, and maintenance of landscape aesthetics. Third, biodiversity conservation should be complemented by more effective interpretation programs, guided wildlife observation activities, and visitor education initiatives to enhance tourists' appreciation of ecological values and strengthen their emotional connection with nature.

Finally, policymakers should promote adaptive and evidence-based governance by integrating scientific monitoring, community participation, and cross-sectoral collaboration into ecotourism management. Climate adaptation measures, visitor-flow management, and pollution mitigation strategies should also be incorporated into long-term planning to improve the resilience of protected areas. The analytical framework developed in this study may serve as a practical reference for managers and policymakers seeking to balance biodiversity conservation with sustainable tourism development in Vietnam and other protected areas facing similar environmental challenges.

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