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EDITORIAL

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Co-Producing Coastal Sustainability Through Higher Education

Hsiao-Chien Lee [1], Kuei-Chao Chang [2], and Wen-Hong Liu [1]

[1] Department of Fisheries Technology and Management, National Kaohsiung University of Science and Technology, Taiwan
[2] Ocean Affairs Council, Taiwan

Correspondence: Wen-Hong Liu (andersonliu@nkust.edu.tw)

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Abstract

Coastal regions are undergoing rapid environmental and socio-economic transformations, driven by climate change, demographic shifts, and evolving human–ocean interactions. Despite growing scientific knowledge, significant gaps persist in understanding and governing the complex interdependencies between marine ecosystems and human societies. These gaps reflect a broader disconnect between knowledge production, policy implementation, and community practice. In response, sustainability science has increasingly emphasized knowledge co-production and transdisciplinary approaches, which highlight collaborative, context-sensitive, and action-oriented processes involving scientists, policymakers, and societal actors. Within this evolving landscape, environmental governance is being reconfigured as a dynamic process of social learning, negotiation, and adaptation, rather than a purely technocratic exercise. Higher education institutions are emerging as key intermediary platforms that facilitate such processes by connecting science, policy, and society through community-engaged and real-world learning approaches. This thematic issue brings together six case-based studies that examine how these shifts toward co-production, adaptive governance, and institutional innovation are realized in diverse coastal contexts. Collectively, the contributions demonstrate how universities and multi-stakeholder collaborations help bridge the gap between knowledge and action, supporting more integrated, participatory, and context-responsive approaches to sustainability transitions.

Keywords

coastal sustainability; higher education; knowledge co-production; social-ecological systems; sustainability transitions; transdisciplinary research

1. Introduction

Coastal communities and their environments are undergoing rapid and far-reaching transformations. Global shifts in demographics, climate patterns, hydrological systems, and ocean conditions are increasingly reshaping coastal economies, social structures, and ecosystems (Intergovernmental Oceanographic Commission, 2020; Intergovernmental Panel on Climate Change, 2022). These changes not only intensify environmental pressures—such as ocean warming, biodiversity loss, and coastal degradation—but also expose underlying socio-economic vulnerabilities within coastal regions (Bennett et al., 2021). Addressing these interconnected challenges requires approaches that move beyond sectoral management toward the sustainable use and conservation of marine and coastal resources in ways that support ecological integrity, economic vitality, and social resilience.

Despite growing scientific knowledge, significant gaps remain in understanding and governing the complex interdependencies between marine ecosystems and human societies (Folke et al., 2005; Norström et al., 2020). Even where evidence-based strategies for mitigating ecosystem degradation exist, they are often insufficiently integrated into policy and management frameworks (Cvitanovic et al., 2015). In many cases, existing governance approaches remain fragmented and struggle to foster effective collaboration among diverse stakeholders, often resulting in limited or symbolic outcomes (Bodin, 2017). These limitations reflect a deeper structural challenge: the persistent disconnect between knowledge production, policy implementation, and community practice.

In response, there is increasing recognition that sustainability transitions require not only improved knowledge, but new modes of knowledge production and governance. In particular, knowledge co-production has emerged as a central framework in sustainability science, emphasizing the collaborative generation of knowledge among scientists, policymakers, and societal actors (Norström et al., 2020). Closely related, transdisciplinary research highlights the integration of diverse knowledge systems and the co-design of solutions that are context-sensitive and action-oriented (Mauser et al., 2013). Together, these approaches shift the focus from knowledge as an output to knowledge as a relational and iterative process embedded in governance.

Within this perspective, environmental governance is increasingly understood as a process of social learning, negotiation, and adaptation, rather than a purely technical or institutional exercise (Folke et al., 2005). Effective governance therefore depends not only on formal policies and regulatory frameworks, but also on the capacity to bridge knowledge systems, facilitate stakeholder collaboration, and translate knowledge into practice across scales.

Within this evolving landscape, higher education institutions are emerging as key actors in sustainability transitions. Beyond their traditional roles in teaching and research, universities are increasingly positioned as intermediary platforms for knowledge co-production, connecting science, policy, and society (Benneworth & Nieth, 2018; Trencher et al., 2014). Through community-engaged and real-world learning approaches, including project-based and service learning, universities foster interdisciplinary collaboration and cross-sector partnerships, thereby contributing to the co-creation of knowledge and the development of context-sensitive solutions to complex coastal challenges (Brundiers et al., 2010; Mauser et al., 2013).

This thematic issue brings together a set of case-based studies that examine how these shifts toward co-production, transdisciplinary collaboration, and adaptive governance are being realized in diverse coastal contexts. The contributions collectively illustrate how environmental governance is being reconfigured through the integration of knowledge systems, stakeholder participation, and institutional innovation. By emphasizing practical experiences and social impacts, the issue highlights the critical role of universities and collaborative processes in bridging the gap between knowledge and action in sustainability transitions.

2. This Thematic Issue

The six articles included in this thematic issue collectively address the pressing challenges faced by coastal regions under the impacts of climate change and sustainability transitions.

Taken together, they present a coherent trajectory from macro-level environmental pressures to localized governance practices, and further toward the evolving role of higher education in sustainability. Importantly, this trajectory can be understood through the lens of knowledge co-production and transdisciplinary governance, which highlights how environmental change, governance transformation, and institutional innovation are mutually reinforcing.

The thematic issue begins with a systemic perspective on ocean governance. Shih examines expert perceptions of climate-related impacts on marine ecosystems through a mixed-methods design combining a survey of 70 experts with in-depth semi-structured interviews. The study identifies ocean warming, acidification, and biodiversity loss as the most critical threats, with strong consensus among experts regarding their severity. At the same time, governance frameworks are evaluated as only moderately effective, with respondents pointing to fragmented institutional responsibilities, weak enforcement, and limited adaptive flexibility. Importantly, the study highlights a persistent gap between policy ambition and implementation, particularly in relation to community engagement, financial constraints, and the marginalization of local knowledge. This suggests that governance challenges are not merely technical, but institutional and social, reinforcing the need for more adaptive, coordinated, and participatory governance systems.

Building on this foundation, subsequent studies examine governance in specific coastal contexts. Reyes et al. analyze the Guandu Wetlands in Taiwan through the IUCN Global Standard for Nature-based Solutions, drawing on stakeholder interviews with government agencies, conservation organizations, and site managers. By applying the eight Nature-based Solutions criteria, the study provides a structured evaluation of governance performance, revealing differing stakeholder priorities and trade-offs between ecological conservation, socio-economic demands, and institutional feasibility. While dimensions such as adaptive management and design at scale receive relatively strong evaluations, economic sustainability and long-term monitoring remain weak. The findings illustrate how global governance frameworks are interpreted and negotiated within local contexts, where resource constraints and institutional fragmentation shape implementation. In this process, universities and research institutions emerge as key knowledge intermediaries that support monitoring, coordination, and evidence-based decision-making. This can be understood as part of broader knowledge co-production dynamics, where global frameworks are interpreted and negotiated through local stakeholder interactions (Norström et al., 2020).

Similarly, Yu et al. evaluate governance effectiveness in the Qingluo Wetland in Penghu using the Management Effectiveness Tracking Tool. Based on 30 indicators assessed through focus group discussions with stakeholders from government, NGOs, academia, and local communities, the study finds an overall moderate level of effectiveness. While legal frameworks and conservation objectives are clearly established, implementation is constrained by limited human resources, unstable funding, and insufficient community engagement—challenges that are particularly acute in offshore island settings. The study further highlights tensions between conservation goals and local development needs, reflecting broader structural dilemmas in coastal governance. Importantly, Yu et al. introduce university social responsibility as a complementary mechanism, positioning universities as "knowledge nodes" that facilitate co-learning, student engagement, and cross-sector collaboration. This reframes governance as a more integrated and participatory process that extends beyond top-down regulatory approaches. In this context, university social responsibility initiatives can also be seen as transdisciplinary platforms that facilitate co-learning and bridge institutional and societal knowledge systems (Mauser et al., 2013).

Extending beyond formal governance frameworks, Chang shifts the focus to collaborative governance and knowledge co-production in the Caota Sand Dunes Geopark. Using a qualitative case study approach that combines document analysis, participant observation, and interviews, the study examines how local knowledge is generated, translated, and institutionalized within coastal governance processes. The transformation of the site—from a degraded landscape affected by industrial activity to a geopark shaped by multi-stakeholder collaboration—illustrates how governance emerges through ongoing negotiation and adaptation. A key contribution lies in highlighting the integration of local experiential knowledge, such as observations of environmental change, with scientific data through practices like citizen science and participatory monitoring. In addition, cultural translation—through storytelling, walking-based education, and visual media—plays a crucial role in making the landscape accessible and meaningful to the public. At the same time, the study identifies structural challenges, including fragmented institutions and reliance on short-term project funding, underscoring the difficulty of sustaining participatory governance while preserving the contextual richness of local knowledge. This case exemplifies knowledge co-production in practice, where local experiential knowledge, scientific data, and cultural narratives are continuously integrated through ongoing and participatory processes (Mauser et al., 2013; Norström et al., 2020).

Against this backdrop, the thematic issue also foregrounds the growing role of higher education in sustainability and regional development. Lee et al. examine Taiwan–Japan cross-cultural collaborative workshops as a form of experiential and comparative learning. Using a qualitative-dominant mixed-methods approach—including interviews, participant observation, instructor reflections, and post-program surveys—the study explores how students interpret local issues, collaborate across cultures, and develop action-oriented thinking. The findings show that students deepen their understanding of sustainability by comparing different regional contexts, recognizing how demographic trends, cultural identity, and institutional histories shape development pathways. In addition to cognitive gains, students demonstrate significant growth in intercultural communication competence, the ability to navigate trilingual environments, and increased sensitivity to feasibility and community needs. The study also highlights the importance of pedagogical design, including pre-departure preparation, structured field engagement, and post-program reflection, suggesting that sustainability learning is most effective when embedded in real-world, interactive, and cross-cultural contexts. From this perspective, cross-cultural collaborative learning can be understood as a form of transdisciplinary practice, where students actively engage in

knowledge co-production by integrating diverse cultural perspectives and contextual insights into sustainability problem-solving (Mauser et al., 2013).

Finally, Weiss et al. provide a long-term institutional perspective through the case of the University Centre of the Westfjords in Iceland. Drawing on a 20-year longitudinal case study and an insider research approach, the study examines how a higher education institution contributes to regional development in a remote coastal context. With nearly 300 graduates and a strong tendency for students to remain in the region, the university plays a critical role in addressing demographic challenges such as outmigration and skill shortages. Beyond human capital, the institution contributes to broader forms of community capital, including cultural vitality, entrepreneurship, and social cohesion. Conceptually, the study situates the university within the frameworks of peripheral higher education institutions and neo-endogenous development, emphasizing its role as a locally embedded yet globally connected platform. At the same time, it highlights tensions related to funding, governance, and the balance between academic priorities and regional engagement, offering a nuanced understanding of universities as both enabling and constrained actors in regional transformation. This highlights the institutional dimension of knowledge co-production, where universities serve as long-term platforms for sustaining collaborative knowledge systems and enabling regionally embedded yet globally connected development pathways.

Overall, these contributions collectively reveal a clear trajectory: Under the pressures of climate change, coastal environmental governance is shifting from top-down, technocratic models toward more adaptive, participatory, and knowledge-integrated approaches. Such transformation reflects a broader shift toward knowledge co-production and transdisciplinary governance, where sustainability challenges are addressed through collaborative and context-sensitive processes that bridge science, policy, and society (Mauser et al., 2013; Norström et al., 2020).

Within this transformation, higher education institutions are no longer positioned solely as knowledge providers but as active participants, facilitators, and institutional bridges. By enabling co-learning, supporting stakeholder engagement, and connecting global frameworks with local practices, universities play a crucial role in translating knowledge into action. In doing so, they contribute not only to environmental governance but also to the broader reconfiguration of how knowledge is produced, shared, and applied in sustainability transitions.

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Conflict of Interests

The authors declare no conflict of interests.

Data Availability

The data are not publicly available due to privacy considerations.

LLMs Disclosure

LLM tools (e.g., ChatGPT) were used for language editing and translation support.

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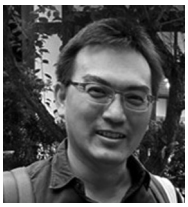
About the Authors

Hsiao-Chien Lee is a professor at National Kaohsiung University of Science and Technology. Her research focuses on university social responsibility, regional revitalization, ocean sustainability, and fishery literacy education, with an emphasis on place-based learning and international collaboration.



Kuei-Chao Chang is a researcher specializing in sustainable coastal development, focusing on public-private partnerships and policy innovation. His work integrates science and governance to enhance community resilience and advance practical solutions for long-term sustainability.

Wen-Hong Liu is a Distinguished Professor at National Kaohsiung University of Science and Technology. His research focuses on ocean governance, fisheries sustainability, and marine technology applications, with recent work on coral monitoring, smart marine technologies, and offshore wind energy development.

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ARTICLE

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Assessing the Impact of Climate Change on Ocean Governance and Coastal Adaptation

Yi-Che Shih

Institute of Ocean Technology and Marine Affairs, National Cheng Kung University, Taiwan

Correspondence: Yi-Che Shih (shih@gs.ncku.edu.tw)

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Abstract

This study examines expert perceptions of the impacts of climate change on ocean ecosystems and the associated challenges for ocean governance and coastal adaptation. Drawing on a mixed-methods expert-elicitation approach combining a survey of 70 experts with qualitative interviews, the research identifies ocean warming, ocean acidification, and biodiversity loss as the most critical climate-related threats to marine systems. Rather than conducting a policy-by-policy evaluation, the study explores how experts assess the perceived effectiveness, limitations, and adaptive capacity of existing international and national ocean governance frameworks, based on their professional experience. The findings indicate a strong consensus on the urgency of strengthening governance arrangements, enhancing international collaboration, and improving adaptive and flexible policy responses. Barriers to community engagement—particularly limited awareness and financial constraints—are highlighted as persistent challenges for coastal adaptation. By integrating quantitative patterns with qualitative insights, this study contributes to the scholarship on ocean governance by clarifying expert-identified governance gaps and priority areas for climate-resilient ocean governance.

Keywords

climate change; coastal adaptation; impact; mitigation; ocean ecosystems; ocean governance

1. Introduction

Climate change, driven primarily by anthropogenic activities, has emerged as one of the most pressing global challenges of the 21st century (Berrang-Ford et al., 2011; Lee et al., 2023). Rising temperatures, melting ice

caps, and altered precipitation patterns have triggered widespread ecosystem change worldwide (Dutton et al., 2015; Grimm et al., 2013; Williams et al., 2021). One of the most vulnerable and ecologically diverse ecosystems facing the brunt of these changes is the world's oceans (Bijma et al., 2013). Oceans cover more than 70% of the Earth's surface, regulating climate, supporting biodiversity, and providing livelihoods for millions of people across the globe (Alverson, 2012; Halpern et al., 2015). However, these vital marine ecosystems are under threat due to climate change-induced phenomena such as ocean acidification, sea-level rise, and altered marine currents (Feely & Doney, 2011; V. Gray, 2007).

In the face of these challenges, effective ocean governance has become imperative (Haas et al., 2022). Ocean governance encompasses a range of activities, from policy formulation to international agreements, aimed at conserving and sustainably managing marine resources (Winther et al., 2020). Addressing climate change impacts on oceans requires comprehensive governance frameworks that transcend national boundaries and integrate scientific knowledge with policy-making (Jaeckel et al., 2017). Moreover, coastal communities—often the most directly affected by climate change-induced hazards such as storm surges and coastal erosion—require adaptive strategies that are socially, economically, and ecologically viable (Adger, 2015; Eisenack et al., 2014; Reed et al., 2009). Recent scholarship further suggests that achieving climate-resilient ocean governance depends on strengthened international collaboration and adaptive polycentric governance arrangements that complement existing institutional frameworks (Kim, 2024; Yadav & Gjerde, 2020). Over the past two decades, ocean governance has evolved through a combination of international legal instruments, regional agreements, and national policy frameworks aimed at conserving marine ecosystems and promoting sustainable use (Bennett et al., 2025; Haas et al., 2022; Haward & Vince, 2009; Rudolph et al., 2020; Shih, 2024). Notable achievements include the establishment of global norms under instruments such as UNCLOS, the expansion of marine protected areas, and growing recognition of integrated and ecosystem-based management approaches. These efforts have improved scientific cooperation, data sharing, and policy coordination across jurisdictions. However, substantial governance challenges persist. Implementation remains uneven across regions, enforcement capacity is often weak, and many governance arrangements struggle to respond adaptively to accelerating climate-driven risks such as sea-level rise, ocean warming, and ecosystem degradation. Fragmented institutional responsibilities and mismatches between ecological processes and administrative boundaries further limit governance effectiveness. Against this backdrop, understanding how experts perceive the strengths, limitations, and priorities of existing ocean governance frameworks is essential for informing future climate-resilient governance pathways.

2. Methods

2.1. Research Design and Methodological Approach

This study adopts a mixed-methods expert-elicitation design, combining semi-structured interviews with a structured expert survey to examine perceptions of climate change impacts on ocean ecosystems, ocean governance frameworks, and coastal adaptation strategies. Expert elicitation is widely used in climate governance and adaptation research to capture informed judgments in contexts characterized by uncertainty, complexity, and limited empirical observability (Parmesan et al., 2013; Spalding & de Ycaza, 2020; Tvinnereim & Fløttum, 2015).

Expert elicitation is widely used in climate governance and adaptation research to capture informed judgments where policy effectiveness, governance capacity, and emerging risks cannot be fully assessed through quantitative indicators alone. Semi-structured interviews were employed to generate in-depth qualitative insights into perceived governance gaps, adaptation challenges, and institutional constraints, while the structured survey enabled the systematic comparison of expert assessments across key dimensions such as perceived severity of impacts, governance effectiveness, urgency, and collaboration needs.

The integration of qualitative thematic analysis with quantitative descriptive and inferential statistics allows for methodological triangulation, strengthening the robustness of the findings. Importantly, this design aligns with the study's objective, which is not to evaluate specific policies or institutions, but rather to identify expert-informed priorities, perceived governance limitations, and strategic directions relevant to climate-resilient ocean governance.

2.2. Participant Selection and Ethical Considerations

Participants were selected using purposive sampling, targeting individuals with demonstrated professional expertise in marine science, climate policy, ocean governance, coastal management, or related fields. Inclusion criteria required participants to have: a minimum of five years of professional or research experience related to oceans or coastal systems; and active involvement in research, policy analysis, governance, or management related to climate change, marine ecosystems, or coastal adaptation.

A total of 70 experts participated in both the survey and interview components of the study. Participants represented diverse professional backgrounds, including academia, government agencies, policy advisory bodies, and applied coastal management organizations.

All participants received an information sheet outlining the study objectives, data usage, and confidentiality provisions. Informed consent was obtained prior to participation. Responses were anonymized, and no personally identifiable information was retained. The study received approval from the relevant institutional ethics review board.

2.3. Semi-Structured Interviews: Design and Themes

Semi-structured interviews were conducted to elicit in-depth qualitative insights into expert assessments of climate change impacts and governance challenges. The interview guide was informed by prior studies on climate impacts, adaptation, and ocean governance (Kim, 2024; Oliver & Morecroft, 2014; Spalding & de Ycaza, 2020). In this study, a "precisely planned interview" refers to a semi-structured interview design based on a predefined interview guide, in which the core questions, thematic domains, and analytical objectives were established in advance. The interview guide was developed directly from the study's research questions and relevant literature on climate change impacts, ocean governance, and coastal adaptation.

Four overarching thematic domains guided the interviews:

1. Perceived climate change impacts on ocean ecosystems (e.g., ocean warming, acidification, and biodiversity change).

2. Effectiveness and limitations of existing ocean governance frameworks, including international and national arrangements.
3. Assessment of coastal adaptation strategies, including engineered, policy-based, and community-based approaches.
4. Governance and societal challenges, including institutional fragmentation, enforcement capacity, and community engagement.

The semi-structured format ensured thematic consistency across interviews, while allowing flexibility for participants to introduce context-specific examples and emergent issues.

2.4. Survey Design and Variables

A structured online survey was administered to the same group of experts to quantitatively assess perceptions identified in the qualitative phase. The survey design was informed by previous expert perception studies in climate and environmental governance (Ding et al., 2017; Tvinnereim & Fløttum, 2015).

Key variables included: (a) perceived severity of climate change impacts (e.g., ocean warming, acidification, and biodiversity loss); (b) perceived effectiveness of ocean governance frameworks; (c) perceived urgency of strengthening ocean governance; (d) perceived importance of international collaboration; (e) confidence in different coastal adaptation strategies; and (f) perceived barriers to community engagement.

Most variables were measured using Likert-scale items, complemented by selected open-ended questions to contextualize responses.

2.5. Data Analysis

2.5.1. Qualitative Analysis

Interview transcripts and open-ended survey responses were analyzed using thematic analysis. An initial coding framework was developed deductively based on the interview themes and research questions, followed by inductive refinement to capture emergent patterns. Codes were grouped into higher-order categories corresponding to climate impacts, governance effectiveness, adaptation strategies, and societal challenges.

This qualitative analysis directly addressed research questions 1–4 by identifying recurring expert narratives, areas of convergence and divergence, and perceived governance gaps.

2.5.2. Quantitative Analysis

Quantitative survey data were analyzed using descriptive and inferential statistical techniques. Descriptive statistics (means, medians, and standard deviations) were used to summarize overall expert perceptions.

To examine relationships between key variables, the following analyses were conducted:

- Spearman's rank correlation and Pearson's correlation to assess associations between perceived government proactivity and urgency of ocean governance.
- Chi-square tests to examine associations between expertise level and frequency of encountering climate change impacts.
- Crosstabulation analyses to explore relationships between collaboration essentiality and perceived governance effectiveness.

Each statistical analysis was explicitly aligned with the relevant research question to ensure analytical coherence and methodological appropriateness.

3. Results

3.1. Expert Perceptions of Climate Change Impacts and Ocean Governance

Among the 70 experts surveyed, rising sea temperatures were identified as the most significant climate change-induced threat to ocean ecosystems, with 64.3% of respondents (n = 45) ranking this factor as their primary concern. Ocean acidification was identified as the most critical threat by 21.4% of experts (n = 15), while 14.3% (n = 10) highlighted biodiversity loss as their main concern.

