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UNDERSTANDING NATURE-BASED SOLUTIONS AND ECOLOGICAL COMPENSATION MECHANISMS ON BIODIVERSITY: A COMPARATIVE PERSPECTIVE

COMPREENDENDO AS SOLUÇÕES BASEADAS NA NATUREZA E MECANISMOS DE COMPENSAÇÃO ECOLÓGICA PARA A BIODIVERSIDADE: UMA PERSPECTIVA COMPARADA

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1. INTRODUCTION

This research evaluates the use of Nature-based Solutions (NbS) and Ecological Compensation Mechanisms (ECM) in biodiversity conservation policies in China's Hainan Tropical Rainforest Park. Nature-based Solutions (NbS) refer to strategies that use natural ecosystems to address environmental challenges, while Ecological Compensation Mechanisms (ECM) involve financial or policy incentives to encourage conservation efforts (Seddon et al., 2021). By situating NbS and ECM within conservation policy and policy transfer frameworks, this research examines the effectiveness of the policy of China's Hainan Tropical Rainforest Park with contrast to Singapore's Bukit Timah Nature Reserve and generates insights applicable to other regions facing similar ecological and governance challenges, contributing to global understanding of biodiversity governance and innovative conservation mechanisms.

Rationale & objective

Human activities such as deforestation, urbanization, and industrial development increasingly threaten ecosystems, causing habitat loss and species extinction (Wang; Li, 2021; Zhang et al., 2023). Nature reserves are central to global and Chinese biodiversity conservation, protecting unique species and ecosystems under pressure from economic growth and environmental degradation (Huang et al., 2019; Wang et al., 2023; Xu et al., 2012). Effective management increasingly relies on Nature-based Solutions (NbS) and Ecological Compensation Mechanisms (ECM), which integrate ecosystem restoration, sustainable use, and economic incentives to engage stakeholders and ensure long-term outcomes (Sowińska-Świerkosz; García, 2022; Wang; Xu, 2023; Wan et al., 2022; Hou et al., 2021; Vaissière; Meinard, 2021). Policy transfer—the cross-jurisdictional adaptation of policy ideas (Haupt, 2023) – is vital in conservation, where NbS and ECM are reshaped by institutional and cultural contexts rather than directly replicated (Stone et al., 2020). A comparison between Hainan's government-led reforestation and compensation programs and Singapore's Bukit Timah, managed through strict land-use and ecological infrastructure, illustrates how tropical rainforest conservation strategies diverge while informing future policy learning (Ho et al., 2019; Chatterjea, 2012).

The objective of this study is to evaluate how NbS and ECM shape biodiversity conservation in Hainan Tropical Rainforest National Park, drawing comparative lessons from Singapore's Bukit Timah Nature Reserve to inform more effective and transferable governance strategies.

2. METHODOLOGY

This study will employ mixed methods, including semi-structured interviews, archival analysis, biodiversity data, and surveys. A total of 10–20 interviews (5–10 perreserve) with managers, officials, residents, tourists, and volunteers will explore perceptions of NbS and ECM effectiveness, with responses thematically coded in ATLAS.ti. Archival data will comprise 30–50 policy documents, reports, research articles, and media items per reserve, sourced from government agencies such as China's National Forestry and Grassland Administration and Singapore's National Parks Board, as well as NGOs like IUCN and WWF; analysis will focus on reforestation, financial incentives,

and community engagement, categorized by conservation stage. Biodiversity indicators—including species richness, Shannon Index, vegetation cover, and ecosystem services—will be derived from secondary datasets and analyzed with GIS and R to compare conditions before and after policy implementation. In addition, structured surveys of about 200 respondents (100 per reserve; 40% residents, 30% park users, 20% professionals, 10% policymakers) will use Likert-scale and categorical questions to assess perceived biodiversity outcomes, policy effectiveness, satisfaction, participation, and awareness. The unit of analysis across methods will be individual responses or documents, enabling cross-case comparison of stakeholder perspectives, policy trajectories, and biodiversity impacts. This mixed-methods design ensures triangulation across qualitative and quantitative data, enhancing reliability and validity.

3. RESULTS AND DISCUSSION

As this study is in its early stage, the results presented here are preliminary insights derived from a review of the existing literature, highlighting key research gaps: (1) a lack of policy analysis in biodiversity studies, (2) limited exploration of NbS and ECM within reserve policies, and (3) insufficient comparative analysis between China's reserves and those in other countries.

Although the literature on biodiversity in nature reserves is extensive, it remains reserves and those in other countries. Although the literature on biodiversity in nature reserves is extensive, it remains dominated by ecological and technical approaches, with limited attention to policy dimensions. Studies frequently assess forest restoration through remote sensing (Ni et al., 2023) or analyze soil contamination (Xie et al., 2014), but rarely evaluate the policies shaping these outcomes. Yet conservation success depends heavily on regulatory frameworks governing resource use, human activity, and financial support (Wu et al., 2011). Without incorporating such analysis, research cannot fully inform evidence-based management or the design of effective conservation strategies (Wang et al., 2023; Wu et al., 2011; Cao et al., 2016).

Nature-based Solutions (NbS) and Ecological Compensation Mechanisms (ECM) have gained prominence as innovative conservation tools, but their integration into reserve governance remains underexplored. Existing studies emphasize ecosystem services and climate mitigation (Sowińska-Świerkosz; García, 2022) or focus on economic spillovers such as tourism (Wan et al., 2022; Hua; Pereira, 2023; Ma et al., 2019).

ECM research often highlights fiscal dependence, efficiency deficits, and overlapping compensation targets. (Ma et al., 2019) However, little attention has been given to how NbS and ECM can be operationalized within the governance structures, stakeholder dynamics, and socio-ecological contexts of protected areas (Hou et al., 2021; Wan et al., 2022).

Despite China's progress in developing reserves, most scholarship remains domestically focused. Research such as Yao's (2024) study on Hainan Tropical Rainforest National Park illustrates advances in ecosystem service assessment but offers little in the way of international comparison. Cross-country studies could reveal divergences from global best practices, identify transferable strategies, and strengthen collaborative approaches to biodiversity governance. Addressing these three gaps in policy analysis, NbS and ECM application, and comparative perspectives is essential to improving both scholarly understanding and the practical effectiveness of conservation in China's reserves.

4. CONCLUSIONS

This research achieves its objective by comparing Hainan Tropical Rainforest National Park and Singapore's Bukit Timah Nature Reserve to assess how governance, socio-economic priorities, and legal frameworks shape conservation policies. By evaluating the effectiveness of NbS and ECM through biodiversity and ecosystem service outcomes, and by examining the institutional and community factors that condition their success, the study identifies transferable lessons from Singapore's integrated urban–ecological model to strengthen future conservation strategies in China and other developing countries.

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