

Developing a demonstration framework for low-carbon ecotourism in national parks within the context of net-zero transformation

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INTRODUCTION

Amid accelerating climate change and global commitments to net-zero emissions, tourism is increasingly recognized as a critical arena for climate governance rather than only an economic and cultural activity. Previous studies estimate that tourism contributes approximately 8–10% of global greenhouse gas emissions, with transportation and accommodation as major sources (Gössling, Scott, & Hall, 2018; Lenzen et al., 2018). The Intergovernmental Panel on Climate Change (IPCC, 2023) further emphasizes that limiting warming to 1.5°C requires rapid and systemic decarbonization across sectors. Under this context, ecotourism in national parks must move beyond low-impact recreation toward measurable carbon reduction, institutional coordination, and policy-oriented governance.

National parks serve multiple functions, including biodiversity conservation, environmental education, visitor management, and ecotourism demonstration. However, current ecotourism practices remain largely focused on environmental friendliness, interpretation, and community participation, while net-zero transition strategies, ESG governance, and carbon accounting mechanisms are not yet fully institutionalized. Existing studies have examined ecotourism benefits (Buckley, 2012; The International Ecotourism Society, 2015), climate adaptation and mitigation in tourism (Scott, Hall, & Gössling, 2016), and collaborative governance (Ansell & Gash, 2008), but an integrated framework linking low-carbon ecotourism, ESG governance, and carbon management in national park contexts remains underdeveloped.

To address this gap, this study develops a demonstration framework for low-carbon ecotourism in national parks under net-zero transformation. It reconceptualizes carbon footprint assessment from a technical measurement tool into a governance-oriented instrument supporting policy design, performance evaluation, and institutional learning. The study asks: (1) What institutional components are required for low-carbon ecotourism in national parks? (2) How can ESG governance integrate net-zero goals with ecotourism practices? (3) How can carbon footprint modules become tools for public governance and policy diffusion?

METHOD

This study adopts a mixed-methods design combining policy analysis, literature review, multiple case studies, semi-structured interviews, carbon footprint modelling, and expert validation. The analytical framework is organized around “net-zero transition × ESG governance × low-carbon ecotourism” and is structured at three levels: the policy level, which examines international climate governance, Taiwan’s net-zero pathway, and protected-area policy; the governance level, which explores ESG integration, stakeholder participation, and collaborative governance mechanisms; and the practice level, which analyzes low-carbon itinerary design, visitor behavior, carbon measurement, and demonstration practices (Geels, 2002; Freeman, 1984; Elkington, 1997).

Data sources include climate policy documents, national park and tourism policy materials, academic literature, representative national park cases, and interviews with approximately 12–20 stakeholders, including park managers, policymakers, local community representatives, tourism operators, and academic experts. Case selection follows purposive sampling and considers ecological diversity and policy relevance, including mountain, wetland, and coastal national park contexts. Data are analyzed through policy analysis, cross-case comparison, and thematic analysis (Braun & Clarke, 2006; Yin, 2018). A modified Delphi method involving 8–12 experts is used to validate the proposed framework, with a consensus threshold of 70%.

A core methodological contribution is the development of a simulation-based tourism carbon footprint module. The functional unit is defined as kgCO₂e per tourist trip, covering five emission

modules: transportation, accommodation, catering, activities, and facilities. The calculation model is: $\text{Carbon} = \text{Activity Data} \times \text{Emission Factor} \times \text{Contextual Weight}$. Emission factors are derived from IPCC guidelines, international databases such as DEFRA, ISO 14064/14067 standards, and relevant tourism carbon literature. To reflect the spatial heterogeneity of national parks, contextual weighting factors are incorporated for mountain, wetland, coastal, lowland, and offshore island settings. This approach balances operational feasibility with policy applicability and enables carbon data to be embedded into governance processes rather than remaining a one-time environmental assessment tool.

FINDINGS

First, the findings indicate that national parks already possess a strong sustainability foundation through ecological interpretation, environmental education, visitor control, and community participation. Nevertheless, net-zero governance remains insufficiently institutionalized. Carbon baselines at the itinerary level, reduction targets, routine monitoring, and disclosure mechanisms are not yet systematically embedded into ecotourism management. As a result, carbon management remains supplementary rather than a core governance function.

Second, transportation is identified as the dominant structural source of emissions, often accounting for the largest share of trip-related carbon output. This result is consistent with tourism carbon research highlighting the importance of mobility systems in decarbonization (Scott et al., 2016; Lenzen et al., 2018). However, low-carbon transportation requires cross-sector coordination among park agencies, transport authorities, local governments, accommodation providers, and visitors. Therefore, transport decarbonization is not only a technical issue but also an institutional coordination challenge.

Third, ESG provides an integrative governance framework for low-carbon ecotourism. The environmental dimension supports carbon measurement, reduction strategies, and resource efficiency; the social dimension strengthens community participation, local value creation, and environmental education; and the governance dimension enables stakeholder coordination, information disclosure, and performance evaluation. This suggests that ESG can evolve from a corporate sustainability tool into a public governance language for national park management.

Fourth, the carbon footprint module improves policy operability by making emissions more visible, comparable, and actionable. Rather than serving only as a calculation exercise, carbon accounting can support itinerary redesign, low-carbon certification, visitor education, and policy prioritization. Through standardization, modularization, and contextual weighting, the module becomes a governance infrastructure that links data, decision-making, and institutional feedback.

Based on these findings, the study proposes a “Three-Level Integration $\times$ Carbon Management Loop” framework. The three levels include: (1) ESG-oriented collaborative governance platforms; (2) institutional tools such as carbon accounting, low-carbon transportation systems, certification schemes, and environmental education mechanisms; and (3) demonstration itineraries as practical sites for experimentation. These levels operate through a carbon management loop of measurement, reduction, offset, redesign, and diffusion. This loop enables low-carbon ecotourism to shift from isolated activities to a scalable governance system.

CONCLUSION

This study contributes to sustainable tourism research by reframing ecotourism from an environmental management practice into an institutional arena for climate governance. It demonstrates that national parks can function as demonstration platforms where carbon management, community participation, visitor education, and governance innovation are integrated. The proposed framework also extends socio-technical transition theory by showing how localized demonstration itineraries may serve as niche innovations that support wider institutional learning and policy diffusion (Geels, 2002).

The study offers three practical implications. First, national park authorities should incorporate carbon reduction into core governance indicators by establishing itinerary-level carbon baselines, low-carbon performance indicators, and regular monitoring mechanisms. Second, ESG-based collaborative platforms should be developed to coordinate public agencies, local communities, tourism operators, and

visitors. Third, simplified and standardized carbon tools should be embedded into itinerary planning, interpretation, certification, and performance disclosure, thereby transforming carbon data into a basis for decision-making and behavioral change.

Overall, the proposed “Three-Level Integration × Carbon Management Loop” framework provides an operational and scalable pathway for low-carbon ecotourism under net-zero transformation. It enables national parks to move beyond conservation-oriented management toward climate-responsive governance and offers a replicable model for sustainable tourism development in the Asia-Pacific region.

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