Regarding the frequency of encountering climate change-related impacts in their professional activities, 40% of respondents (n = 28) reported occasional encounters, 28.6% (n = 20) reported rare encounters, and 21.4% (n = 15) reported frequent encounters. Only 10% (n = 7) indicated that they had never encountered such impacts in their work.

In terms of awareness of existing ocean governance policies and frameworks, 55% of experts (n = 39) considered themselves well informed, while 30% (n = 21) reported moderate awareness and 15% (n = 10) indicated limited awareness.

Assessments of current ocean governance frameworks indicated mixed perceptions of effectiveness. Half of the respondents (50%, n = 35) perceived existing frameworks as moderately effective, whereas 32% (n = 22) viewed them as ineffective. Only 18% (n = 13) considered current governance arrangements to be highly effective.

Despite these mixed evaluations, there was a strong consensus on the urgency of strengthening ocean governance. A total of 91% of experts (n = 64) rated the urgency of enhancing ocean governance as high or extremely high. Similarly, international collaboration was viewed as essential, with 88% of respondents (n = 62) assigning scores of 6 or 7 on a 7-point Likert scale, underscoring widespread agreement on the need for coordinated global responses to climate change impacts on ocean systems.

3.2. Qualitative Insights From Expert Interviews

Qualitative analysis of semi-structured interviews and open-ended survey responses provided deeper insights into expert perceptions of climate change impacts, governance challenges, and adaptation barriers.

As summarized in Table 1, experts consistently identified ocean warming as a systemic driver of ecological change, intensifying coral bleaching, altering species distributions, and amplifying other stressors such as ocean acidification. Biodiversity loss was frequently discussed in relation to cascading effects across marine food webs and ecosystem stability.

Table 1. Guiding questions, emergent themes, and illustrative expert quotations.

Guiding question	Emergent theme	Illustrative expert quote
What do you perceive as the primary climate change-induced threats to ocean ecosystems?	Ocean warming as a systemic driver	Rising sea temperatures are not just an isolated stressor—they intensify coral bleaching, alter species distributions, and amplify other pressures such as acidification
	Ocean acidification and ecosystem fragility	Acidification fundamentally changes ocean chemistry and threatens shell-forming species and ecosystem stability
	Biodiversity loss and food-web disruption	Cascading effects across marine food chains are becoming increasingly evident as key species decline or migrate
How effectively do you think existing policies and governance frameworks address climate change impacts on ocean ecosystems?	Governance ambition, but implementation gap	There are strong international agreements on paper, but enforcement and coordination remain weak at the national level
	Fragmented institutional responsibilities	Ocean governance is divided across agencies that often lack effective coordination, slowing adaptive responses
	Need for adaptive and flexible governance	Governance frameworks were not designed for rapid climate change and must become more adaptive and forward-looking
What are the primary barriers to community engagement in coastal adaptation efforts?	Limited awareness and risk perception	Many coastal communities do not perceive climate change as an immediate risk, which limits proactive adaptation
	Financial and resource constraints	Even when awareness exists, the costs of adaptation measures often exceed local financial capacity
	Cultural resistance and institutional exclusion	Top–down planning frequently overlooks local knowledge, reducing community ownership and engagement
How urgent is it to enhance ocean governance and coastal adaptation efforts in response to climate change impacts?	High urgency and time sensitivity	Environmental change is occurring faster than governance systems can respond, creating serious risks
	Need for targeted, place-based interventions	Vulnerable regions require tailored and immediate governance responses rather than generic solutions

Note: The guiding questions shown represent core prompts used across semi-structured interviews and open-ended survey items. Interviews were thematic and included follow-up and probing questions depending on participants' expertise.

Experts highlighted a persistent gap between governance ambition and implementation. While international agreements were often described as well-designed in principle, interviewees emphasized weak enforcement, fragmented institutional responsibilities, and limited adaptive capacity at the national and sub-national levels. Many experts noted that existing governance frameworks were not designed to respond to the pace

and uncertainty associated with climate change, reinforcing calls for more flexible and forward-looking governance arrangements.

Barriers to community engagement in coastal adaptation were also emphasized. Limited awareness and risk perception were commonly cited, alongside financial constraints that restrict the ability of local communities to implement adaptation measures. Several experts further highlighted cultural resistance and top–down planning approaches that marginalize local knowledge and reduce community ownership of adaptation initiatives.

Across interviews, there was near-unanimous agreement on the urgency of enhancing ocean governance and coastal adaptation. Experts stressed that climate-driven changes are occurring faster than governance systems can respond, increasing risks for vulnerable ecosystems and coastal communities and underscoring the need for timely, place-based governance interventions.

3.3. Quantitative Analysis

Most respondents, comprising 45% of the participants, were moderately knowledgeable, signifying a substantial understanding of the subject matter. This diverse range of expertise among the respondents allowed for comprehensive insights into the perceptions and attitudes concerning climate change impacts on ocean ecosystems and coastal adaptation strategies.

3.3.1. Primary Threat to Ocean Ecosystems

Upon delving into the primary climate change-induced factors threatening ocean ecosystems, rising sea temperatures emerged as the most significant concern among experts. This consensus was robust, with 64.3% of participants ranking it the top threat. Ocean acidification and loss of marine biodiversity followed closely, with 21.4% and 14.3% of respondents, respectively, highlighting these factors. These findings underscore the gravity of rising sea temperatures as a critical issue demanding immediate attention and comprehensive solutions.

3.3.2. Frequency of Climate Change-Related Impacts

Experts reported sporadically encountering climate change-related impacts on ocean ecosystems in their professional work. The intermittent nature of these events was noted, with 40% of respondents indicating occasional encounters and 28% reporting rare incidents. While not daily occurrences, these events remained significant, emphasizing the sporadic yet impactful nature of climate-driven changes in ocean ecosystems.

3.3.3. Awareness of Policies and Governance Effectiveness

Regarding awareness of international agreements and national policies related to ocean governance and climate change mitigation/adaptation, 55% of participants considered themselves well-informed. However, a notable portion, constituting 30% of respondents, revealed a need for more awareness in this area. This discrepancy highlights existing gaps in knowledge dissemination, indicating a need for more targeted efforts in education and information sharing within the expert community.

3.3.4. Effectiveness of Current Ocean Governance Frameworks

Participants generally perceived current ocean governance frameworks as moderately effective. This moderate rating, provided by 50% of the experts, indicated the need for continuous improvements to effectively address challenges arising from climate change impacts on oceans. This feedback emphasizes the importance of refining existing governance structures to enhance their efficacy in the face of evolving climate-related challenges.

3.3.5. Essentiality of Collaboration and Adaptability of Frameworks

The survey revealed a unanimous consensus among experts on the essentiality of international collaboration to address climate change impacts on ocean governance. On a scale from 1 to 7, where 7 signifies *extreme essentiality*, the average rating for the importance of international collaboration was 6.5, indicating a high degree of consensus on the necessity for global cooperation. Additionally, the adaptability of current ocean governance frameworks was rated moderately high, averaging at 5.8. While indicating a certain degree of flexibility, these responses also suggested room for enhancements to address emerging climate-related issues effectively.

3.3.6. Preferred Coastal Adaptation Measures and Barriers to Community Engagement

Engineered solutions were resoundingly considered the most viable and sustainable coastal adaptation measure, with 68% of respondents expressing this preference. This preference for technological interventions highlighted experts' faith in engineered solutions to mitigate climate change impacts on coastal areas. Simultaneously, lack of awareness and education emerged as the primary barriers to community engagement in coastal adaptation efforts, as indicated by 42% of the respondents. This finding underscores the importance of public education initiatives in fostering community participation and overcoming barriers to engagement.

3.3.7. Confidence in Engineering Solutions and Support for Policy-Based Measures

Experts expressed moderate to high confidence in the effectiveness of current coastal engineering solutions. With 48% of participants indicating high confidence and 32% expressing moderate confidence, there exists a substantial level of trust in these measures. Additionally, 60% of the experts reported a likelihood to professionally support policy-based coastal adaptation measures, highlighting their openness to engage with regulatory and policy initiatives.

3.3.8. Government Proactivity, Urgency, and Optimism and Public Awareness Significance

Perceptions of government proactivity in implementing policies that address climate change impacts on coastal areas varied among respondents. While 35% perceived government efforts as moderately proactive, indicating a moderate confidence level, there is room for improvement to enhance governmental initiatives further. There was unanimous agreement among experts on the urgency to enhance ocean governance and coastal adaptation efforts in response to climate change impacts. On a scale from 1 to 7, the average urgency rating was 6.8, emphasizing the pressing nature of this issue and the need for immediate

action and comprehensive strategies. However, optimism about the future effectiveness of ocean governance and coastal adaptation measures varied among experts, ranging from low optimism to high optimism. These diverse viewpoints underscore the complexity of the challenge and the need for nuanced, context-specific approaches.

3.4. Qualitative Analysis

In-depth qualitative exploration provided nuanced insights into experts' perspectives on climate change impacts on ocean ecosystems. Interviews were instrumental in capturing the complexities of their views. Table 1 showcases critical questions posed to the experts, unveiling their nuanced responses, thereby enriching the qualitative dimension of the study.

3.4.1. Open-Ended Questions

Regarding the primary climate change-induced threats, a variety of concerns were raised. Rising sea temperatures emerged as a significant worry, emphasizing their adverse effects on marine species and ecosystems. Ocean acidification was underscored for its detrimental impact on shell-forming organisms, while the loss of marine biodiversity was highlighted, raising concerns about disruptions in food chains and ecosystems. Some experts also linked the increased frequency of extreme weather events to coastal erosion and habitat destruction, further emphasizing the complexity of climate-driven challenges.

Opinions on the effectiveness of existing policies and governance frameworks varied widely. While certain international agreements received praise, criticism was directed at their enforcement. Gaps in national policies were noted, raising concerns about insufficient regulations to curb overfishing and pollution. The need for more stringent enforcement mechanisms and increased international cooperation was emphasized to effectively address policy shortcomings.

Barriers to community engagement in coastal adaptation efforts were identified, highlighting obstacles faced during implementation. Lack of awareness was a common issue, with communities often underestimating the urgency of climate change impacts. Financial constraints created significant challenges due to the high costs of implementing adaptive measures. Cultural factors, including resistance to change in traditional coastal communities, emphasized the need for culturally sensitive approaches. Additionally, bureaucratic hurdles and limited community involvement in policy-making processes were major obstacles that hindered effective engagement.

Experts unanimously emphasized the need for immediate action to improve ocean governance and coastal adaptation efforts. They highlighted the rapid pace of climate change and its serious impacts on coastal communities and ecosystems. Rising sea levels and more frequent extreme weather events were identified as urgent threats that demand quick responses. Vulnerable regions were specifically pointed out, emphasizing the importance of targeted, timely measures to avoid irreversible damage.

3.4.2. Interviews

In-depth interviews with experts provided valuable insights into observed changes in ocean ecosystems due to climate change. During these interviews, experts noted coral reef bleaching caused by rising sea

temperatures, highlighting the loss of vibrant marine life. They attributed shifts in fish species' migration patterns to changing ocean conditions, thus illustrating the dynamic nature of marine ecosystems. Discussions on coastal erosion affecting local communities emphasized the need for immediate protective measures. These real-life examples illuminated the tangible impact of climate change on ocean ecosystems, reinforcing the urgency for comprehensive strategies.

Experts viewed international collaborations from different perspectives. They shared successful joint research projects and information exchanges, showing the positive results of global cooperation. However, they also expressed frustrations about bureaucratic delays and a lack of funding that hinder collaborative efforts. The need for a unified global approach and the diversity of national priorities were recognized. Despite these challenges, experts stressed the importance of ongoing international efforts, highlighting the interconnectedness of ocean ecosystems and the necessity for coordinated responses.

The critical role of local communities in shaping effective coastal adaptation strategies was emphasized throughout the interviews. Experts recognized residents as repositories of valuable traditional knowledge about coastal ecosystems and adaptation practices. They stressed the essentiality of involving local communities in decision-making processes to ensure the sustainability and cultural appropriateness of adaptation measures. Community engagement catalyzes behavioral change, underscoring the importance of education and awareness initiatives tailored to specific local contexts (Galappaththi et al., 2024; Hügel & Davies, 2020). The interviews highlighted the necessity of empowering local communities to actively participate in adaptation planning and implementation processes, reflecting the holistic approach needed for practical coastal adaptation efforts.

4. Statistical Analysis

Table 2 illustrates a detailed crosstabulation between respondents' perceptions of government proactivity (categorized as "not proactive at all," "moderately proactive," and "very proactive") and the corresponding levels of urgency attributed to ocean governance (ranging from "not urgent at all" to "extremely urgent").

Table 2. Crosstabulation between government proactivity and urgency of ocean governance.

Government Proactivity—Urgency Ocean Governance Crosstabulation									
Count									
		Urgency ocean governance							Total
		Not urgent at all	Very low urgency	Low urgency	Moderate urgency	High urgency	Very high urgency	Extremely urgent	
Government proactivity	Not proactive at all	19	15	15	11	11	5	6	82
	Moderately proactive	15	25	9	8	12	3	11	83
	Very proactive	9	7	7	7	4	4	3	41

Pearson's R and Spearman correlation coefficients were calculated to explore the correlation between government proactivity and the urgency attributed to ocean governance. These coefficients, hovering close to zero, indicate exceptionally weak correlations. This signifies virtually no linear relationship between respondents' perceptions of government proactivity and the urgency they associate with ocean governance.

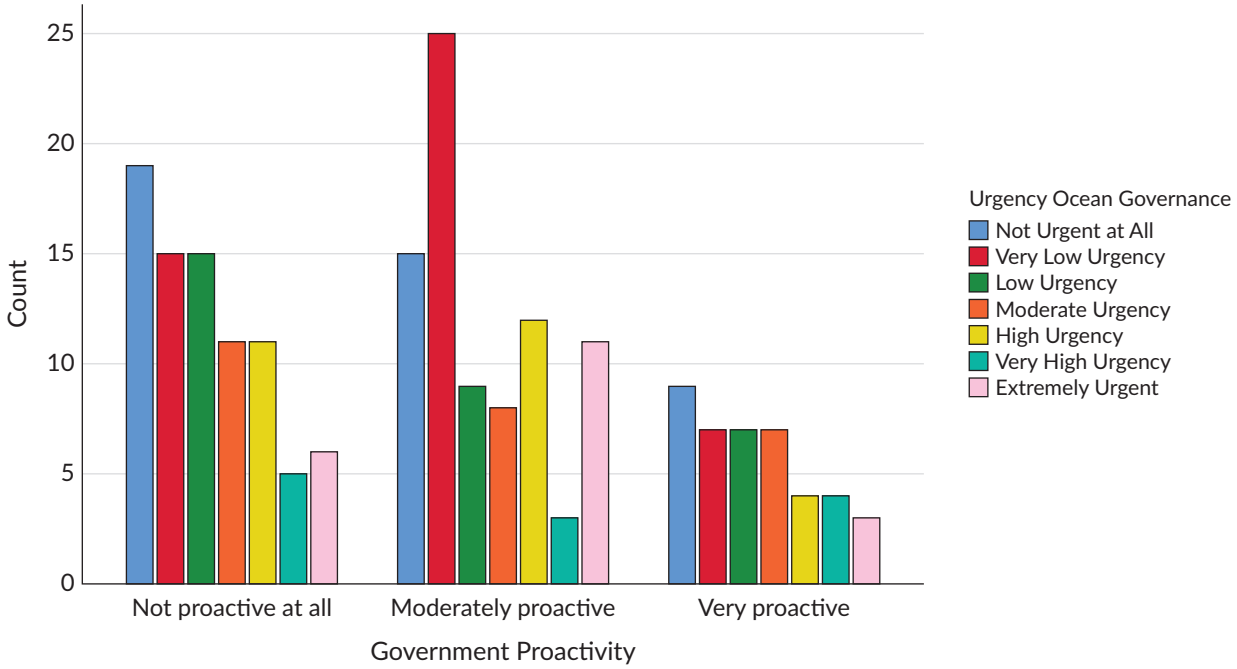

Figure 1. Perceived government proactivity vs. urgency of ocean governance.

The bar chart illustrates the relationship between respondents' perceptions of government proactivity (categorized as "not proactive at all," "moderately proactive," and "very proactive") and the corresponding levels of urgency attributed to ocean governance (ranging from "not urgent at all" to "extremely urgent"). While there are slight fluctuations in perceived urgency across different levels of government proactivity, the lack of a significant trend indicates a complex and nuanced understanding among respondents regarding the urgency of addressing climate change impacts on ocean governance.

Table 3 presents the relationship between respondents' self-assessed familiarity with ocean ecosystems (categorized as "very knowledgeable," "moderately knowledgeable," "slightly knowledgeable," and "not knowledgeable") and the frequency of encountering climate change-related impacts (ranging from "frequently" to "never"). Chi-square tests indicated a significant association ($p < 0.001$) between familiarity with ocean ecosystems and the frequency of encountering climate change-related impacts. Pearson's R and Spearman correlation coefficients further confirmed a strong positive correlation, emphasizing the influence of expertise on the occurrence of these impacts.

Table 3. Crosstabulation and correlation analysis between familiarity with ocean ecosystems and frequency of climate change-related impacts.

Familiarity Ocean Eco—Encounter Frequency Crosstabulation						
Count						
	Encounter frequency					Total
	Frequently	Occasionally	Sometimes	Rarely	Never	
Very knowledgeable	50	27	2	0	0	79
Moderately knowledgeable	23	46	18	1	0	88
Slightly knowledgeable	0	5	9	8	1	23
Not knowledgeable	0	1	5	7	3	16

Figure 2 visually represents the relationship between respondents' familiarity with ocean ecosystems and the frequency of encountering climate change-related impacts. The bar chart demonstrates a clear trend of higher encounter frequencies as familiarity levels increase.

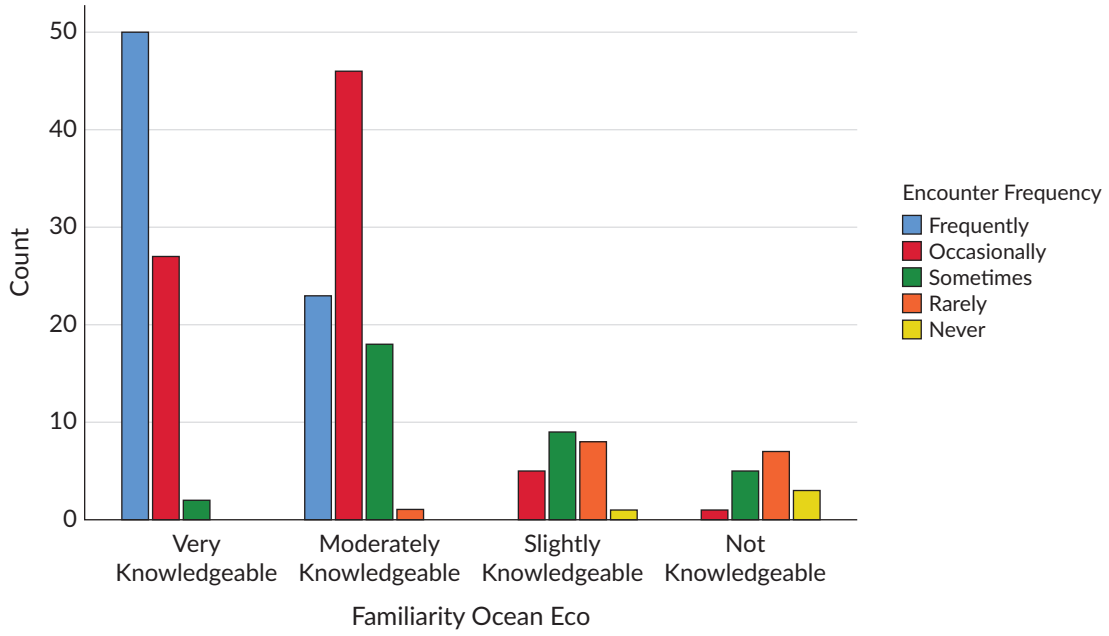

Figure 2. Relationship between familiarity with ocean ecosystems and frequency of climate change-related impacts.

Table 4 presents the relationship between respondents' perceptions of collaboration essentiality (categorized from "extremely essential" to "not essential at all") and their evaluation of governance effectiveness (classified as "very effective," "moderately effective," and "ineffective"). Despite various levels of collaboration essentiality, the distribution of effectiveness perceptions among respondents shows no significant association, as indicated by the chi-square tests ($p > 0.05$). The symmetric measures support this finding, demonstrating negligible correlations between collaboration essentiality and governance effectiveness.

Table 4. Crosstabulation between collaboration essentiality and governance effectiveness.

Collaboration Essentiality—Governance Effectiveness Crosstabulation					
Count					
		Governance effectiveness			Total
		Very effective	Moderately effective	Ineffective	
Collaboration Essentiality	Extremely essential	13	22	4	39
	Highly essential	19	28	9	56
	Essential	19	11	4	34
	Fairly essential	7	11	3	21
	Moderately essential	9	10	3	22
	Slightly essential	8	10	5	23
	Not essential at all	3	6	2	11

Figure 3 illustrates respondents' perceptions of collaboration concerning the effectiveness of governance (denoted as "very effective," "moderately effective," and "ineffective"). The varying shades represent different levels of collaboration essentiality. While the chart displays diverse opinions on collaboration's importance, there is no discernible pattern in the effectiveness ratings, indicating a lack of direct correlation between the perceived essentiality of collaboration and the effectiveness of governance measures.

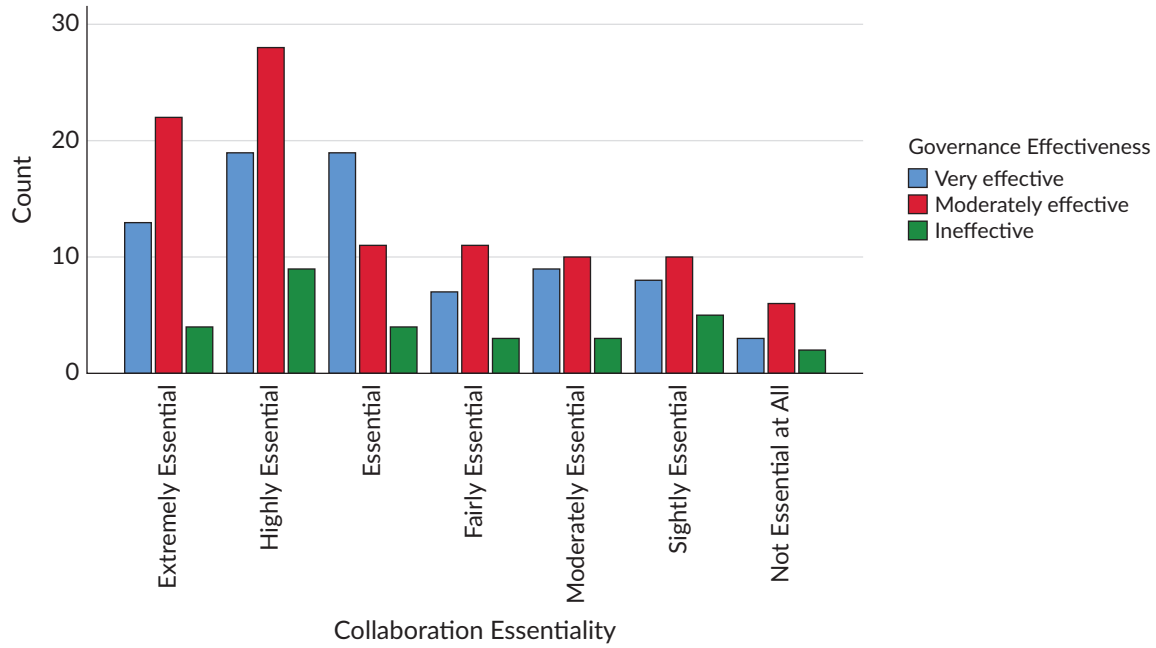

Figure 3. Perceived collaboration essentiality vs. governance effectiveness.

5. Discussion

The comprehensive analysis of experts' perspectives on climate change impacts on ocean ecosystems offers valuable insights into the multifaceted challenges coastal communities and marine environments face. Rising sea temperatures, ocean acidification, and loss of marine biodiversity are the primary climate change-induced

threats. These findings align with previous research, emphasizing the urgent need for targeted interventions to mitigate the adverse effects on marine ecosystems and the communities reliant on them (Doney et al., 2009; Halpern et al., 2008; Hoegh-Guldberg et al., 2008; Pinsky et al., 2013).

The multifaceted nature of climate change impacts on ocean ecosystems underscores the urgency of addressing these issues through integrated approaches (Lin et al., 2021; Suprayitno et al., 2024). Rising sea temperatures and ocean acidification are two interrelated challenges. Ocean warming directly affects marine species and ecosystems and amplifies ocean acidification. The latter, driven by increased CO_2 absorption, severely threatens shell-forming organisms and disrupts marine food chains (Connell et al., 2013; Gattuso et al., 2015). It is crucial to recognize these interconnected impacts to develop comprehensive mitigation and adaptation strategies. The loss of marine biodiversity is another pressing concern (Virtanen et al., 2024; Worm et al., 2006). The disruption of ecosystems due to climate change affects the availability of resources and services that coastal communities depend on (Doney et al., 2012; J. S. Gray, 1997; Halpern et al., 2009). It also has far-reaching implications for global fisheries and food security (Ding et al., 2017). Implementing effective policies and governance frameworks to preserve marine biodiversity is critical (Shih, 2025).

Assessing the effectiveness of existing policies and governance frameworks revealed a diverse range of opinions among experts. While certain international agreements received accolades, concerns were raised about their enforcement mechanisms. Gaps in national policies, particularly in curbing overfishing and pollution, emerged as significant hurdles. The findings emphasize the need for enhanced global cooperation and more stringent enforcement strategies to bridge policy gaps and ensure the sustainable management of ocean ecosystems (Folke et al., 2005). The effectiveness of governance frameworks is pivotal in adapting to climate change impacts and safeguarding marine ecosystems.

Community engagement in coastal adaptation efforts presents a complex landscape marked by challenges such as a lack of awareness, financial constraints, and cultural resistance to change. Traditional knowledge, deeply rooted in local communities, emerges as a valuable asset in shaping effective adaptation strategies. Empowering these communities and integrating their insights into decision-making processes are pivotal to fostering resilience and promoting culturally sensitive approaches (Berkes et al., 2000; Ford et al., 2013). Community involvement in adaptation planning is essential, as it enhances the relevance and effectiveness of adaptation measures (Adger et al., 2003). International collaboration surfaced as a consensus point among experts, underscoring its pivotal role in addressing climate change impacts on ocean governance. The need for coordinated, transnational efforts is vital to tackling the cross-border challenges marine ecosystems face. The findings align with global initiatives such as the Paris Agreement, emphasizing the importance of shared responsibilities and collective action to combat climate change (UN, 2015; UN Framework Convention on Climate Change, n.d.).

It is essential to recognize that the impacts of climate change on ocean ecosystems are experienced differently across regions, and understanding these variations is crucial for developing effective policies and adaptation strategies.

Longitudinal studies assessing the efficacy of adaptation measures over time are imperative for refining policies and strategies. The evolving nature of climate change and its impacts necessitate ongoing assessments and adjustments to adaptation and governance frameworks.

Despite its contributions, this study has several limitations that should be acknowledged. First, the analysis is based on expert perceptions rather than direct evaluation of policy outcomes or governance performance. While expert elicitation is well-suited to contexts characterized by complexity, uncertainty, and limited empirical observability, perceptions may reflect professional experiences, disciplinary backgrounds, and institutional positions rather than objective measures of effectiveness.

Second, although the study draws on a diverse group of 70 experts from academia, government, and applied coastal management, the sample size and composition limit the generalizability of the findings. The perspectives captured may not fully represent regional, sectoral, or cultural variations in ocean governance and coastal adaptation, particularly those of local communities, Indigenous groups, or private-sector actors.

Third, the study adopts a cross-sectional design, capturing expert views at a single point in time. Given the rapidly evolving nature of climate change impacts and governance responses, expert assessments may change as policies, technologies, and institutional arrangements develop. Longitudinal research would be valuable for examining how perceptions of governance effectiveness and adaptation priorities evolve over time.

Finally, the study does not assess the effectiveness of specific governance instruments or adaptation measures. Instead, it focuses on identifying perceived risks, governance gaps, and priority areas. Future research could complement this perception-based approach with comparative policy evaluations, case studies, or empirical outcome indicators to strengthen causal inference and policy relevance.

Recognizing these limitations does not diminish the value of the study; rather, it clarifies the scope of its contribution and highlights opportunities for future research to build on expert-informed insights into climate-resilient ocean governance.

6. Conclusion

This study examined expert perceptions of climate change impacts on ocean ecosystems, ocean governance frameworks, and coastal adaptation strategies using a mixed-methods expert-elicitation approach. The findings reveal strong consensus among experts that ocean warming, ocean acidification, and biodiversity loss represent the most critical climate-related threats to marine systems, while existing governance frameworks struggle to respond adaptively to accelerating climate risks.

The results highlight persistent governance challenges, including fragmented institutional responsibilities, uneven implementation, and limited community engagement, alongside a shared recognition of the importance of international collaboration and adaptive governance arrangements. Rather than evaluating specific policies, the study contributes by clarifying expert-identified governance gaps and priority areas that require attention in efforts to strengthen climate-resilient ocean governance.

By integrating quantitative patterns with qualitative insights, this research provides an expert-informed perspective that can support agenda-setting, policy prioritization, and future research. Future studies could build on these findings through longitudinal analysis, broader stakeholder inclusion, and empirical evaluation of governance outcomes to further advance evidence-based and adaptive responses to climate change in ocean and coastal governance systems.

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Conflict of Interests

The author declares no conflict of interests.

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About the Author

Yi-Che Shih is an associate professor at the Institute of Ocean Technology and Marine Affairs, National Cheng Kung University, Taiwan. His research focuses on marine environmental management, ocean governance, marine environmental monitoring, marine environmental assessment, marine pollution, coastal zone management, and marine policy.

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Applying the IUCN Global Standard for Nature-Based Solutions in Guandu Wetlands, Taiwan

Mariana Gabrielle Cangco Reyes [1], Yi-Hsin Tan [2], Yu-Chen Hsu [1,3], and Syuan-Jyun Sun [1]

[1] International Program in Climate Change and Sustainable Development, National Taiwan University, Taiwan
[2] School of Forestry and Resource Conservation, National Taiwan University, Taiwan
[3] ESADE Business School, Ramon Llull University, Spain

Correspondence: Syuan-Jyun Sun (sjs243@ntu.edu.tw)

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Abstract

Guandu Wetlands, an educational and research center in Taipei, provides conservation education for the public and university researchers. Mangroves within the wetlands deliver essential ecosystem services, socio-economic benefits, and play a critical role in mitigating rising CO_2 emissions. However, these ecosystems face threats from climate change and anthropogenic pressures. Nature-based Solutions (NbS) have emerged as an effective approach to address such societal and environmental challenges, and the International Union for Conservation of Nature (IUCN) has developed a Global Standard to ensure rigor and accountability in NbS projects. Implementing NbS in resource-limited contexts, however, poses challenges for long-term monitoring and management. This study aims to evaluate how the Guandu Wetlands align with the IUCN Global Standard for NbS, identifying stakeholder priorities, gaps, and trade-offs in wetland management. Interviews were conducted between April and June 2024 with key stakeholders—including Guandu Nature Park, the Forestry Bureau, the Taipei City Hall Hydrology Department, and the Wild Bird Society—using questions aligned with the IUCN Global Standard for NbS. The knowledgeable stakeholders independently scored each of the eight criteria, and the results were analyzed to identify priorities, gaps, and perceived trade-offs in wetland management. These findings highlight how each stakeholder perceives and prioritizes conservation and management strategies. Balanced trade-offs, adaptive management, and design at scale scored the highest, while sustainability & mainstreaming and economic feasibility scored low. This case study provides insights into NbS implementation and the role of universities, research, and education centers in monitoring wetland ecosystems. This research emphasizes opportunities to strengthen sustainable management, community engagement, and ecosystem stewardship. Overall, the study demonstrates how collaborative, science-based strategies can inform decision-making and generate tangible ecological and societal benefits of blue ecosystems.

Keywords
blue ecosystems; nature-based solutions; stakeholder engagement; wetlands

1. Introduction

Wetlands are increasingly under threat from global pressures, including biodiversity decline, land reclamation, pollution, and human-driven climate change (Barbier, 2011). Wetlands contribute a variety of ecosystem services, encompassing ecological, economic, and protective functions. They provide habitats for diverse terrestrial and aquatic wildlife populations, contribute to local economies, act as carbon sinks, trap sediments, regulate nutrient cycles, and serve as natural defenses against floods and storms. Additionally, wetlands play a crucial role in reinforcing coastal stability by reducing erosion and turbidity (Faunce & Serafy, 2006; Gu et al., 2022; Kathiresan, 2021; Malik et al., 2015; Taillardat et al., 2018). However, increasing anthropogenic pressures have led not only to widespread wetland degradation but also to changes in habitat composition and structure, particularly where mangrove expansion, restoration, or encroachment may occur at the expense of open mudflat habitats. Between the 1980s and 1990s, it was estimated that 35% of mangrove forest area was in decline while other regions suffered from 50–80% in loss (Romañach et al., 2018). To this end, wetlands must be recognized as natural assets that are essential to solving societal and environmental challenges (Barbier, 2011).

In response to the rising global concerns, Nature-based Solutions (NbS) have become an integral solution during the 2019 United Nations Climate Summit and the 2021 COP 26 (International Union for Conservation of Nature [IUCN], 2020). NbS aim to put nature at the forefront to address a spectrum of societal challenges, such as, but not limited to, climate change adaptation and mitigation, disaster risk reduction, ecosystem degradation and biodiversity loss, food security, human health, social and economic development, and water security (IUCN, 2020; Y. Liu et al., 2022). These solutions aim to maximize ecological benefits while ensuring resilience and cost-effectiveness (Chee et al., 2021; Guannel et al., 2016; C.-W. Liu et al., 2014; Taillardat et al., 2018). To ensure the quality and impact of NbS projects, the IUCN has established a Global Standard focused on accountability, outcome measurement, and continuous learning. However, this standard faces challenges that complicate achieving its goals, including issues with long-term monitoring, financial and logistical constraints, scalability, and a lack of systematic assessment and evaluation (Bautista et al., 2009; Meroni et al., 2017). For instance, restoring degraded mangrove areas can be costly, and scaling up NbS can be challenging due to their site-specific requirements and ecological sensitivities (Dahdouh-Guebas et al., 2021).

After nearly three decades under the Heritage Preservation Law, Taiwan advanced its environmental governance in 2015 by enacting the Wetland Conservation Act and the Coastal Management Act, positioning itself as a regional leader in wetland protection. These policies have supported the sustainable use of wetland ecosystem services and established frameworks for designating areas of "Wetland of Importance" (Y.-C. Chen & Shih, 2019; Su, 2014). Within this context, the Guandu Nature Reserve serves as a key case study for examining the dynamics of mangrove expansion and their encroachment into estuarine regions. The challenges outlined in this research closely mirror those faced in the Guandu Wetlands, where rapid urban development, agricultural demands, and climate pressures intersect with the need to conserve critical wetland ecosystems. Guandu Wetlands demonstrates the delicate balance between sustaining

biodiversity and meeting human needs, underscoring the importance of science-based, participatory approaches to resource management. In this context, universities play a vital role as collaborative platforms by conducting ecological monitoring and evaluating various research within Guandu Nature Park. By bridging research, community engagement, and policy discussions, universities help translate scientific insights into actionable frameworks for sustainable wetland management.

This study examines the extent to which the Guandu Wetlands align with the IUCN Global Standard for NbS. It contributes to the global NbS discourse by presenting a practical case of how stakeholder engagement and interdisciplinary research can inform conservation outcomes. Through interviews with representatives from Guandu Nature Park, the Forestry Bureau, the Taipei City Hall Hydrology Department, and the Wild Bird Society (Supplementary File, Table 1), this research assesses Guandu Wetlands' alignment with NbS. By understanding perspectives from various stakeholders, this research seeks to provide valuable insights for future conservation efforts, supporting the development of adaptive management strategies for the effective preservation of the Guandu Wetlands and similar ecosystems. The findings have broader implications for urban wetland governance, demonstrating how structured evaluation using global NbS standards can guide sustainable ecosystem management, strengthen collaboration among stakeholders, and support policy decisions aimed at maintaining ecological integrity while addressing societal needs. Ultimately, the study aims to enhance the understanding of wetland dynamics and contribute to the formulation of informed conservation strategies that can be applied more broadly.

1.1. Societal Issues & Interventions

For an intervention to be considered NbS, it must address one or more societal challenges. The Guandu Wetlands confront a multitude of pressing issues that necessitate the implementation of NbS to address key societal challenges. The three paramount societal challenges in Guandu Wetlands are climate change mitigation and adaptation, environmental degradation and biodiversity loss, and disaster risk reduction (IUCN, 2020; Table 1).

The Guandu Wetlands face pollution and low wastewater collection rates, leading to reduced food sources. The construction of embankments and alterations to riverbanks compress living spaces for various species. Coastal cementation and budgetary constraints further exacerbate habitat reduction. Human activities like sand and gravel collection, river dredging, and urban development contribute to habitat loss, disrupting the natural balance of ecosystems ("Rang women hai," 2018). Moreover, threats of human development have been an ongoing issue that the Taipei City Hydrology Department and the Guandu Nature Park Managers have to face publicly (Supplementary File, Tables 2 and 4). At a global scale, climate change and rising temperatures are driving changes in wetland ecosystems, influencing multiple habitat types, including bird habitats and wetland communities (Desta et al., 2012). While mangroves are inherently dynamic and respond to climatic variability, this broader context highlights the importance of NbS for enhancing ecosystem resilience in areas such as Guandu (Ayassamy, 2025). The Ramsar Convention emphasizes the importance of preserving wetlands, urging concerted efforts to address environmental challenges and promote sustainable practices ("Shi di zhongxin," 2014; "Xun hui tan tu," 2022). Additionally, harmful human activities such as illegal dumping of trash by unscrupulous companies and pesticide use threaten the wetland's biodiversity and result in water pollution ("Chongsheng de shi," 2013; Guandu Nature Park, 2013).

The Guandu Wetlands area was originally composed of marsh wetlands. After the severe dumping of waste soil, the primary focus shifted to habitat restoration. In late 2005, water from Shuomokeng Creek was redirected into the area to establish artificial wetlands, accompanied by the planting of various aquatic plant species. Years later, Guandu Wetlands managers still implement restoration projects for birds and plants to make better habitats for them to increase their biodiversity ("Chongsheng de shi," 2013). Another human intervention the managers implement is the exchange of saltwater to increase the biodiversity of the wetland. Increased food availability resulting from this process supports a larger bird population. Additionally, the presence of saltwater helps suppress the growth of invasive weeds. Guandu Nature Park managers have an array of conservation measures and environmental education projects that help in preserving the wetland's pristineness. Geographically located at the estuary, the Guandu Wetlands are strongly influenced by tidal conditions, resulting in frequent flooding. The area has also suffered substantial losses from multiple severe typhoon-induced floods (C.-W. Liu et al., 2014; Shih et al., 2022). The Guandu Wetlands' conservation efforts involve a bundle of NbS interventions implemented in collaboration with central competent authorities to enhance biodiversity and reduce flood risks (Supplementary File, Table 2). These continuous efforts include the restoration of salt marshes through controlled saltwater exchange, which maintains optimal salinity levels, increases food availability for waterbirds, supports the growth of native halophytic plants, and suppresses invasive weeds. Mangrove management and selective removal are also carried out to balance bird habitat availability while retaining the ecosystem services provided by mangroves, such as carbon storage and shoreline stabilization. In addition, continuous planting of native aquatic vegetation in restored wetlands provides nesting and foraging habitats and supports overall wetland biodiversity. Because the wetlands near Guandu are ecologically interconnected, managers coordinate interventions to minimize indirect impacts on neighboring wetlands, anticipating bird movement during restoration and other activities. All interventions are accompanied by ongoing monitoring of bird populations, vegetation, and water quality to guide adaptive management and enhance risk mitigation. While each NbS addresses specific ecological goals, they are implemented as an integrated bundle to collectively mitigate habitat degradation, reduce flood risks, and enhance waterbird habitats. For instance, although mangrove management may have localized unintended effects on bird populations, combining it with saltwater exchange and vegetation restoration maximizes overall biodiversity outcomes. Despite these continuous efforts, there remains a need for systematic planning, prioritization, and evaluation of interventions. To address this gap, our research employs the IUCN NbS framework to evaluate the effectiveness of the various interventions at Guandu Wetlands. Specifically, interviews were conducted with diverse stakeholders and scored each intervention, allowing us to assess their ecological and social outcomes, identify shortcomings in current management practices, and provide recommendations for improvement. This approach ensures that our study not only documents ongoing NbS efforts but also generates actionable, evidence-based insights to guide more effective, stakeholder-informed wetland management. A collaborative relationship exists between Guandu Nature Park managers and university researchers, which supports the conservation of these important NbS. For example, the park actively encourages students and scholars to carry out field studies within its boundaries (Supplementary File, Table 2). Professors and researchers are recognized as influential stakeholders valued for their informed perspectives, and they are generally positioned at the center of discussions and decision-making processes concerning Guandu Nature Park ("Shi di zhongxin," 2014; Supplementary File, Table 3). Until now, there have been 28 master's and doctoral dissertations studying Guandu Nature Park (2014); this body of research on Guandu Nature Park reflects the evolution of Taiwan's approaches to wetland conservation, environmental education, and community engagement over nearly three decades.

Table 1. Summary of societal challenges found in Guandu Wetlands and their description from previous literature.

Climate Change Mitigation and Adaptation	Environmental Degradation and Biodiversity Loss	Disaster Risk Reduction
Rising temperatures which lead to habitat loss.	Pollution and industrial water waste result in food reduction. The construction of embankments and alterations to riverbanks compress living spaces for various species. Coastal cementation and budgetary constraints further exacerbate habitat reduction. Human activities like sand and gravel collection, river dredging, and urban development contribute to habitat loss, disrupting the natural balance of ecosystems.	The Guandu Wetlands, situated at the estuary of the Tanshui and Keelung Rivers, are strongly influenced by tidal fluctuations and experience flooding twice daily. This area has suffered significant losses due to multiple severe typhoon-induced floods.

Sources: "Chongsheng de shi" (2013); Guandu Nature Park (2013); C.-W. Liu et al. (2014); "Shi di zhongxin" (2014); S.-S. Shih et al. (2022); "Xun hui tan tu" (2022).

2. Methods

2.1. Study Site

The study site is the Guandu Wetlands (Figure 1 and Supplementary File, Figure 1), located in the southwestern part of the Guandu Plain in Taipei, Taiwan, approximately 10 kilometers from the Tamsui River estuary (Hsu & Lee, 2018). The nature reserve covers an area of 57 ha and is primarily composed of Kandelia obovata mangroves and Phragmites patches, both of which are tolerant of cold conditions (Guandu Nature Park, n.d.; S.-C. Yang et al., 2013). The wetlands are influenced by multiple factors, including tidal fluctuations, arsenic-contaminated soils, and the uniform salinity of the estuary (C.-W. Liu et al., 2014; S.-C. Yang et al., 2013). Originally established as the Guandu Nature Reserve by the Taipei Municipal Government under the Cultural Heritage Preservation Law (Hsu & Lee, 2018), the site has been the focus of mangrove restoration efforts since the 1940s, driven by scientists, government officials, and conservation managers. Following its reclassification in 2021, entry into the wetlands no longer requires a permit. Over time, spatiotemporal changes have reshaped the wetlands, with mangrove coverage steadily expanding (Hsu & Lee, 2018). The wetlands support a diverse bird community, including members of the families Ardeidae, Shorebird sp.(Charadriidae, Glareolidae, Haematopodidae, Recurvirostridae, Rostratulidae, Scolopacidae), Laridae, Anatidae, Threskiornithidae, and Eastern cattle-egret (*Ardea coromanda*). Given its history of restoration and protection, combined with its rich biodiversity, cultural importance, and observable mangrove expansion, the Guandu Wetlands provide an ideal setting for this study (Figure 2).

Figure 1. Aerial map of the study site at Guandu Wetlands and Nature Park, Taipei, Taiwan. The red point indicates the official reference coordinates, and the yellow polygon delineates the official boundary of the Guandu Wetlands. Coordinates: 121.458718, 25.108917, 121.486183, 25.117767. Maps of park facilities are provided in the Supplementary File, Figure 1.

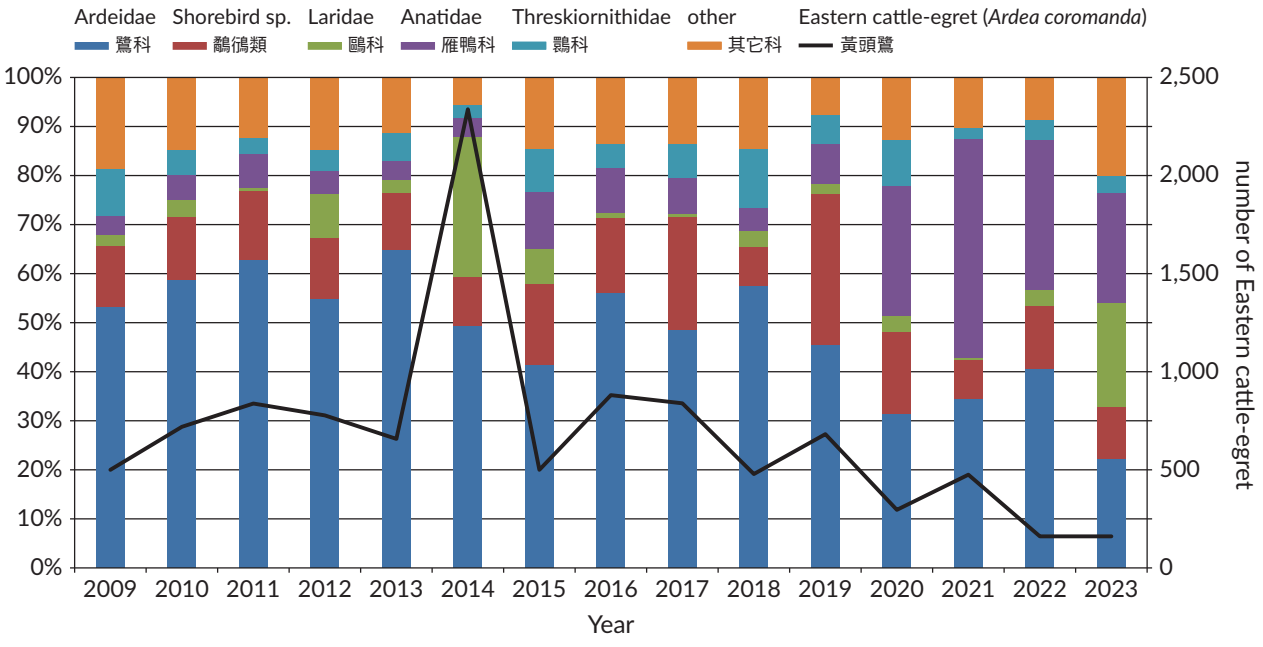

Figure 2. Bird biodiversity survey provided by Guandu Nature Park.

The organizational map in Figure 3 illustrates the division of labor and responsibilities among key stakeholders at Guandu Nature Park. At the top, the Taipei Wild Bird Society oversees the park through its Board of Directors, with a Director and Deputy Director managing operations. The Taipei City Government Animal Protection Office participates via the Camp Steering Committee, linking government oversight to park management. Park operations are divided into two main functional groups: Public Promotion and Field

Service. The Public Promotion Group includes the Public Affairs Department, which handles communications, marketing, and public relations, and the Ministry of Environmental Education, responsible for educational program development and resource management. The Field Service Group includes the Sales Service Department, which manages visitor services, ticketing, and on-site maintenance, and the Ministry of Environment Conservation, which oversees biodiversity research, wildlife habitat management, and infrastructure maintenance for ecological management. Supporting administrative tasks (e.g., finances, Figure 4) are coordinated through the administrative room, reporting to the Deputy Director. This structure ensures coordinated management of educational, operational, conservation, and administrative functions, with input from both governmental and non-governmental stakeholders.

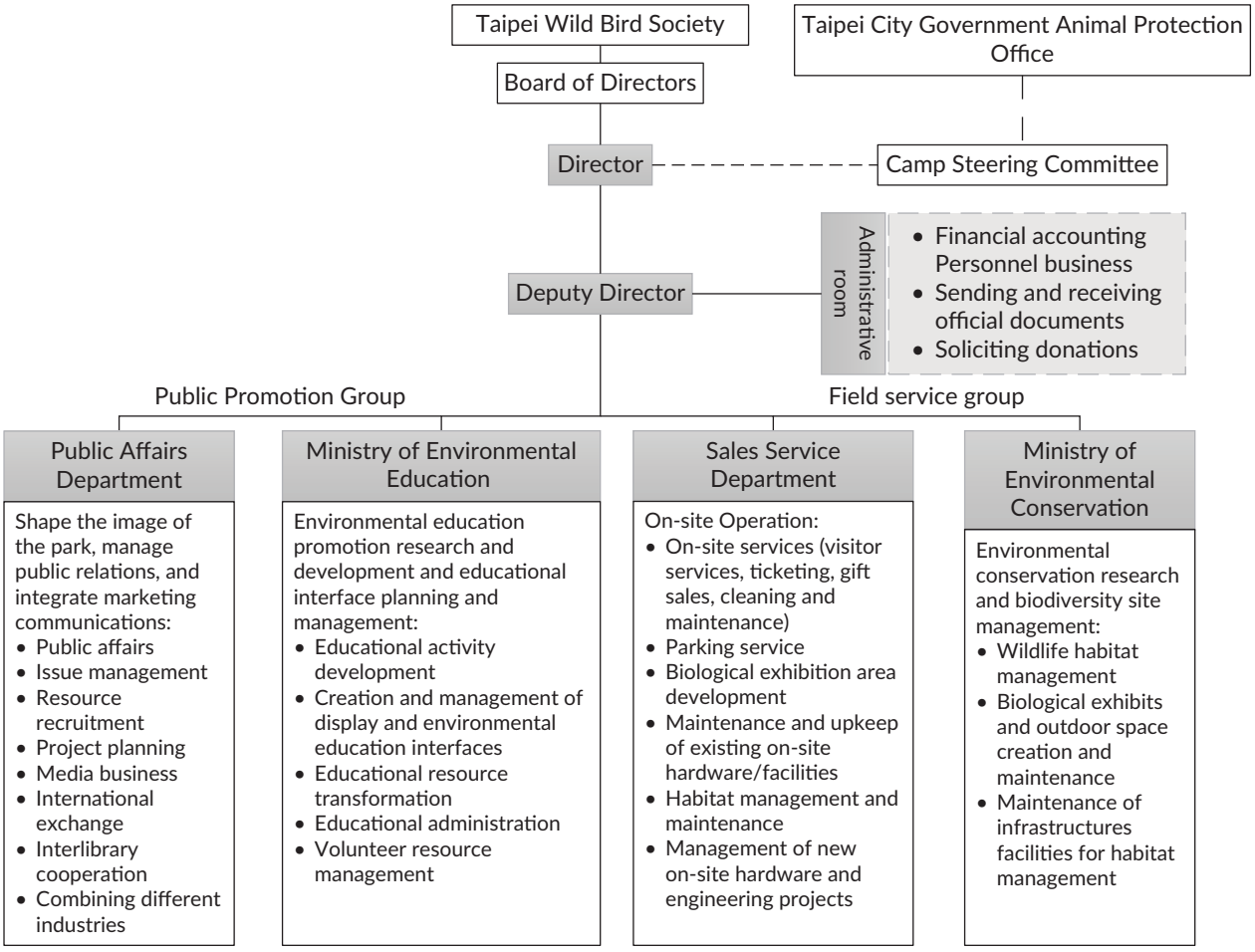

Figure 3. Stakeholder map of Guandu Nature Park managers with their respective responsibilities.

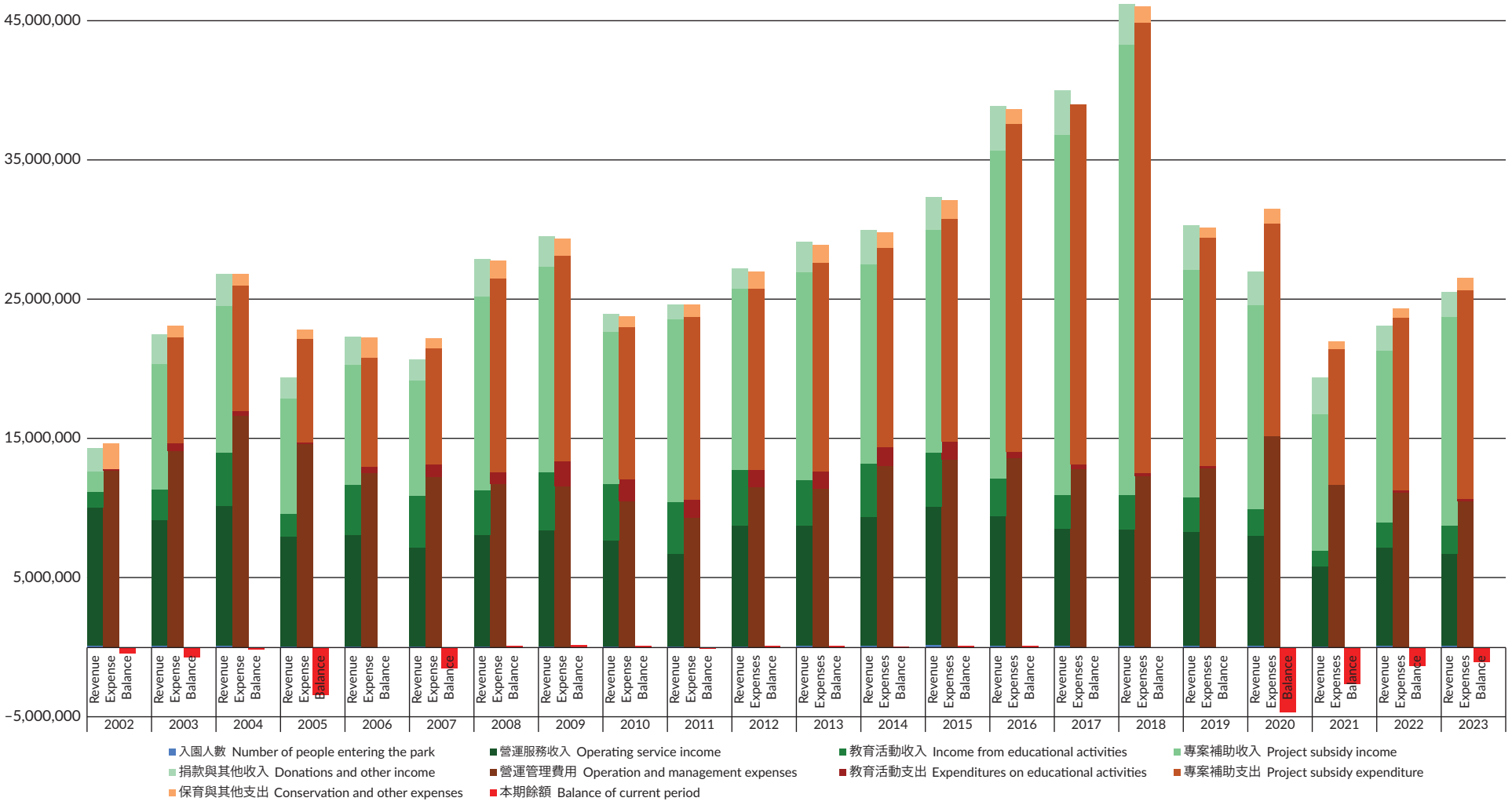

Figure 4. Guandu Nature Park economic feasibility with expenditures and revenues in TWD.

2.2. Data Collection & Framework

The IUCN Global Standard for NbS offers a comprehensive framework that guides stakeholders about the design, implementation, and verification of NbS (IUCN, 2020). Applying the IUCN criteria to the Guandu Wetlands allows us to systematically evaluate the effectiveness of past and ongoing restoration and management actions, highlight areas for improvement, and demonstrate how interdisciplinary stakeholder engagement and adaptive management contribute to the realization of NbS outcomes. This tool has been applied in various contexts, such as guiding sustainable aquaculture practices in Zanzibar (Le Gouvello et al., 2023). Its eight criteria (societal challenges, design at scale, biodiversity net-gain, economic feasibility, inclusive governance, balance trade-offs, adaptive management, and sustainability and mainstreaming) have each of them 3–5 indicators, totaling 28 indicators (Le Gouvello et al., 2023). In this research, the English version of the standard was translated into Chinese, with additional guiding questions introduced to deepen the understanding of each criterion and indicator (Supplementary File, Questionnaire 1). Key interviewees were selected based on their extensive knowledge and active involvement in Guandu Wetlands management, including representatives from Guandu Nature Park, the Forestry Bureau, the Taipei City Hall Hydrology Department, and the Wild Bird Society (Supplementary File, Table 1). These interviews were conducted from April to June 2024. Since there are two representatives from Guandu Nature Park with different specialties, they provided independent scores for the criteria they have extensive knowledge about. As some discrepancies were observed between their assessments, the scores were averaged to obtain a balanced measure, reflecting both operational and conservation perspectives.

All interviewees assigned individual scores to each indicator using a scoring scheme adapted from Le Gouvello et al. (2023; 0 = insufficient, 1 = partial, 2 = adequate, 3 = strong). Detailed descriptions of each scoring level were provided with the questionnaire (Supplementary File, Questionnaire 1). Criterion-level scores were calculated by summing indicator scores, dividing by the maximum possible score for each criterion, and normalizing the result to a percentage scale (×100).

3. Results

3.1. Score of Indicators

Among the individual indicators, the highest scoring was 5.3 Stakeholders Identification and Involvement, which achieved an average of 91.7% among four stakeholders, reflecting strong performance in recognizing and including relevant actors. This was closely followed by 6.2 Rights, Usage of, and Access to Land and Resources at 87.5%, and both 6.1 Costs and Benefits of Associated Trade-offs and 5.4 Stakeholders Involvement in Decision Making, each with 83.3%. Another indicator showing strong performance was 5.1 Grievance Resolution Mechanism with 79.2%. Indicators with adequate performance, including 8.2 Policy, Regulations, and Laws, 8.1 Information Sharing for Transformative Change, 7.2 Monitoring and Evaluation Plan, 3.2 Biodiversity Conservation Outcomes, 2.1 Interactions Between Economy, Society, and Ecosystems, and 1.2 Documented Societal Challenges, all scored 75.0%. Slightly lower were indicators 7.3 Framework for Adaptive Management, 6.3 Periodic Review of Safeguards, and 5.5 Decision-making Beyond Jurisdictional Borders, each at 70.8%. Indicators at the lower tier of the adequate category included 4.2 Cost-effectiveness Study, 3.3 Unintended Adverse Consequences, 2.2 Complementarity and Synergies, and 1.1 Identification and Prioritization of Societal Challenges, each at 66.7%. Even lower were 7.1 NbS

Strategy, 4.1 Direct and Indirect Benefits and Costs, 3.4 Enhancement of Ecosystem Integrity and Connectivity in NbS Strategy, 3.1 Ecosystem State and Drivers of Degradation and Loss, and 2.3 Risk Identification and Management, each scoring 58.3%, along with 4.4 Resourcing Options and 4.3 Alternative Solutions to Test Effectiveness, both at 50.0%. The lowest results were observed in 1.3 Identified Human Well-Being Outcomes at 41.7%, while two indicators, 8.3 National and Global Targets and 5.2 Indigenous People Involvement, scored 0%, indicating a complete lack of evidence or action in these areas (Table 2 and Figure 5).

Table 2. Summary of the total 28 indicator scores in percentage.

Indicator	Average Score (%)	Qualitative Scores
1.1 Identification and Prioritization of Societal Challenges	66.7	Adequate
1.2 Documented Societal Challenges	75.0	Strong
1.3 Identified Human Well-Being Outcomes	41.7	Partial
2.1 Interactions Between Economy, Society, and Ecosystems	75.0	Strong
2.2 Complementarity and Synergies	66.7	Adequate
2.3 Risk Identification and Management	58.3	Adequate
3.1 Ecosystem State and Drivers of Degradation and Loss	58.3	Adequate
3.2 Biodiversity Conservation Outcomes	75.0	Strong
3.3 Unintended Adverse Consequences	66.7	Adequate
3.4 Enhancement of Ecosystem Integrity and Connectivity in NbS Strategy	58.3	Adequate
4.1 Direct and Indirect Benefits and Costs	58.3	Adequate
4.2 Cost-Effectiveness Study	66.7	Adequate
4.3 Alternative Solutions to Test Effectiveness	50.0	Adequate
4.4 Resourcing Options	50.0	Adequate
5.1 Grievance Resolution Mechanism	79.2	Strong
5.2 Indigenous People Involvement	0.0	Insufficient
5.3 Stakeholders Identification and Involvement	91.7	Strong
5.4 Stakeholders Involvement in Decision Making	83.3	Strong
5.5 Decision-making Beyond Jurisdictional Borders	70.8	Adequate
6.1 Costs and Benefits of Associated Trade-Offs	83.3	Strong
6.2 Rights, Usage of, and Access to Land and Resources	87.5	Strong
6.3 Periodic Review of Safeguards	70.8	Adequate
7.1 NbS Strategy	58.3	Adequate
7.2 Monitoring and Evaluation Plan	75.0	Strong
7.3 Framework for Adaptive Management	70.8	Adequate
8.1 Information Sharing for Transformative Change	75.0	Strong
8.2 Policy, Regulations, and Laws	75.0	Strong
8.3 National and Global Targets	0.0	Insufficient

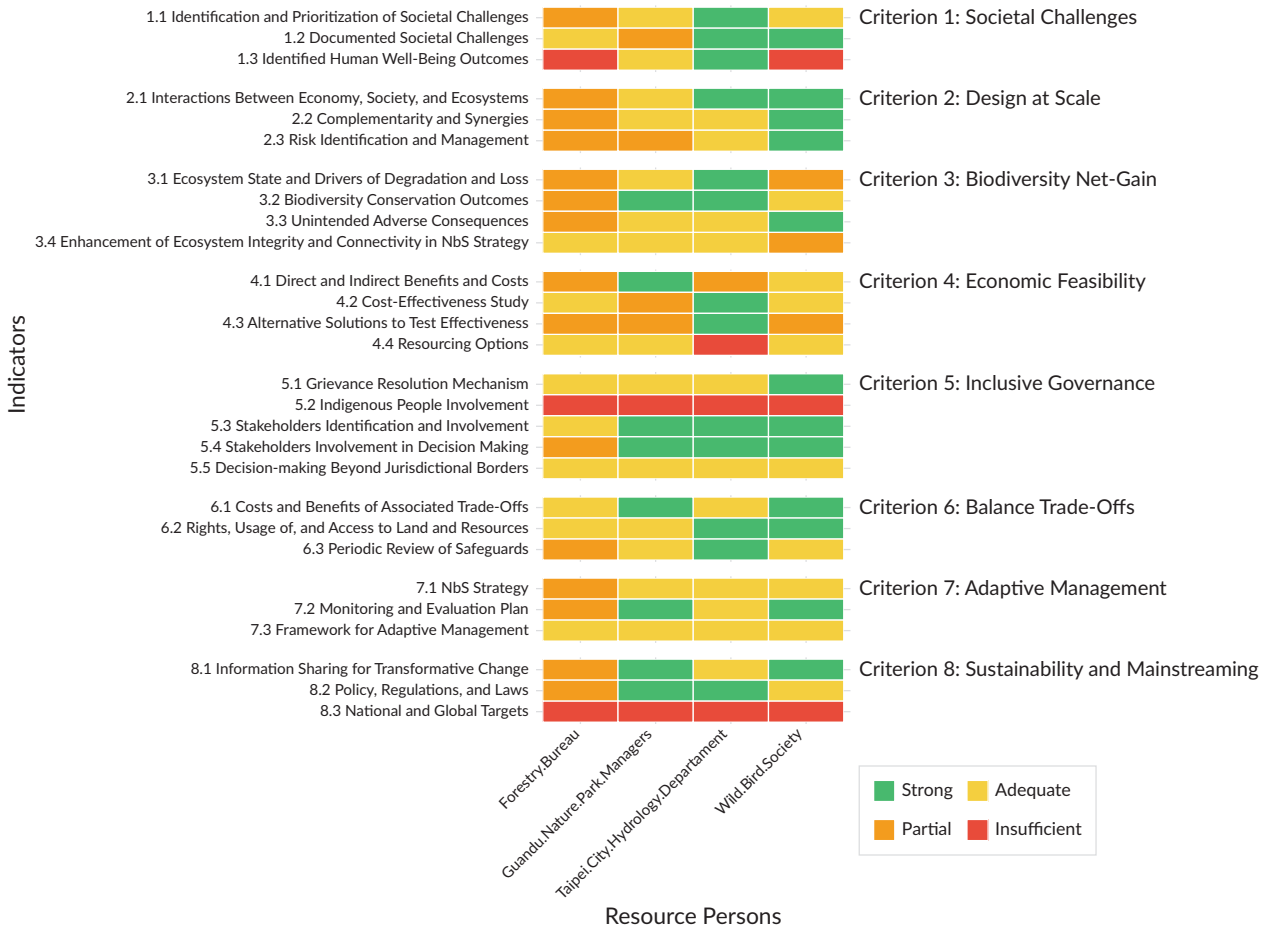

Figure 5. Results of the IUCN NbS self-assessment tools across all 28 indicators for each interviewee.

3.2. Results by Criterion

From the four stakeholders, Criterion 6: Balance Trade-Offs achieved the highest score with an average of 2.42 (80.6%), indicating strong performance in addressing costs, benefits, rights, and safeguards. This was followed by Criterion 7: Adaptive Management with an average score of 2.04 (68.1%), and Criterion 2: Design at Scale with 2.00 (66.7%), both showing adequate performance. In the middle range, Criterion 5: Inclusive Governance scored 1.95 (65.0%), and Criterion 3: Biodiversity Net-Gain scored 1.94 (64.6%), suggesting partial to adequate progress. Criterion 1: Societal Challenges followed closely with 1.83 (61.1%). The lowest scoring criteria were Criterion 4: Economic Feasibility with 1.69 (56.2%) and Criterion 8: Sustainability and Mainstreaming with 1.50 (50.0%), highlighting areas where improvements are most needed to strengthen the overall NbS assessment (Table 3 and Figure 6).

Table 3. Summary of the total eight criterion scores in percentage.

Criterion	Average Score (%)	Qualitative Score	Qualitative Summary
1: Societal Challenges	61.1	Adequate	Societal issues are identified and documented but further improvements in focusing on human well-being must be addressed.
2: Design at Scale	66.7	Adequate	Guandu Nature Park has many partnerships (e.g., NGOs, donors, schools) but their framework for conservation is not transferable or applicable to others.
3: Biodiversity Net-Gain	64.6	Adequate	Bird biodiversity is continuously monitored, including during periods affected by typhoons; however, the ecological effects of management interventions require time to manifest as measurable changes in biodiversity.
4: Economic Feasibility	56.2	Adequate	Costs are transparently documented, and corporate sponsorship supports conservation efforts; however, funding constraints indicate the need for cost–benefit analysis.
5: Inclusive Governance	65.0	Adequate	Multiple government departments actively engage the public through surveys, public consultations, and designated public engagement offices. Guandu Nature Park employs a feedback system that enables residents and visitors to report concerns via direct communication, government channels, or on-site staff.
6: Balance Trade-Offs	80.6	Strong	Stakeholders understand the ecological and economic trade-offs, but a cost–benefit analysis is required.
7: Adaptive Management	68.1	Adequate	Guandu Nature Park managers oversee external reviews related to environmental education and safety, maintain certification standards, and conduct real-time biodiversity monitoring with high-quality bird data. Management activities are scheduled based on long-term ecological observations, with construction halted during breeding seasons and maintenance timed to minimize disturbance to resident and migratory wildlife.
8: Sustainability and Mainstreaming	50.0	Partial	Guandu Nature Park actively engages in national and international collaborations through exchanges, training programs, and partnerships with organizations. Guandu Nature Park abides by governmental policy and regulations.

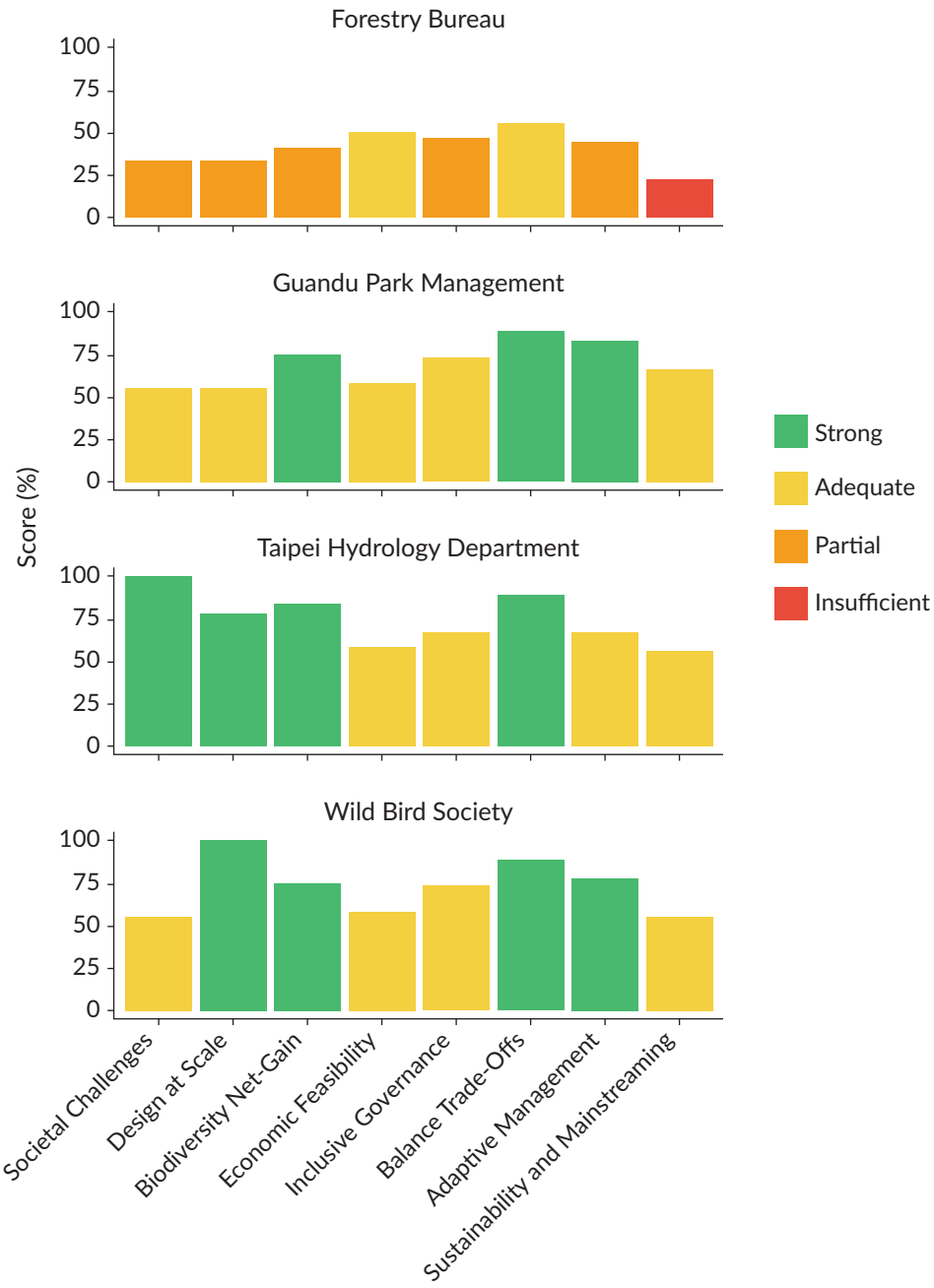

Figure 6. Results of the IUCN NbS self-assessment tools across the eight criteria for each interviewee.

4. Discussion

This study applied the IUCN Global Standard for NbS to assess the Guandu Wetlands, offering insights into the site's performance across key criteria and highlighting stakeholder-specific strengths and areas for improvement. Overall, Guandu Wetlands demonstrated a satisfactory level of alignment with the Global Standard, especially in the areas of stakeholder participation, adaptive management, and trade-off recognition. In addition, selected student dissertations were incorporated as supplementary evidence to illustrate how ongoing academic research aligns with and supports specific criteria of the IUCN Global Standard for NbS. The following sections discuss the site's performance across all eight criteria in detail.

4.1. Criterion 1: Addressing Societal Challenges

Guandu Wetlands has established mechanisms to engage stakeholders and document societal challenges, including flood prevention, public health, and ecosystem services. While conservation efforts are supported by government regulation and documented stakeholder involvement, public understanding of wetland benefits, such as flood mitigation and connections to human well-being, remains limited, and development pressures from private landowners persist. Integrating social and economic factors, monitoring human well-being, and clearly communicating environmental benefits are needed to strengthen public support and justify NbS investments (Aguilera-Rodríguez et al., 2025).

4.2. Criterion 2: Design at Scale

Design at scale emphasizes that NbS should extend beyond site-specific interventions to consider broader ecological connectivity, cross-sectoral coordination, and long-term scalability (IUCN, 2020). In the context of Guandu Wetlands, scaling NbS requires continuous monitoring and the alignment of actions across landscapes and institutions to ensure that local interventions contribute to wider ecosystem outcomes.

The conservation department in Guandu Nature Park is central to guiding the present and future of the wetlands. While the department possesses substantial expertise and operational capacity, its management framework is not always directly transferable to other sites due to differences in ecological conditions, legal contexts, and governance arrangements. Nevertheless, Guandu Nature Park contributes to knowledge exchange through networks such as Wetland Link International, facilitating information sharing and learning among wetland sites (Supplementary File, Tables 2, 6, and 7).

At the local level, partnerships with schools and educational programs support long-term environmental monitoring while enhancing conservation education. These collaborations not only enrich student learning but also generate valuable ecological data. Expanding data sharing across wetlands in Taiwan could further strengthen understanding of environmental change and migratory bird dynamics, reinforcing regional cooperation in wetland conservation (Supplementary File, Table 3).

Despite these opportunities, scaling NbS beyond Guandu remains challenging. Park managers and Forestry Bureau representatives highlighted constraints related to limited resources, legal boundaries, competing land-use interests, and nearby polluting industries. While invasive species and habitat management can be effectively addressed within the park, extending such measures beyond its boundaries is difficult, leaving broader ecological pressures such as invasive species spread largely unmanaged (Supplementary File, Table 2).

Connectivity among wetlands also introduces ecological risks that must be carefully managed (Kininmonth et al., 2015). Construction or habitat modification within Guandu may displace birds to nearby wetlands, while mangrove removal in surrounding areas can similarly alter species distribution. To mitigate these risks, the Taipei City Hydrology Department has recommended smaller-scale construction approaches to minimize disturbance. Ongoing monitoring, cross-agency coordination, and adaptive management are essential to addressing these interconnected impacts (Supplementary File, Table 4).

Stakeholder coordination was repeatedly emphasized as critical for effective scaling. Interviewees recommended establishing issue-specific working groups with clearly defined responsibilities, improving data accessibility, and strengthening mechanisms for communication and accountability. Such measures can enhance participation from government agencies, NGOs, corporations, and the public, while fostering broader awareness of NbS principles (Supplementary File, Tables 3 and 5).

Overall, while Guandu Wetlands provides a valuable reference for multi-stakeholder NbS implementation, interviewees consistently noted that upscaling remains difficult due to limited public awareness and contextual differences among sites. As echoed by Megyesi et al. (2024), effective scaling of NbS requires not replication, but adaptation grounded in local ecological conditions, governance structures, and stakeholder capacities.

4.3. Criterion 3: Biodiversity Net-Gain

Early studies conducted by university students (e.g., Chiang, 2001; Lin, 1995) focused on the ecological impacts of landscape change and the dynamics of bird communities, complementing the Guandu Nature Park managers surveys and together providing a strong foundation for understanding biodiversity conservation within the park. This ecological baseline enabled subsequent research to explore the human dimensions of conservation, particularly visitor attitudes, environmental behaviors, and ecotourism (Feng, 2006; Lee, 2001; C.-W. Liu et al., 2014; Tsai, 2005). Biodiversity monitoring in Guandu Nature Park remains complex, particularly due to the influence of migratory and invasive species on long-term records. Water birds are the primary indicator species, providing quantifiable measures of ecosystem health, though counts can fluctuate even when environmental improvements occur, likely reflecting broader ecological or migratory changes. Despite challenging weather conditions and occasional construction activities that may obscure observations, the Guandu Nature Park managers continue regular surveys. Historical baseline data spanning the past 20 years highlight trends in bird populations and underscore the importance of long-term monitoring. While the Forestry Bureau believes that management efforts are maintaining habitat quality, it remains unclear whether biodiversity outcomes are consistently measurable or improving as expected. Evidently, utilizing the baseline data is important. Overall, ongoing monitoring at Guandu provides critical insight into the park's biodiversity dynamics, emphasizing the value of long-term datasets and the need to consider both natural and anthropogenic factors in conservation assessments.

4.4. Criterion 4: Economic Feasibility

Criterion 4 was the second-lowest indicator, as economic barriers have made upscaling, implementing, and monitoring NbS difficult (Martin et al., 2025). Guandu Nature Park is no exception. All costs are documented and communicated to the public, as transparency is a key aspect of the wetlands' governance. Revenue comes from entrance fees, parking, souvenir shops, restaurants, donations, and grants from corporations (e.g., HSBC; Supplementary File, Tables 6 and 7), as well as government funding. While government agencies provide project-based funding, Guandu Nature Park does not receive direct subsidies, making self-generated income crucial. Corporate sponsorships vary annually, adding to financial uncertainty. Despite these challenges, Guandu Nature Park managers effectively track income sources, ensuring compliance with regulations, though additional funding is needed to sustain operations and expand conservation efforts. The score reflects that all costs and revenues are considered, rather than financial gains (Figure 4).

There are always pressures to develop the wetlands for potential revenue. However, the site is already protected, and its management relies on a combination of city government support, corporate funding, and self-generated income through shops and restaurants. Government agencies depend on Guandu Nature Park managers to implement ecological work and environmental education, while corporations contribute to enhance their environmental, social, and governance (ESG) image. Compared to corporations, government funding is less flexible and varies with policies and leadership. Given this uncertainty, additional resourcing options are desirable. Potential approaches include leveraging community contributions, such as labor from students or company employees, and generating income through rentals for photoshoots, events, or advertisements. Detailed site data could also support proposals to organizations like the IUCN to enable international collaborations. All initiatives should be carefully designed to maintain environmental quality and align with public welfare objectives (Supplementary File, Table 3).

According to the Forestry Bureau, local residents benefit from the flood control, education, and tourism provided by Guandu Wetlands, although no cost-effectiveness studies were reported. Although quantifying both tangible and intangible benefits is challenging, natural solutions may surpass artificial ones (Supplementary File, Table 3). This is because natural systems often provide multiple co-benefits simultaneously, whereas artificial designs are typically developed to address a single function (Raymond et al. 2017). Therefore, preserving the natural environment often proves more effective than human-made designs. It is essential to identify benefits that support both people and ecosystems, particularly in disaster prevention, green spaces, and areas that promote stress relief. Ideally, protection costs should remain low and focus on minimizing disturbances; however, expenses typically increase once human interventions are introduced (Supplementary File, Table 5). Comparing these results with a prior study on sustainable aquaculture in Zanzibar (Le Gouvello et al., 2023), it is noteworthy that both Taiwan and Zanzibar, despite differing socio-economic contexts, face similar challenges related to the economic viability of NbS projects.

4.5. Criterion 5: Inclusive Governance and Stakeholder Engagement

Over time, university-based research has increasingly examined institutional frameworks and collaborative governance in Guandu Nature Park. For example, Z.-S. Chen (2014) and Ho (2011) underscored the role of civil society groups, government agencies, and local communities in shaping the park's governance structures. Similarly, Huang (2014) highlighted how partnerships between the park and private organizations, such as HSBC, contributed to advancing environmental education and outreach. These studies reflect a growing recognition that successful conservation requires strong partnerships and inclusive decision-making processes. Another significant research trajectory centers on environmental education and capacity building. Numerous dissertations (e.g., S. H. Chen, 2005; K. M. Liu, 2004; W.-R. Yang, 2012) have evaluated the effectiveness of curricula, interpretive programs, and volunteer engagement. Collectively, these works illustrate how Guandu Nature Park has served as a living laboratory for developing and testing innovative education strategies, particularly those designed for school groups, teachers, and community volunteers. Such initiatives not only enhance ecological literacy but also foster long-term stewardship. In addition, Guandu Nature Park has been studied as a site of socio-ecological interactions. Research on ecotourism, leisure activities, and residents' perceptions (e.g., Hung, 2009; Y.-W. Liu, 2011; Tsai, 2005) reveals both opportunities and tensions. While ecotourism provides economic and educational benefits, it also raises questions about managing visitor impacts and balancing conservation goals with community needs. Political ecology perspectives (Hung, 2009) have further illuminated how governance decisions

intersect with issues of equity, access, and power. Taken together, these studies demonstrate that Guandu Nature Park is more than a protected area; it is a nexus of ecological, social, and institutional dynamics. The park has become a testing ground for integrating biodiversity conservation with education, recreation, and community development. However, the literature also points to persistent challenges, including the need for more effective policy integration, stronger long-term monitoring of ecological change, and sustained collaboration among diverse stakeholders. Future research may benefit from explicitly connecting ecological outcomes with social impacts, thereby advancing understanding of how urban wetland parks can simultaneously support conservation, education, and community well-being.

4.6. Criterion 6: Balancing Trade-Offs

Balanced trade-offs require that stakeholders recognize the existence of such compromises (IUCN, 2020). Moreover, trade-offs must be both quantitatively and qualitatively determined (IUCN, 2020). When trade-offs arise, clear boundaries between stakeholders and the use of resources must be maintained and respected to prevent destabilization of NbS (IUCN, 2020). Trade-offs are an inevitable aspect of environmental management, particularly in multifunctional ecosystems like wetlands (Gibson, 2013). In Guandu, conservation is prioritized over potentially conflicting uses such as land development and tourism-related disturbances (e.g., photographers entering core conservation zones; Supplementary File, Table 2). In an ecological context, balancing ecological benefits such as allowing seawater into the wetland represents a trade-off between ecological gains and agricultural concerns. The controlled inflow enhances biodiversity by supporting benthic organisms and bird populations, while also lowering maintenance costs by reducing weed growth. At the same time, too much seawater could increase soil salinity, threatening nearby farmland. To balance these outcomes, managers regulate the process by limiting gate openings to once or twice a month, ensuring both ecological integrity and agricultural sustainability (Supplementary File, Table 2). The protection of monetary trade-offs is safeguarded by the accountants in Guandu Nature Park to ensure transparency. Additionally, frameworks such as climate resilience, net-zero initiatives, Sustainable Development Goals (SDGs), and third-party certification and verification mechanisms (e.g., Société Générale de Surveillance) are ensured by the Guandu Nature Park managers. Both regular evaluations internally and internal frameworks ensure respect and limits between various trade-offs (Supplementary File, Tables 2 and 4). In regard to respecting trade-offs, interestingly, the idea of a Guandu Wetlands NbS working team was raised, emphasizing the need for open communication among stakeholders and the importance of addressing their concerns. Such discussions may lead to one of two possible outcomes: a mutual agreement, or a decision where some stakeholders remain partially dissatisfied but are willing to compromise (Supplementary File, Table 3).

4.7. Criterion 7: Adaptive Management

Wetland ecosystems undergo dynamic changes; thus, stakeholders are in charge of adjusting NbS management strategies. In the past, legal restrictions limited effective management; however, following the reclassification of Guandu Nature Park, operations were able to address emerging issues as they arose. Regular monitoring now ensures stability, prevents deterioration, and serves as the foundation of various conservation projects (Supplementary File, Tables 2 and 5). In terms of adaptive management, Guandu Nature Park has obtained various government standards and licenses to be able to manage and operate the park. For instance, local knowledge and real-time monitoring data were used to determine the best time

when construction, grass trimming, and conservation efforts are optimal for minimal disruption of natural habitats, especially for migratory birds. From March to May, the managers stop construction to avoid disturbing the breeding season of birds, insects, and small mammals. August to September is considered a suitable time for tasks like weeding, as most young animals have matured and can move independently. However, all work must be completed before November, when migratory birds arrive for the winter, as any disturbances could drive them away permanently. Their 20 years of experience allow them to predict seasonal patterns and plan management activities accordingly to minimize ecological disruption (Supplementary File, Table 2). The previous example mentioned is grounded in adaptive management and iterative learning, where challenges are continuously identified, solutions are applied, and strategies are refined based on results. The Guandu Nature Park managers utilize farming processes, emphasizing the need to work in harmony with seasonal cycles. By observing nature's rhythms, managers can make informed decisions that balance conservation goals with necessary interventions. When managing NbS, flexibility is key as unforeseen ecological shifts may demand adaptive responses (Smith & Chausson, 2021). Long-term monitoring and collaboration with local communities also strengthen the effectiveness of interventions. Practical insights, often gained through trial and error, play a vital role in improving conservation practices. At the same time, recognizing human impacts on ecosystems and integrating scientific research can enhance management outcomes. Ultimately, effective environmental management relies on a blend of experience, evidence, and adaptability (Supplementary File, Table 2). The Wild Bird Society mentions that monitoring of these changes is adequate, but planning for the future is more substantial (Supplementary File, Table 5).

4.8. Criterion 8: Sustainability and Mainstreaming

Although Criterion 8 received the lowest score in Guandu Wetlands, this was primarily because there are no predominant aboriginal communities in this part of Taipei, Taiwan. Guandu Nature Park actively engages in national and international collaborations, staff training, and knowledge exchange, while conducting environmental education and SDG-related programs to enhance public awareness and learning. Park managers participate in wetland construction and decision-making, collaborating with NGOs and professionals to analyze monitoring data and develop iterative improvement plans. While government regulations and policy promotion support NbS implementation, inconsistent stances between local and central authorities remain a key challenge to mainstreaming NbS.

4.9. Recommendations

Based on the interviews, it is recommended that stakeholders reach consensus on the adoption of NbS, beginning with clear definitions of what qualifies as NbS and the standards that must be met. This endeavor requires a lot of coordination that may potentially lead to misunderstandings (Directorate General for Research and Innovation, 2023). Its success depends on whether the stakeholders are engaged with the establishment and expansion of NbS despite its challenges (Teo et al., 2023). A major challenge in the upscaling of NbS is financial funding. Scholars argue that NbS funding can co-exist with broader climate financing mechanisms (Molloy et al., 2024). However, existing NbS such as Guandu Wetlands still rely on financial support from the private sector, government sources, and non-governmental organizations, rather than high-level or dedicated climate-related funding mechanisms. Based on this study on Guandu Wetlands, there is a lack of attention to economic feasibility in Guandu Wetlands and even other sites (e.g., Zanzibar; Chairat & Gheewala, 2024; Le Gouvello et al., 2023).

In this case study, where ecological monitoring and financial data are available, a database of NbS would be valuable for stakeholders and university researchers to facilitate the scaling up of NbS (Supplementary File, Table 2; Almassy et al., 2018; Chee et al., 2021; Molloy et al., 2024). Overall, when it comes to management and boundaries and limits to trade-offs, all stakeholders are responsible and knowledgeable of tasks and well-defined laws (Supplementary File, Table 5). For example, the Forestry Bureau leaves the democratic decision-making to the Guandu Nature Park managers but still participates in steering committees, contributing to the high score in inclusive governance. This finding aligns with previous studies that claim participation has a positive impact on environmental governance outcomes (Newig et al., 2023). Despite the use of progressive ecological management approaches, it remains essential to translate ecological benefits into quantifiable costs and benefits in order to convince a broader range of stakeholders to adopt NbS. More often than not, negative impacts of gray solutions are not accounted for; this is vital to highlight the benefits of NbS (Anderson et al., 2021). Assessment of NbS is critical to confirm that they effectively address climate-related challenges and to evaluate their impacts on ecosystem structure, functioning, and biodiversity outcomes. For instance, the Taipei Hydrology Department has implemented selective mangrove management, including controlled thinning, to maintain water flow capacity and open mudflat habitats, with the dual aim of mitigating localized flooding risk and supporting waterbird populations (Supplementary File, Table 4). Other recommendations include aligning with the Taskforce on Nature-related Financial Disclosures, as suggested by interviewees, which could help attract corporate partnerships and emphasize biodiversity outcomes (Supplementary File, Table 3).

4.10. Limitations

While the NbS criteria were translated into Chinese, some indicators proved challenging to interpret without additional context provided by guided questions. Notably, Criterion 2 (Design at Scale) did not score as highly for representatives from the Forestry Bureau and Guandu Nature Park managers as it did for the Taipei Hydrology Department and the Wild Bird Society. Furthermore, since the questionnaire was mostly for NbS managers, the perspectives of the private donors and residents in Taipei City were not taken into account, as NbS does not have a high public awareness yet in Taipei City. Future works must include the perspectives of residents in NbS implementation and planning.

5. Conclusion

The application of the IUCN Global Standard for NbS to the Guandu Wetlands highlights the importance of balancing trade-offs, practicing adaptive management, and designing interventions at scale. These principles are particularly relevant in ecologically sensitive and urban-adjacent environments such as Guandu Wetlands. While stakeholders including the Forestry Bureau, local authorities, and academic institutions are represented in governance structures and planning forums, the translation of shared objectives into on-the-ground interventions varies in scope and intensity. In this context, researchers and the academe play a critical role by generating ecological evidence and providing studies on the management of Guandu Wetlands—they give an independent basis for evaluating NbS performance. By integrating scientific evidence into management decisions, policymakers can prioritize interventions that maximize ecological and social benefits, while also justifying resource allocation for restoration and conservation initiatives. Strengthening the interface between scientific research and management practice, alongside continuous monitoring of ecological transitions, will be essential for adaptive management and for informing future NbS

initiatives in Guandu and comparable urban wetlands. Furthermore, lessons learned from Guandu's multi-stakeholder approach can guide other urban wetland projects, support biodiversity conservation, enhance ecosystem services, and inform regional and national policies on sustainable wetland management.

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Conflict of Interests

The authors declare no conflict of interests.

Data Availability

Data are available upon request.

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Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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About the Authors

Mariana Gabrielle Cangco Reyes is a postdoctoral researcher at National Taiwan University, with research interests spanning ecological restoration, nature-based solutions, GIS research, and species distribution modelling.

Yi-Hsin Tan is a former research assistant and a current master's student at the School of Forestry and Resource Conservation, National Taiwan University. She has worked on campus tree surveys and nature-based solutions interview translation, and is currently studying vegetation ecology.

Yu-Chen Hsu is a graduate student in the master of research program in management science at ESADE, within the Department of Society, Politics, and Sustainability of Ramon Llull University. Her research interests focus on sustainability transitions, organizational and institutional governance, employee well-being, and the social dimensions of corporate and policy-led transformation. She is particularly interested in how sustainability-related policies and organizational practices are interpreted and enacted in real-world contexts, and how these processes affect motivation, behavior, and long-term societal outcomes.

Syuan-Jyun Sun is a behavioral ecologist, broadly interested in how biodiversity arises and persists in a rapidly changing world. Particularly, he is interested in biotic responses to environmental changes and the importance of biodiversity to ecosystem functioning. He is currently an assistant professor in the international program in climate change and sustainable development at National Taiwan University.

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Integrating Management Effectiveness and University Social Responsibility: A Co-Learning Model for Qingluo Wetland

Shyi-Liang Yu, Wei-Zhen Kang, and Ying-Chien Chu

Department of Tourism and Leisure, National Penghu University of Science and Technology, Taiwan

Correspondence: Ying-Chien Chu (verna323@gms.npu.edu.tw)

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Abstract

This study evaluates the management effectiveness of the Qingluo Wetland in Penghu, Taiwan, with the aim of identifying its governance strengths and challenges as a "nationally important wetland." The site possesses significant ecological value and plays multiple roles in supporting sustainable local development and social participation. However, its island geography and competing land-use demands impose considerable constraints on management, particularly in balancing conservation objectives with local development pressures. The study employs the Management Effectiveness Tracking Tool as its analytical framework, applying 30 indicators across five dimensions—planning, inputs, process, outputs, and outcomes—scored on a scale from 0 to 3. Based on focus group interviews with key stakeholders, the results indicate a moderate level of management effectiveness (average score = 0.62). While the wetland performs relatively well in terms of legal status and conservation objectives, notable deficiencies remain in staffing, financial stability, community engagement, and threat management. Beyond providing targeted recommendations, this study highlights the importance of incorporating island-specific governance contexts and strengthening cross-sectoral co-management mechanisms. Furthermore, by examining the involvement of the National Penghu University of Science and Technology, the research demonstrates how university social responsibility initiatives can function as knowledge intermediaries, bridging governance gaps through student engagement and community co-learning. The findings offer practical insights for advancing sustainable management and regional revitalization in similar offshore wetland contexts.

Keywords

collaborative governance; island wetland governance; Qingluo Wetland; university social responsibility

1. Introduction

In the global context of climate change, biodiversity loss, and wetland degradation, the importance and complexity of wetland governance have drawn increasing attention. As critical providers of ecosystem services, wetlands regulate climate, conserve water resources, and play essential roles in sustaining biodiversity and supporting human well-being. While international frameworks such as the Ramsar Convention emphasize "wise use," many protected areas worldwide struggle with management effectiveness gaps due to resource scarcity. Since Taiwan launched its wetland conservation policy in 2001, a hierarchical "Nationally Important Wetlands" system has gradually been established. Among them, the Qingluo Wetland in Penghu was designated a national-level wetland in 2015, highlighting its significance in ecological conservation and coastal sustainability.

However, as a typical offshore island site, the Qingluo Wetland faces multifaceted governance challenges stemming from its insular geography and fragile landscape. The management practices are often caught in a tug-of-war: On one hand, there are strict conservation mandates for indicator species; on the other, there are pressing demands for local recreation and economic development. This tension, exacerbated by limited human resources and financial dependence, often results in fragmented and contradictory governance outcomes. Thus, systematically assessing its current governance status and fostering local co-learning have become critical issues for both practice and scholarship.

This research presents a case study on the integration of university social responsibility (USR) into the governance of protected areas. It employs the internationally recognized Management Effectiveness Tracking Tool (METT) as a diagnostic framework to systematically evaluate the site's operational performance. In parallel, the study builds on literature concerning higher education sustainability and collaborative governance, which emphasizes universities as boundary-spanning actors within socio-ecological systems (Lozano et al., 2013; Trencher et al., 2014; Etzkowitz & Leydesdorff, 2000). By involving students in project-based learning and ecological education, the study examines how USR can complement formal management efforts.

This study fills a critical research gap in island wetland governance. Unlike mainland wetlands, island sites face higher degrees of isolation and resource constraints, making the governance gap more pronounced. The findings aim to serve as an integrative reference for policy implementation and academic dialogue, demonstrating how wetland governance can transition from a top-down regulatory approach toward a resilient model of co-learning and co-management that is applicable to similar coastal and island contexts globally. To provide spatial context for the study area, Figure 1 illustrates the geographic location and habitat zoning of the Qingluo Nationally Important Wetland, including its regional setting within the Taiwan Strait and key ecological zones.

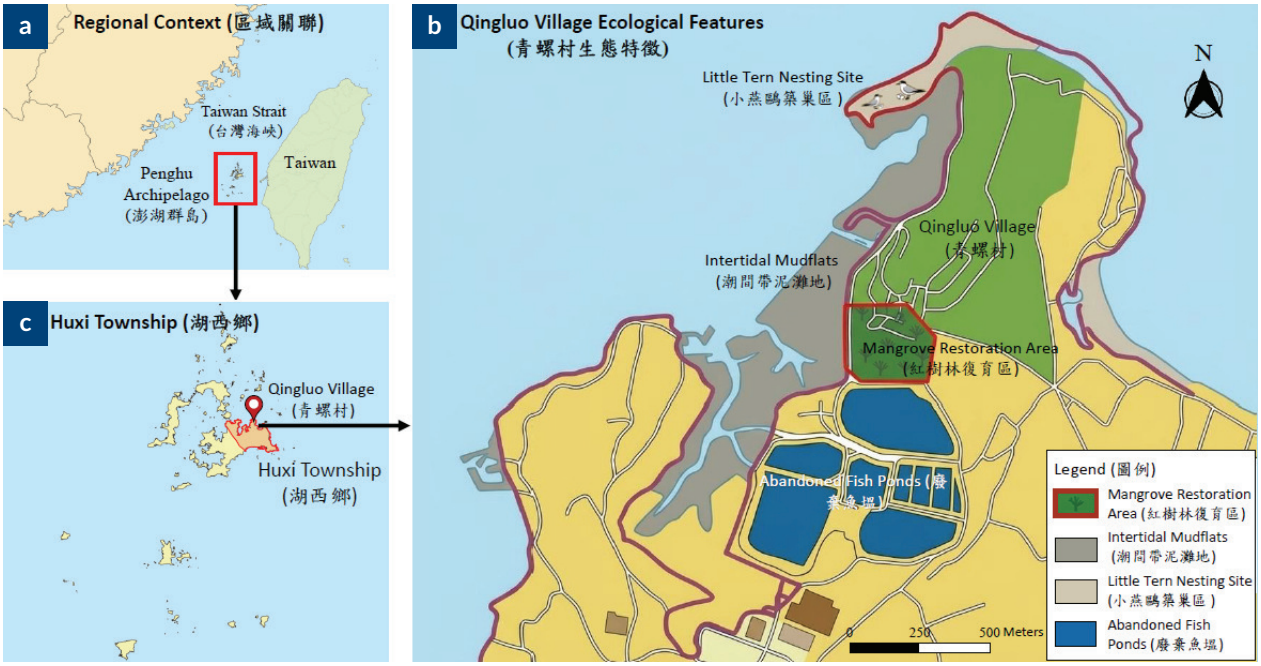

Figure 1. Geographic location and habitat zoning of the Qingluo Nationally Important Wetland: (a) location of the Penghu Archipelago within the Taiwan Strait; (b) spatial extent of the 55-hectare wetland in Huxi Township; (c) detailed zoning and key ecological features, including mangrove restoration areas, intertidal mudflats, and nesting habitats of the little tern (*Sterna albifrons*). Note. Adapted from national wetland conservation report, by Construction and Planning Agency (2024).

2. Literature Review

2.1. Wetland Governance: From Control to Collaboration

Wetlands are critical providers of ecosystem services and play an essential role in climate regulation and biodiversity conservation. Since the adoption of the Ramsar Convention on Wetlands in 1971 (Ramsar Convention Secretariat, 2013), global wetland management has gradually shifted from a strict resource control model toward collaborative governance and ecosystem-based management. Although Taiwan is not a contracting party to the Ramsar Convention, the Wetland Conservation Act has established a graded management system since 2001. Previous research indicates that effective governance depends on adaptive capacity and multi-stakeholder participatory mechanisms (Ostrom, 2009; Reed, 2008). Effective governance increasingly relies on adaptive co-management, which emphasizes knowledge generation and social learning among bridging organizations (Armitage et al., 2009; Berkes, 2009).

2.2. The METT Framework in Island Contexts

The METT, developed by the IUCN and the World Bank, is a globally recognized diagnostic framework for protected areas. It evaluates governance through five dimensions: planning, inputs, process, outputs, and outcomes. While METT has been applied to over 3,000 sites worldwide (Leverington et al., 2010), its application in offshore island wetlands remains limited. This study employs METT not only as an assessment tool, but also to identify the governance gaps specific to insular environments—where financial and human resource inputs often lag behind legal designations.

2.3. USR as a Complementary Governance Mechanism

USR expands the role of higher education from traditional teaching to active social and environmental engagement. According to Wang and Lin (2018), USR integrates ethical responsibility and knowledge contribution into local contexts. In wetland governance, universities act as knowledge nodes, using curriculum design and citizen science to bridge the gap between academic research and community needs (Huang, 2019; Li, 2019; Lin, 2020). This aligns with broader perspectives on co-learning governance, which emphasize iterative knowledge exchange between institutions and communities (Trencher et al., 2014).

This study conceptualizes USR as a locally grounded complement to formal governance. By documenting the engagement of NPU in the Qingluo Wetland, we propose an integrated framework where USR practices compensate for the low "input" and "process" scores often revealed by METT evaluations, thereby fostering a model of co-learning and co-management.

3. Research Methods

3.1. Study Area: Overview of the Qingluo Wetland, Penghu

The Qingluo Wetland is located along the coast of Qingluo Village in Huxi Township, Penghu County. It is a typical intertidal mudflat wetland covering approximately 55 hectares and was designated as a "Nationally Important Wetland" in 2015 under the Wetland Conservation Act of Taiwan. This designation functions as a protected-area status, managed by the Interior Ministry's Land Administration Office in coordination with the Penghu County Government. Governance is dictated by the Qingluo Wetland Conservation and Utilization Plan, which mandates the protection of core habitats while allowing for "wise use" in peripheral zones. However, enforcement remains complex due to overlapping jurisdictions between fisheries, tourism, and environmental bureaus.

The Qingluo Wetland encompasses mangroves, halophytic plant communities, intertidal algae, and habitats for protected species such as the little tern (*Sterna albifrons*) and the tri-spine horseshoe crab (*Tachypleus tridentatus*), reflecting the broader ecological characteristics of the Penghu marine environment (Marine National Park Headquarters, 2016). These ecosystems are embedded within a wider socio-ecological system shaped by long-term fisheries practices and marine resource utilization in Penghu (Fisheries Research Institute, 2024).

Beyond its ecological value, the wetland is also situated within a socially embedded landscape. The implementation of community co-learning workshops follows established USR models that bridge higher education with regional revitalization (Huang, 2019; Li, 2019). In this context, the use of visual and participatory learning tools—such as mind mapping and other interactive approaches—has been shown to enhance environmental awareness and facilitate stakeholder engagement (Lozano et al., 2013; Reed, 2008).

In addition, the cultural significance of the area, including local beliefs and traditional seaweed harvesting practices, has been documented as an integral component of the region's socio-ecological fabric (Cai, 2015; H. Zhang, 2017; Z. Zhang, 2017).

3.2. Research Framework and Data Collection Methods

This study adopts a mixed-methods case study approach, integrating the METT with an analysis of USR practices. To ensure academic rigor and transparency, the following sections describe the procedures that were implemented.

3.2.1. METT Assessment and Focus Group Discussions

The METT component applies the 2016 assessment framework, comprising 30 indicators across five dimensions—planning, inputs, process, outputs, and outcomes—each scored on a scale of 0 to 3 based on specific criteria defined by the IUCN. The scoring was conducted through a consensus-building process during two focus group meetings held between May and June 2024. To provide an overview of the study participants, Table 1 summarizes the composition and background of the focus group members ($N = 12$).

Table 1. Composition of focus group participants ($N = 12$).

Sector	Representing Organizations	No. of Participants
Government	Penghu County Bureau of Agriculture and Fisheries; Environmental Protection Bureau	2
Community	Qingluo Community Development Association; local volunteer groups	4
NGOs	Wetland conservation-focused NGOs	3
Academia	NPU; local high schools	3
Total		12

3.2.2. USR Data Collection for the USR Component

The study analyzed documentation from NPU projects conducted between 2021 and 2024. Data were selected based on their direct relevance to wetland governance, including student fieldwork reports, course-based project outcomes (e.g., interpretive maps), community workshop records, and citizen science survey data. This allows for a cross-comparison between formal governance performance and university-led action-oriented interventions.

3.2.3. Research Ethics and Data Analysis

Adhering to research ethics, all participants provided informed consent prior to the focus groups. Participants were informed of the study's purpose, their right to withdraw, and the guaranteed anonymity of their contributions. Quotations used in the results were de-identified to protect participant privacy. Quantitative METT scores were synthesized and visualized through radar and bar charts to highlight performance gaps. Qualitative data from focus group transcripts and USR documents were analyzed using content analysis to identify key themes (e.g., "resource shortage," "knowledge gaps"). This integrative analysis examines how USR initiatives fill the governance gaps revealed by the METT evaluation.

4. Research Results and Analysis

This section presents the management effectiveness evaluation of the Qingluo Wetland based on the five dimensions of the METT. It further analyzes the impacts of USR initiatives and synthesizes their potential to fill identified governance gaps.

4.1. Evaluation Results of the Five METT Dimensions

The assessment followed the 2016 METT framework. Based on these indicators, the Qingluo Wetland achieved an overall management effectiveness index of 0.62. While the score reflects "moderate" performance, qualitative feedback from stakeholders reveals a more nuanced picture of progress and resilience. Table 2 provides a detailed score breakdown, and Figure 2 illustrates the dimension-based performance.

Table 2. Detailed METT indicator scores for Qingluo Wetland (2024).

Dimension	Indicator	Score (0–3)	Key Observations
Planning	Legal Status	3	Designated National Importance in 2015.
	Management Plan	2	Plan exists but lacks long-term vision.
	Land/Water Use	2	Coordination with spatial planning in progress.
Inputs	Staffing Levels	1	Reliance on volunteers; no permanent staff.
	Current Funding	1	Dependent on annual government subsidies.
	Resource Inventory	3	Comprehensive ecological data available.
Process	Local Participation	0	Lack of institutionalized co-management.
	Law Enforcement	2	Routine patrols present but enforcement is weak.
	Climate Adaptation	0	No specific climate strategy for the wetland.
Outputs	Threat Reduction	2	Issues with marine debris and stray dogs.
	Education Program	1	Ceremonial events rather than systematic curricula.
	Visitor Facilities	1	Infrastructure remains underdeveloped.
Outcomes	Natural Values	3	Indicator species (little terns, fiddler crabs) show stable breeding.
	Habitat Status	2	Anthropogenic disturbances (tourism) persist.

4.1.1. Planning: Legal Foundation and Vision Ambiguity

The high scores in legal status and objectives (3 points) reflect the site's stable status as a national-level wetland. However, stakeholders highlighted a lack of long-term strategic clarity. As one participant noted, the absence of a visible roadmap makes it difficult to align local development with conservation.

4.1.2. Inputs: Resource Scarcity and Volunteer Dependency

This dimension remains the weakest link (scoring 1 point in staffing and funding). Management is heavily dependent on external subsidies and local goodwill. Participants expressed concerns that without permanent, professional conservation staff, the long-term monitoring of the site's ecological health remains precarious.

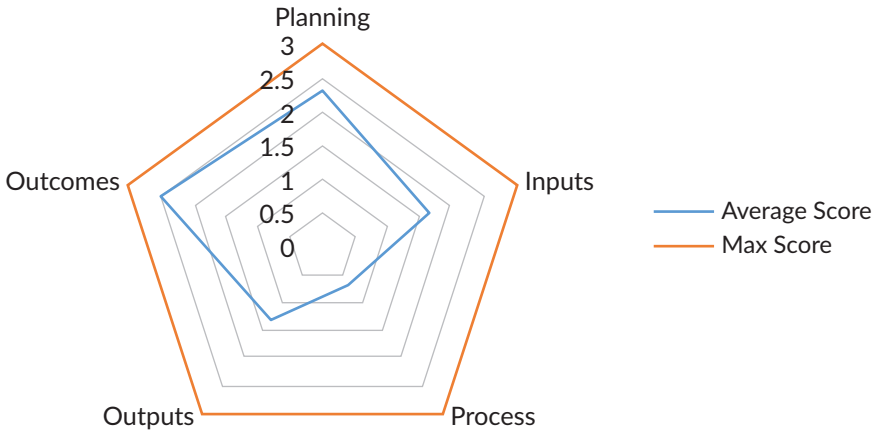

Figure 2. Radar chart of management effectiveness across the five METT dimensions. The chart illustrates a significant performance gap where Planning and Outcomes remain strong, while Process and Inputs represent the primary governance challenges in the Qingluo Wetland.

4.1.3. Process: Strategic Intervention and Active Management

In the process dimension, the study found that active management measures have begun to show results. Indicators such as resource management (2 points) are supported by strategic interventions. One participant highlighted the benefits of active habitat maintenance:

> Moderate thinning is actually beneficial to the wetland. It is not just about visual openness; it allows the entire ecosystem to restore its original functions. (Participant F)

Another stakeholder emphasized that "protection" should not be equated with "non-interference":

> Conservation doesn't mean doing absolutely nothing. Proper intervention actually helps biodiversity, and we can clearly see the effects of this in the Qingluo Wetland. (Participant G)

4.1.4. Outputs: Institutionalizing Visibility and Awareness

While threat reduction (2 points) and education programs (1 point) show progress, they lack institutionalized tracking. Despite these gaps, the overall output is perceived as positive in terms of preventing further environmental decline. As a summary of recent efforts, one manager remarked:

> Although there is still room for improvement in habitat conditions, overall, the management of the Qingluo Wetland in recent years has been effective; at the very least, it has successfully prevented the degradation of resources. (Participant L)

4.1.5. Outcomes: Ecological Stability and Asset Evaluation

The Qingluo Wetland excels in its outcome indicators, particularly in key species conservation (3 points). Stakeholders provided strong evidence of a positive trajectory:

> From our observations, the Qingluo Wetland is not yet at its ideal habitat state, but we have seen clear improvements over the past few years. As management measures have been implemented, the overall ecological environment has become more stable than before. (Participant A)

Comparing the current state with the past, another participant noted:

> Compared to five years ago, the current habitat conditions have progressed. Although there are still structural issues to address, the site is no longer in a state of neglect. (Participant B)

Indicators of health are particularly tied to natural and cultural assets. Fiddler crabs, a key indicator species in Qingluo, serve as a benchmark:

> Natural environments, cultural backgrounds, and indicator species like fiddler crabs have not shown significant degradation. This suggests that the general direction of management has been correct. (Participant I)

Another expert added:

> The population and activity levels of fiddler crabs have remained stable without a noticeable decline, which is a critical basis for our judgment of the wetland's health. (Participant J)

4.2. USR Actions: Filling the Governance Gaps at Qingluo Wetland

While the METT assessment in Section 4.1 identified significant gaps in "inputs" and "process," the analysis of USR projects (2021–2024) conducted by the NPU reveals how academic intervention serves as a critical governance supplement. These actions are categorized into three strategic dimensions, presented in the next three sections.

4.2.1. Addressing "Inputs" Gaps Through Citizen Science and Student Engagement

The METT evaluation revealed a critical shortage of permanent staff and consistent funding (scores of 1). To compensate, NPU utilized its USR framework to mobilize students as a flexible conservation workforce. Between 2022 and 2024, over 150 students participated in systematic ecological monitoring as part of their coursework. By utilizing citizen science tools (e.g., iNaturalist) to document the population dynamics of the fiddler crab and the little tern, the university provided the high-resolution longitudinal data that the formal management office lacked due to budget constraints. This effectively transformed a low-input situation into a data-rich environment through academic resource reallocation.

4.2.2. Strengthening the "Process" Through Community Co-Learning

The lowest score in the METT assessment was assigned to "local participation" (score of 0), reflecting a top-down management style that alienated residents. NPU's USR initiatives acted as a neutral intermediary through the establishment of community co-learning workshops. Instead of ceremonial lectures, these workshops utilized project-based learning, where students and residents co-created interpretive materials

and sustainable tourism maps. This process moved the community from passive subjects to active knowledge partners, creating a platform for dialogue between government bureaus and local stakeholders that had previously been absent.

4.2.3. Enhancing "Outputs" via Educational Innovation

METT scores for "education programs" were low (score of 1) because existing government-led programs were often sporadic. NPU addressed this by institutionalizing ecological education. Key outputs included:

1. Curriculum integration: Developing 12 specialized lesson plans based on the Qingluo ecosystem for local elementary schools.
2. Technological application: Implementing QR-code-based interpretive systems and digital storytelling to increase the wetland's visibility among younger generations.
3. Waste management initiatives: Organizing design-thinking workshops to repurpose marine debris collected during beach cleanups into local handicrafts, directly addressing the threat management gap identified in Section 4.1.4.

4.3. Synthesis: USR as a Governance Intermediary

Based on an integrated analysis of empirical findings and prior literature on USR and co-learning governance (Huang, 2019; Li, 2019; Lin, 2020), this study finds that university involvement functions as a governance intermediary within the broader socio-ecological system. Specifically, USR initiatives facilitate knowledge exchange, enhance local engagement, and support adaptive governance processes.

By bridging scientific knowledge and local ecological practices, universities help reduce the disconnect between formal policy frameworks and community-based realities. This intermediary role enables more responsive and context-sensitive governance, particularly in resource-constrained island settings. The resulting tripartite collaboration—where government provides institutional structure, universities contribute with intellectual and human capital, and communities offer local ecological knowledge—constitutes a resilient model for addressing the structural limitations of island wetland governance.

4.3.1. Visualization of the Governance Compensation Effect

By overlaying the USR intervention data onto the METT dimensions, a clear compensation effect is observed. While the "inputs" and "process" dimensions initially showed the lowest performance due to resource scarcity, the USR actions—such as student-led monitoring and community workshops—effectively functioned as a "bridge," elevating the site's operational capacity without requiring immediate increases in government subsidies.

4.3.2. The Tripartite Governance Framework

Based on the synthesis, this study proposes a tripartite collaboration model for island wetland governance. In this model:

1. Government (the anchor): Provides legal status, long-term conservation objectives, and basic infrastructure ("planning" and "outcomes").
2. University (the knowledge node): Provides human capital, data monitoring, and educational innovation, filling the "input" gaps.
3. Community (the context provider): Provides traditional ecological knowledge (TEK) and local participation, ensuring the sustainability of management processes ("process").

The synthesis demonstrates that when a university acts as a collaborative partner, it significantly lowers the threshold for effective governance in remote island contexts, creating a social-ecological buffer against resource fluctuations.

5. Discussion and Recommendations

5.1. Challenges in Governance Practice Revealed by METT Gaps

The METT assessment of the Qingluo Wetland reveals a common paradox in protected area management: a strong legal framework ("planning") but weak operational execution ("inputs" and "process"). With an effectiveness index of 0.62, the site faces significant capacity shortfalls, particularly in staffing and financial security. These findings align with the global analysis by Gill et al. (2017), which argued that adequate staffing and budget are the most critical predictors of conservation success. In the case of Qingluo, the reliance on unpaid volunteers and temporary subsidies reflects a systemic institutional difficulty common in offshore island regions. Furthermore, while policy advocacy emphasizes community participation, the METT results show it remains largely passive. This lack of substantive co-management mechanisms limits the social resilience of the wetland, making it difficult to translate conservation objectives into local well-being.

5.2. The Potential of USR Actions as a Collaborative Bridge

Compared with the limitations of conventional top-down governance, USR initiatives offer a "third path" of governance that acts as a complementary supplement. This study demonstrates that USR practices address METT-identified gaps in three primary ways. First, USR teams improve information transparency by building ecological databases through citizen science, which compensates for the lack of formal monitoring staff. Second, they deepen community engagement by acting as neutral intermediaries, facilitating two-way exchanges between residents and management agencies. Finally, USR functions as a platform for cross-sectoral collaboration, aligning the diverse needs of local schools, government bureaus, and NGOs. These actions transform the university from a mere educational institution into a knowledge node that bridges the gap between conservation policy and local practice.

5.3. Comparison: Island vs. Inland Wetland Governance

It is important to consider the geographical specificity of these results. Unlike inland wetlands that may have access to larger urban resources and diverse funding streams, island wetlands such as Qingluo are characterized by geographical isolation and a smaller, more centralized stakeholder base. In such contexts, the governance gap is often more acute because the failure of a single government subsidy can stall all management activities. Consequently, the role of a local university becomes even more vital in offshore

regions. The university provides a stable, long-term intellectual presence that can sustain monitoring and education efforts even when political or financial cycles fluctuate. This suggests that the USR-integrated governance model proposed here is highly relevant for other small-island developing states or remote coastal protected areas globally.

5.4. Study Limitations and Future Perspectives

Despite the insights gained, this study has certain limitations. First, as a single-case study focused on the Qingluo Wetland, the results may not be directly generalizable to all types of protected areas without local adaptation. Second, the METT assessment relies on the consensus of a specific focus group; different participants might produce slightly different scores. Finally, the project-based nature of USR initiatives means that their long-term sustainability is not guaranteed. Future research should involve multi-site comparisons across different island wetlands in Taiwan and abroad. Additionally, developing a standardized set of USR performance indicators that can be integrated into the formal METT framework would provide a more robust tool for managers to evaluate the impact of academic partnerships.

5.5. Governance Recommendations

Based on the findings, this study proposes three strategic recommendations for future wetland governance:

1. Institutionalize assessment mechanisms: Management agencies should regularly implement METT evaluations to move beyond "ceremonial conservation" and establish data-driven policy reviews.
2. Formalize university–government partnerships: USR initiatives should transition from short-term projects to long-term collaboration agreements, ensuring that student engagement and research outcomes are officially recognized within management plans.
3. Establish co-learning platforms: Fostering a co-governance culture requires ongoing dialogue among residents, faculty, and managers. By transforming the wetland into a shared learning space, stakeholders can co-create knowledge and shift from conflict-oriented to collaboration-oriented management.

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Conflict of Interests

The authors declare no conflict of interest.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy and ethical restrictions involving the participants of the focus group interviews.

LLMs Disclosure

Gemini 1.5 was used during the preparation of this manuscript for the purpose of language editing, structural refinement of the abstract, and translation assistance. The authors reviewed and edited the content as needed and take full responsibility for the content of the published work.

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About the Authors

Shyi-Liang Yu (PhD) is a professor at the National Penghu University of Science and Technology and former dean of the College of Tourism and Leisure. He earned his PhD from the University of Nebraska, USA. His practice focuses on island tourism and natural resource management, including leading Penghu Marine Geopark and National Park planning.

Wei-Zhen Kang holds an MA in tourism and leisure from the National Penghu University of Science and Technology. A native of Penghu and a secondary school teacher, she is passionate about wetland research. Her work focuses on the intersection of environmental education, community engagement, and sustainable wetland management.

Ying-Chien Chu is an assistant professor at the National Penghu University of Science and Technology. Her research employs qualitative methods to examine natural resource management and sustainable island tourism. She is particularly interested in the intersection of tourism planning and ecotourism, focusing on community engagement and sustainable resource use.

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Regenerating Coastal Landscapes Through Local Knowledge: Sustainability in Taiwan's Caota Sand Dunes

Wan-Lin Chang

Department of Taiwan Literature, National Taiwan University, Taiwan

Correspondence: Wan-Lin Chang (d00145001@ntu.edu.tw)

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Abstract

This study examines the regeneration of coastal landscapes and local knowledge through collaborative governance at the Caota Sand Dunes Geopark in Taiwan. Drawing on document analysis, participant observation, and interviews, it explores how citizen science, walking pedagogy, and cultural translation reshape relations among landscape, community, and governance. Findings show that geopark governance operates as a place-based framework linking monitoring, education, and policy. Knowledge circulates between residents and experts, enabling the co-production of environmental data and cultural meaning. Participatory initiatives institutionalize local knowledge while strengthening community identity. Interpreted through power/knowledge, symbolic capital, critical pedagogy, and cultural sustainability, the case demonstrates how ecological restoration and cultural regeneration reinforce each other. Rather than separating local and scientific knowledge, the study highlights their interaction within a dynamic governance field, illustrating collaborative governance as an ongoing process of social learning and sustainability.

Keywords

collaborative governance; cultural sustainability; Taiwan; walking pedagogy

1. Introduction: Research Background and Problem Awareness

Taiwan is a maritime island society whose approximately 1,200-km coastline has long fostered diverse coastal settlements and place-based forms of local knowledge shaped through sustained human–environment interactions. Since the Qing dynasty, coastal communities have developed situated knowledge in response to intertidal zones, sandbars, and fishing harbors. However, postwar industrialization,

urban expansion, and energy infrastructure development have progressively transformed coastal environments, weakening everyday connections between residents and the ocean.

In response to these pressures, geoparks have emerged in Taiwan as place-based governance frameworks that integrate geological heritage conservation, environmental education, community participation, and sustainable regional development. Rather than functioning solely as protected areas, they emphasize the relationship between landscapes and communities, highlighting how geological features are embedded in cultural practices and local knowledge. As of 2026, Taiwan has established a national network of 11 geoparks overseen by the Forestry and Nature Conservation Agency under the Ministry of Agriculture, the national authority for geological heritage conservation and geopark management.

Designated in 2025 as Taoyuan City's first geopark, the Caota Sand Dunes Geopark, located along Taiwan's northwestern coast, represents one of the few remaining naturally formed coastal dune belts in northern Taiwan. Shaped by aeolian processes, monsoon dynamics, and long-term human engagement, Caota constitutes a distinctive coastal landscape and an empirically rich site for examining how geological conservation, ecological protection, and community participation can be integrated within contemporary sustainability frameworks (Lin & Su, 2019). As shown in Figure 1, the Caota Dune system extends across the Dayuan and Guanyin Districts and is situated within the broader geomorphological and conservation context of northern Taiwan. Following decades of waste dumping and landscape degradation, collaborative efforts between the Taoyuan City Government and civic organizations have transformed the area from a neglected coastal margin into a geopark integrating dune conservation, citizen science, environmental education, and community-led interpretation (V. M. van Onselen et al., 2025; V. V. van Onselen & Lin, 2022).

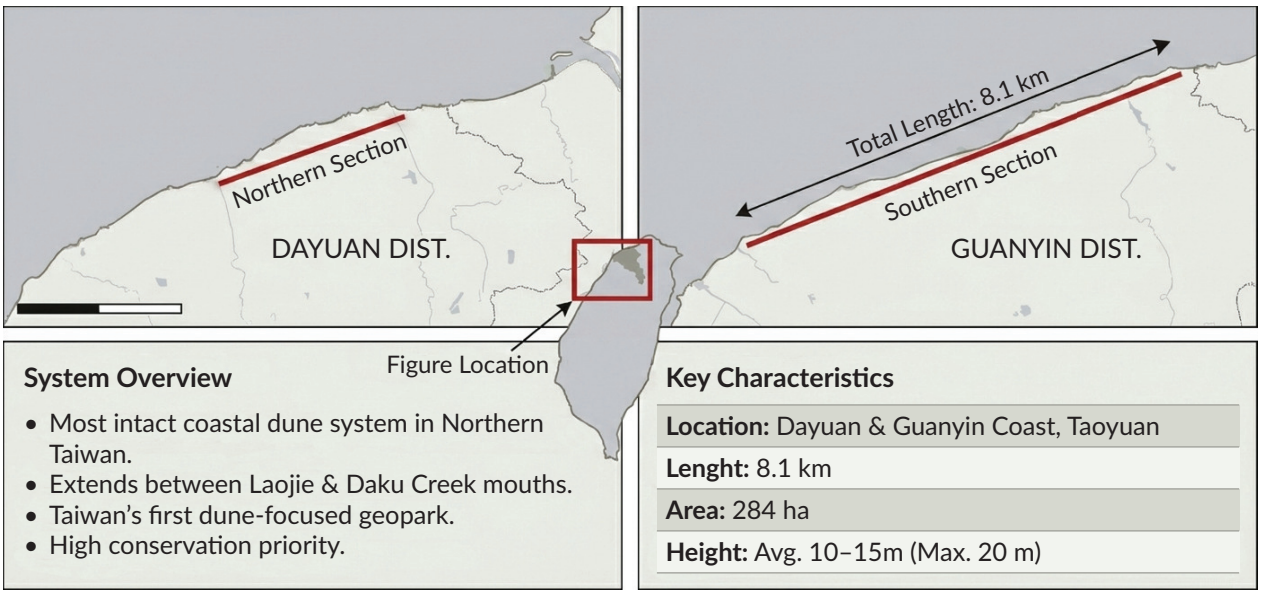

Figure 1. Overview of the Caota Dune System, showing its location across Dayuan and Guanyin Districts, with a context map of Taiwan, key geographical characteristics, and conservation status.

This study examines how local knowledge is regenerated, translated, and institutionalized within the sustainable governance of coastal landscapes, using the Caota Sand Dunes Geopark as a qualitative case study. It asks how dispersed forms of lived experience, environmental memory, and cultural practice

embedded in local communities are reconfigured into shared and actionable knowledge systems capable of fostering collective environmental awareness and responsibility. From an environmental humanities perspective, sustainability is approached not as a technical outcome but as a cultural and social process enacted through everyday practices of governance, pedagogy, and cultural production.

The article is organized as follows. Section 2 introduces the landscape transformation and governance context of the Caota Sand Dunes. Section 3 outlines the theoretical perspectives informing the analysis. Section 4 describes the qualitative methodology. Sections 5 to 7 present and discuss the empirical findings, and Section 8 concludes with key insights, limitations, and directions for future research.

2. The Transformation of Landscape Governance in Caota Sand Dunes

2.1. Evolution of the Natural Landscape and Human Disturbance

Situated between Guanyin and Dayuan Districts in Taoyuan City (see Figure 1), the Caota Sand Dunes represent one of the few remaining dune systems in northern Taiwan that preserve their natural depositional morphology. Their formation can be traced back several millennia, when sediments carried by the Tamsui River and Xinwu Creek were shaped by ocean currents and monsoon winds to form multiple parallel dune ridges along the coast (Lin & Su, 2019). The resulting geomorphology combines aeolian dunes and lagoonal deposits, creating a distinctive geological landscape characteristic of Taiwan's northwestern coastline (Lin & Su, 2019).

Since the postwar period, however, the Caota region has experienced repeated human disturbances. In the 1960s, government initiatives promoting coastal industrial zones and aquaculture ponds led to the large-scale removal of native vegetation. During the 1980s, urban waste dumping and illegal landfilling further accelerated dune degradation. According to official project reports (Taoyuan City Environmental Protection Bureau, 2025), strong winds and heavy rains during this period frequently caused dune collapse and sand drift, resulting in damage to the agricultural fields and settlements located below the dunes.

Such transformations are not isolated incidents but rather cumulative *socio-ecological processes* unfolding over time. The transition from wasteland to environmental education site marks a shift in perceptions—from development to regeneration and from external governance to local co-governance.

2.2. Formation of the Governance System and the Model of Multi-Stakeholder Collaboration

2.2.1. Institutional Framework and Public Sector Governance

Since 2020, the Taoyuan City Government has promoted the Caota Sand Dunes Geopark initiative through an interdepartmental governance framework led by the Environmental Protection Bureau and the Land Administration Bureau, with support from the Agriculture Bureau and the Education Bureau. The public sector has been primarily responsible for land preparation, environmental monitoring, infrastructure development, and institutional management, including the delineation of conservation zones, ecological surveys, and the establishment of environmental interpretation systems.

According to official project reports (Taoyuan City Environmental Protection Bureau, 2025), the development of the geopark proceeded in three phases: (1) preliminary investigation (2020–2021), focusing on geological profiling and vegetation mapping; (2) infrastructure development (2022–2023), involving the construction of walkways, viewing platforms, and exhibition facilities; and (3) the operational phase (2024–present), emphasizing community collaboration, citizen science, and educational interpretation. To situate these transformations temporally, Figure 2 summarizes the major milestones, interventions, and actor configurations across different phases of Caota Sand Dunes governance.

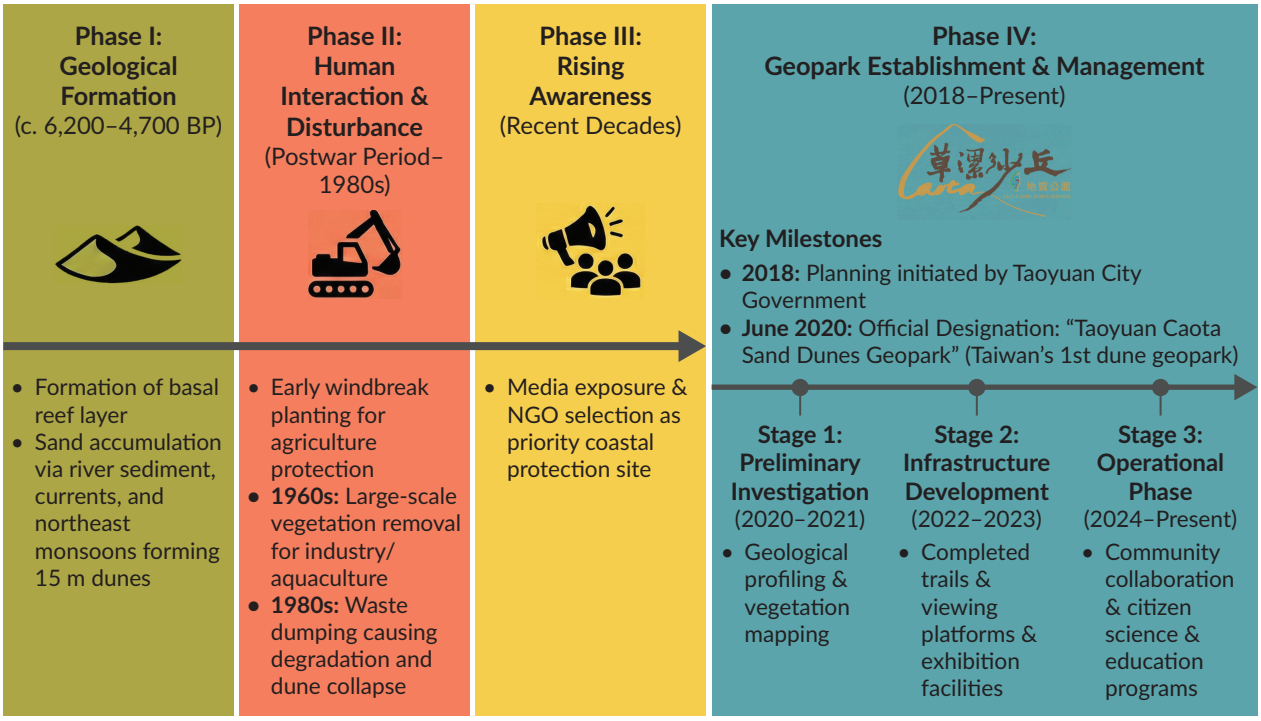

Figure 2. Timeline of the development of Taoyuan Caota Sand Dunes Geopark.

2.2.2. The Mediating Role of Local Organizations

The sustainable governance of the Caota Sand Dunes has been co-constructed through collaboration among diverse local and professional organizations rather than driven by a single government agency. Groups such as the Caota Sand Dunes Geopark Interpretation Team, the Shulin and Beigang Community Development Associations, and the Heda International Management Consulting Group have played key mediating roles by bridging communities, schools, and research institutions. Through this collaboration, a governance network has emerged that integrates scientific research, cultural interpretation, and public participation.

As the park's professional advisory team, Heda International Management Consulting Group conceptualizes environmental education as a form of local governance. Through guided walking tours, comic-based teaching materials, educational manuals, and thematic exhibitions, the dunes are transformed into a readable landscape that reconnects citizens with place through embodied experience. Their approach integrates ecological monitoring, social participation, and cultural translation, understood here as the re-valuing of knowledge through narrative and design in social space, preserving the dunes not only as geomorphological formations but also as shared arenas for knowledge production, public communication, and social learning.

2.2.3. Participatory Practices of Residents and Schools

Local residents and schools constitute the core actors in advancing sustainable governance. Since 2022, the Taoyuan Environmental Protection Bureau has collaborated with civic groups to train Caota Citizen Scientists, who participate in ecological monitoring and biodiversity surveys using a one-household, one-record approach to document flora, fauna, and seasonal environmental change, based on participant observation conducted by the author.

In parallel, Caota Elementary School and Guanyin Senior High School have established Geopark Learning Programs in which students engage in microclimate observation, dune change documentation, and oral history interviews. These initiatives embed local knowledge within the formal education system and translate external expertise into residents' lived practices, forming a social learning mechanism aligned with theories of situated learning and communities of practice (Healey, 1997; Lave & Wenger, 1991).

2.3. Translation of Local Knowledge in Landscape Governance

Within the governance framework of the Caota Sand Dunes, residents' long-term observations of wind direction, tidal movement, and vegetation patterns complement scientific monitoring data. For example, local knowledge regarding intensified dune movement during the northeast monsoon season has been incorporated into the city government's geological stability monitoring plan.

Local knowledge is further regenerated through cultural interpretation and creative design. The geopark's interpretive system adopts "the path of the wind" as its central thematic axis and employs a mascot, Little Wind of the Dunes, to narrate geomorphological processes, rendering abstract geological concepts accessible while reinforcing local identity. This process may be conceptualized through three interrelated dimensions—experiential engagement, practical governance action, and interpretive reconstruction (K.-C. Chang, 2024). The initiatives at the Caota Sand Dunes demonstrate how these dimensions interact to revitalize local knowledge in shaping sustainable landscapes.

2.4. Challenges of Governance and Institutionalization

Despite its recognition as a model of local revitalization, the governance of the Caota Sand Dunes Geopark continues to confront structural and institutional challenges. Management responsibilities are fragmented across multiple administrative domains under existing frameworks of cultural heritage preservation and wildlife conservation, complicating policy coordination and long-term integration.

While public–private collaboration has enhanced operational flexibility and community engagement, many initiatives remain dependent on short-term project cycles and annual funding, constraining the consolidation of sustained governance capacity. A further challenge lies in the institutionalization of local knowledge. As experiential and place-based knowledge is incorporated into formal education systems and citizen science programs, it risks decontextualization and the loss of situational nuance.

Sustainable governance in Caota, therefore, requires not only institutional coordination but also the introduction of flexibility in managing the dynamic relationship between environment and human

interaction. The central task is to balance formalization with adaptive responsiveness, ensuring that local knowledge retains its contextual vitality while gaining institutional recognition.

Overall, the Caota Sand Dunes demonstrate that sustainable development is not a linear technical process but a multi-layered socio-ecological system, offering insights into adaptive and locally driven forms of coastal governance.

3. Theoretical Framework and Related Studies

This study examines the regeneration of local knowledge and sustainable governance in coastal landscapes from an environmental humanities perspective. Rather than adopting a single theoretical model, the analysis draws on complementary perspectives as sensitizing concepts that guide interpretation while remaining grounded in empirical observation. These perspectives enable an examination of how knowledge, power, culture, and governance intersect in the transformation of the Caota Sand Dunes Geopark.

3.1. Local Knowledge, Power, and Governance

The relationship between knowledge and governance has been a central concern in critical social theory. Foucault's concept of power/knowledge emphasizes that knowledge is produced and legitimized within specific institutional and discursive contexts rather than functioning as a neutral representation of reality (Foucault, 1980). In environmental governance, this perspective has been widely used to explain how scientific expertise often gains epistemic authority while local or experiential knowledge is marginalized.

Recent studies of coastal governance increasingly emphasize the integration of local knowledge under conditions of ecological complexity and uncertainty. Rather than treating such knowledge as supplementary, sustainability governance is conceptualized as a process of knowledge co-production among residents, experts, and institutions (Berkes, 1999; Jasanoff, 2004; Ostrom, 2010). In the Caota case, practices such as citizen science and participatory monitoring provide an empirical setting to examine how power/knowledge relations are reconfigured, as local knowledge gains legitimacy through participation, documentation, and educational practices.

3.2. Cultural Production, Symbolic Capital, and Knowledge Translation

To examine how local knowledge enters the public sphere beyond formal governance processes, this study draws on Bourdieu's theory of cultural production and symbolic capital (Bourdieu, 1986, 1993). Symbolic capital refers to forms of recognition and legitimacy through which cultural meanings acquire social efficacy.

In landscape governance, symbolic capital emerges when environmental knowledge is translated into culturally resonant forms, including narratives, visual representations, educational materials, and design objects. Cultural translation thus refers to a process through which knowledge is re-articulated and re-valued within social space, rather than merely transmitted as information (Bourdieu, 1986; Clifford, 1997).

Research on cultural landscapes and community-based tourism demonstrates that storytelling and aesthetic mediation can transform environmental sites into meaningful cultural spaces. The Caota case illustrates how

comics, mascot design, and narrative branding operate as mechanisms of knowledge translation, enabling local knowledge to acquire symbolic capital and greater public visibility. From this perspective, cultural production can be understood as an integral element of governance rather than merely an adjunct to sustainability.

3.3. Pedagogy, Participation, and Embodied Learning

Education plays a central role in the regeneration of local knowledge. Freire's (1970) concept of critical pedagogy emphasizes learning as a dialogical process grounded in lived experience rather than passive transmission. In environmental contexts, this approach informs place-based and experiential education that prioritizes participation and reflection.

Walking pedagogy is conceptualized here as an embodied form of place-based learning in which knowledge emerges through movement and situated engagement with the environment (Freire, 1970; Ingold, 2000). In Caota, learning occurs through direct interaction with the landscape rather than classroom instruction alone, aligning with theories of experiential and social learning that emphasize knowledge formation through shared practice (Lave & Wenger, 1991).

By situating walking education and citizen science within a pedagogical framework, this study conceptualizes participation as a mode of knowledge production and empowerment. Pedagogy thus functions as a key mechanism through which governance is socialized, and sustainability is enacted in everyday practice.

3.4. Cultural Sustainability and Collaborative Governance

To situate these processes within broader sustainability debates, this study draws on Throsby's (2001) concept of cultural sustainability, which positions culture as a foundational dimension of sustainable development alongside environmental, social, and economic considerations. Cultural sustainability emphasizes the continuity and adaptive reproduction of cultural values and practices over time.

In this study, cultural sustainability functions as an analytical lens for understanding sustainability as a value-based and process-oriented practice rather than solely a set of measurable outcomes. In the Caota case, sustainability emerges not only through ecological restoration or policy compliance but through ongoing negotiation among governance institutions, community actors, and cultural practices.

This perspective aligns with scholarship on collaborative and polycentric governance, particularly Ostrom's (2010) work on commons management, which highlights shared responsibility, local participation, and institutional diversity in complex socio-ecological systems. While Throsby provides a normative framework, Ostrom offers an institutional perspective for analyzing how such values are enacted through governance arrangements. By integrating these approaches, the Caota Sand Dunes Geopark is framed as a site where sustainability is enacted as a cultural and social process rather than merely a technical solution. Local knowledge is thus understood not only as an epistemological resource but also as a form of social practice embedded in everyday life.

Within this framing, UNESCO's Creative Cities Network serves as a comparative lens highlighting how cultural production mobilizes civic engagement in place-based governance.

3.5. Positioning the Caota Case Within Existing Studies

Existing research on geoparks, community-based landscape governance, and coastal sustainability has largely focused on policy frameworks, tourism development, or environmental management outcomes. Recent studies on Caota and comparable sites have examined residents' environmental perceptions, tourism resilience, and geopark development trajectories.

While these studies provide important context, they often treat local knowledge as a variable or outcome rather than as a dynamic process. This study addresses this gap by foregrounding how local knowledge is regenerated, translated, and institutionalized through governance, pedagogy, and cultural production. By integrating perspectives on power/knowledge, cultural production, pedagogy, and cultural sustainability, the Caota case advances an interdisciplinary framework for understanding collaborative governance as a form of cultural practice.

The theoretical perspectives discussed in Sections 3.1–3.4 are employed as sensitizing concepts rather than deterministic or causal frameworks. They illuminate patterns of power relations, cultural production, pedagogical practice, and sustainability observed in the case, while the study refrains from claiming universal applicability. The analytical emphasis, therefore, lies on contextual interpretation and analytical generalization rather than empirical generalization.

4. Methodology

4.1. Research Design

This study adopts a qualitative case study approach to examine how local knowledge is regenerated, translated, and institutionalized within the sustainable governance of coastal landscapes, using the Caota Sand Dunes Geopark in northern Taiwan as the primary case. A case study design is appropriate because Caota's transformation is shaped by complex interactions among governance institutions, community participation, cultural practices, and policy frameworks that cannot be adequately captured through variable-oriented methods.

Rather than seeking statistical generalization, the study aims for analytical generalization by generating theoretical insights from an in-depth socio-ecological case. Caota was selected for three primary reasons. First, it represents one of the few remaining naturally formed coastal dune systems in northern Taiwan. Second, it has undergone a rapid transformation from environmental degradation to a geopark-oriented governance model. Third, it offers a rich empirical context in which citizen science, environmental education, cultural translation, and collaborative governance converge. Empirical materials were collected between 2020 and 2025, corresponding to key phases in the geopark's development.

4.2. Data Collection

To capture the multifaceted dynamics of landscape governance and knowledge regeneration, this study draws on multiple qualitative data sources for triangulation, such as document analysis, participant observation, and semi-structured interviews.

Document analysis focused on policy documents, project reports, management plans, and educational materials related to the Caota Sand Dunes Geopark, including reports issued by the Taoyuan City Environmental Protection Bureau and community-produced publications such as the *Caota Sand Dunes Geopark Guidebook* (Taoyuan City Environmental Protection Bureau, 2023). These materials provided institutional context, policy rationales, and chronological information on governance mechanisms.

Participant observation was conducted through the author's involvement in guided walking programs, citizen science training, dune-cleaning initiatives, educational workshops, and cultural creative courses. Field notes documented how knowledge was produced, communicated, and negotiated through embodied learning, informal interaction, and collective action.

Semi-structured interviews complemented documentary and observational data by capturing local perspectives on governance, knowledge practices, and participation. Interviewees included community organizers, residents, educators, and project participants selected through purposive sampling based on their engagement in geopark activities. All interviews were voluntary and conducted with informed consent; interview materials were anonymized and analyzed thematically to support triangulation.

4.3. Interviews

Interviews served as qualitative sources for understanding the experiential dimensions of local knowledge regeneration and governance practices, rather than as statistically representative data. They were used to complement document analysis and participant observation by capturing situated perspectives on environmental change, participation, and governance processes.

4.3.1. Participants and Sampling

Semi-structured interviews were conducted between March 2024 and October 2025 with key stakeholder groups involved in Caota's governance and knowledge practices (total $n = 31$). Participants comprised community residents and program participants ($n = 10$); representatives from enterprises and educational institutions, including students ($n = 10$); public-sector officials responsible for planning and site management ($n = 6$); and supporting and mentoring bodies, such as facilitators, partner organizations, and consultants ($n = 5$). As several interviewees held multiple roles, these categories were not mutually exclusive.

Recruitment combined purposive sampling with snowball referrals to ensure representation of actors engaged at different stages and scales of the geopark's development.

4.3.2. Interview Procedure and Ethics

Interviews addressed three thematic areas: (1) long-term observations and memories of environmental change; (2) experiences of participation in citizen science, environmental education, and cultural creative initiatives; and (3) reflections on governance processes, evolving roles, and coordination among stakeholders. For public-sector officials and supporting bodies, additional questions explored governance rationales and the incorporation of community input into planning and management.

All interviews were conducted in Mandarin and Taiwanese, lasted approximately 20–30 minutes, and were carried out with informed consent. Personal identifiers were removed during transcription, and quotations are cited using anonymized stakeholder codes.

4.3.3. Analytic Use of Interviews

Interview materials were interpreted in conjunction with policy documents, project reports, and participant observation fieldnotes through qualitative triangulation. Rather than being analyzed in isolation, interview insights were used to contextualize empirical examples presented in subsequent sections—such as citizen science practices, walking pedagogy, cultural narration, and collaborative governance—illustrating how local knowledge is articulated, negotiated, and institutionalized in practice.

4.4. Data Analysis and Triangulation

Data analysis followed an iterative thematic and interpretive approach integrating three sources: documents, participant observation field notes, and interview materials. The process unfolded in three stages. First, data were organized chronologically to reconstruct the trajectory of governance development. Second, thematic coding examined how local knowledge was mobilized through practices such as citizen science and walking pedagogy. Third, the findings were interpreted from the perspectives of power/knowledge, symbolic capital, critical pedagogy, and cultural sustainability.

Triangulation enhanced analytical credibility by cross-referencing data sources and identifying convergent and divergent patterns in governance and knowledge practices.

4.5. Methodological Considerations and Limitations

Several methodological considerations should be noted. As a qualitative case study, the findings are context-specific and do not claim statistical generalizability; instead, the study aims to generate transferable insights into collaborative governance and knowledge co-production in coastal settings. The researcher's engagement in participant observation entails positionality, which was addressed through triangulation across data sources. Finally, due to time and access constraints, not all stakeholder groups were equally represented; future research could expand interview coverage or incorporate comparative cases.

5. From Knowledge to Action: Citizen Science and Walking Pedagogy

Sections 5–7 present the empirical findings and interpretive discussion of this case study, organized around three domains of practice through which local knowledge is regenerated and mobilized: landscape governance, walking-based education, and cultural translation.

5.1. From Environmental Awareness to Action

Citizen science is commonly understood as the active involvement of non-professional participants in scientific research processes, including data collection, observation, and knowledge production (Bonney et al., 2009). The regeneration of the Caota Sand Dunes represents not only landscape restoration but also the revival of

local knowledge. At its core lies the transformation of knowing into doing—turning environmental awareness into the driving force of collective practice and social action (Freire, 1970; Lave & Wenger, 1991).

In this context, citizen science and walking education function as two complementary mechanisms in this transformation. The former establishes a foundation for knowledge co-creation through participatory scientific practices, while the latter reconnects bodily experience with place-based memory through culturally situated walking. Together, these practices constitute a knowledge-based process through which the sustainable development of the Caota Sand Dunes Geopark is enacted.

5.2. The Promotion and Localization of Citizen Science

5.2.1. Institutional Foundations and Curriculum Framework

Since 2021, the Taoyuan City Government has commissioned professional teams to implement the Caota Sand Dunes Citizen Scientist Program, aiming to realize the geopark's core values of environmental education and community participation. According to official project reports (Taoyuan City Environmental Protection Bureau, 2025), the program has conducted 6 citizen scientist workshops, 12 dune-cleaning events, 4 walking tours, and 15 dune-related educational activities, engaging over 1,100 participants.

The curriculum integrates geology, ecology, and environmental monitoring, covering dune succession, vegetation mapping, biodiversity surveys, and marine waste classification. Residents, students, and volunteers are trained to collect and upload data using accessible methods, forming a localized environmental database. Through this process, the Caota Dunes are reframed not only as a conservation site but also as a platform for knowledge production and data co-construction.

5.2.2. Local Participation and Knowledge Transformation

Unlike conventional citizen science programs dominated by academic institutions, the Caota model emphasizes knowledge localization, positioning residents as co-creators rather than passive data providers. For example, long-term residents observed that the northeast monsoon from October to March produces the most intense dune movement. Once verified by scientific measurement, this observation was incorporated into official dune stabilization and ammophila planting strategies.

These interactions demonstrate that local knowledge is no longer treated as anecdotal but as situated wisdom contributing directly to policy formation. As Berkes (1999) argues, traditional ecological knowledge functions as a dynamic and adaptive system. Through participatory monitoring, Caota residents have helped establish a co-governance model that bridges lived experience and scientific practice.

5.2.3. The Social Diffusion Effect of Dune-Cleaning Initiatives

Citizen science in Caota is closely linked to dune-cleaning actions. What began as occasional cleanups has developed into an ongoing environmental campaign involving residents, volunteers, corporate groups, and student organizations (Taoyuan City Environmental Protection Bureau, 2025). These activities extend beyond waste removal to include waste-source analysis and carbon-emission estimation, transforming cleanup into a platform for social learning and environmental ethics (Berkes, 1999; Freire, 1970).

This action-based knowledge enhances scientific literacy and strengthens participants' identities as environmental citizens. Through collective engagement, governance of the Caota Sand Dunes has expanded beyond administrative boundaries into a cross-sectoral socio-ecological alliance (Ostrom, 2010).

5.3. Walking Education, Knowledge Regeneration, and Cultural Memory

5.3.1. The Design of Walking Courses

In this study, walking education is understood as a pedagogical approach that emphasizes learning through embodied movement, sensory engagement, and situated interaction with specific environments. This approach also resonates with scholarship on place-based education, which emphasizes learning through direct engagement with local environments and the cultivation of ecological and civic responsibility (Gruenewald, 2003). The Walking the Dunes program is guided by the principle that walking is learning, integrating ecological observation, cultural interpretation, and artistic creation. According to official reports (Taoyuan City Environmental Protection Bureau, 2025), the curriculum includes modules such as dune aesthetics, geo-ecological tours, and community story documentation, jointly conducted by local interpreters and partner school instructors. Each walk covers two main trails and one surrounding site, using bilingual interpretation to introduce participants to the area's geomorphology and cultural history.

Through these embodied practices, the initiative operationalizes place-based education by engaging participants in sensory interaction with the landscape—feeling wind patterns, observing vegetation, and sensing tidal rhythms. As Ingold (2000) suggests, knowledge emerges through dwelling and sensory engagement, transforming abstract geological concepts into lived experience and strengthening emotional ties to place.

5.3.2. Cultural Translation and Narrative Storytelling

As W.-L. Chang (2024) notes, community teams in Caota integrate local knowledge with cultural creativity to produce educational materials and cultural products, including the *Dune Stories* comic series, mascot-themed scarves, and dune-inspired baked goods that incorporate local ingredients and visual motifs derived from the landscape. Through these mascot-driven narratives, elements of local ecology, geomorphology, and settlement memory become accessible and emotionally resonant.

This process represents the narrativization of knowledge: abstract geological and ecological concepts are translated into participatory stories. In doing so, residents and students re-inscribe coastal experiences, enabling the simultaneous regeneration of knowledge and identity (Ingold, 2000; Throsby, 2001).

5.3.3. The Social Meaning of Walking Education

Walking education extends beyond knowledge transmission to the re-inscription of collective memory. Residents' childhood memories—such as flying kites or collecting shells—are incorporated into tour narratives and exhibitions, fostering shared authorship of local history. Learning thus becomes a dialogical and experiential process shaped through movement and conversation.

This aligns with Freire's (1970) concept of critical pedagogy in which education enables reflection on human–environment relations. Through walking education, the dunes function simultaneously as a classroom and memoryscape, integrating learning, remembrance, and action.

5.4. The Interplay Between Citizen Science and Walking Education

In Caota, citizen science and walking education function as mutually reinforcing practices rather than parallel initiatives. Citizen science emphasizes data and action, while walking education foregrounds narrative and perception. Their intersection produces a co-construction of knowledge in action (Leff, 2015). Walking provides contextual settings for observation and documentation, while citizen-generated data strengthens the credibility of community narratives. For example, vegetation restoration data are incorporated into guided tours to illustrate dune regeneration, while residents' accounts of long-term landscape change have informed adjustments to monitoring indicators.

These reciprocal flows exemplify Leff's (2015) concept of co-constructed environmental knowledge, integrating local knowledge, scientific methods, and education into a dynamic system. By relocating knowledge production from professional domains into everyday social practice, this model transforms residents from objects of governance into active agents of coastal stewardship and offers a replicable framework for sustainable coastal transformation in Taiwan.

6. Cultural Translation and the Aesthetic Turn

6.1. From Landscape Conservation to Cultural Narration

The development of the Caota Sand Dunes Geopark demonstrates that sustainable development involves not only environmental governance but also processes of cultural representation. When local knowledge is translated into stories and visual imagery, it becomes a means of shaping local identity.

In recent years, the community planning advisory team, Heda International Consulting Group, has collaborated with local residents to reinterpret the dune landscape through cultural creativity and aesthetic design. Through this collaboration, conservation has evolved into narration, and education into cultural expression.

This shift from nature to culture resonates with Clifford's (1997) notion of culture as travel and translation. The Caota case thus reveals how local communities, through cultural translation, convert ecological forms into shared social meanings.

6.2. The Emergence of Landscape Mascots and Local Narratives

6.2.1. Mascot Design and the Strategy of Storytelling

In Caota, co-creation workshops were organized to develop narrative mascots inspired by local flora, fauna, and natural phenomena. Ecological elements such as wind and dune vegetation were anthropomorphized to form the Caota Sand Dunes Family (W.-L. Chang, 2024). These mascots serve educational functions while carrying collective community memories. Residents recalled their childhood experiences of playing on the

dunes and incorporated personal memories and local vocabulary into story themes, including narratives centered on wind-shaped hills and flowing sand. The resulting texts combine scientific knowledge with emotional storytelling and were later adapted into comics, coloring books, and interpretive teaching materials, forming a story-based model of landscape education.

This storytelling strategy carries dual significance. Personification makes ecological knowledge more accessible, while the mascots function as visual symbols of the community's cultural identity. This locally generated narrative branding demonstrates how local knowledge is transformed into cultural assets.

6.2.2. Educational Extensions through Comics and Creative Products

Cultural creativity in Caota extends beyond storytelling to encompass product design and educational media. According to official project reports (Taoyuan City Environmental Protection Bureau, 2025), residents co-created dune-themed comics and related cultural products: the dune chocolate gift box modeled on dune topography; dune-inspired baked products and locally made flowing sand buns that combine local ingredients with dune-inspired visual imagery; and mascot-themed scarves and textile designs featuring the geopark's mascot, serving both commemorative and educational functions.

These products function not merely as tourist souvenirs but as media of knowledge. Each design is paired with a story card explaining dune formation and ecology, enabling learning through sensory experience. By combining aesthetics and education, local knowledge extends beyond academic texts or guided tours and becomes embedded in everyday life through taste, touch, and visual design (Figures 3–5).

Figure 3. To promote wedding photography activities featuring the sand dune landscape of the Caota coastal settlement, local residents created chocolate pieces representing the different landforms of the sand dunes through a series of creative exchange courses and workshops. Note: These were combined with comic illustrations of the sand dune imagery to design an exclusive local sand dune gift box.

Figure 4. The rich geomorphology and biodiversity of the Caota Sand Dune coastal settlement are translated into mascot figures, each endowed with a distinct personality. Note: Through collaborative comic creation, these narratives are rendered in comic form, and mascot-introduction scarves are produced as souvenirs to promote local landscape tourism and ecological education.

Figure 5. Selected panels from the Caota Sand Dune comic series, translating local geomorphology and biodiversity into participatory storytelling and place-based education.

6.3. Narrative Branding and the Construction of Local Aesthetic

6.3.1. Conceptualizing the Landscape Brand

In the context of local revitalization, a brand represents more than a market identity—it embodies collective memory and emotional resonance. The branding of the Caota Sand Dunes can be interpreted as a reconstruction of the landscape narrative. The visual logo employs soft sand tones and curved line motifs to evoke the flow of wind, symbolizing the convergence of natural forces and cultural memory.

The design foregrounds the concept of landscape as culture, integrating ecological imagery, residents' stories, and local linguistic expressions to establish a distinctive Caota aesthetic lexicon. This process exemplifies Bourdieu's (1986) notion of the production of symbolic capital: when landscapes are culturalized, they acquire not only aesthetic value but also become socially exchangeable resources.

6.3.2. From Environmental Education to Cultural Tourism

The development of the Caota Sand Dunes' cultural brand has fostered a complementary relationship between environmental education and tourism. By integrating walking courses and cultural markets, the dunes are transformed from a passive object of observation into an experiential cultural field. Events such as the Dune Aesthetics Photography Exhibition and Landscape Wedding Photography Project extend the brand's visual identity, showcasing the dunes as symbols of both beauty and sustainability.

This process reflects the resymbolization of cultural landscapes in which the landscape ceases to be merely a natural resource and becomes a carrier of cultural meaning. Visitors participating in photography, tasting local products, or reading comics inadvertently become both recipients and transmitters of local knowledge.

6.4. Social Implications and Challenges of Cultural Translation

6.4.1. Knowledge Co-Creation and Community Empowerment

Cultural and creative actions have strengthened residents' sense of agency. Through participation in mascot design, storytelling, and interpretive training, residents have transformed from subjects of research into producers of knowledge. This process enhances community cultural confidence while fostering intergenerational collaboration—elders contribute with oral histories, while younger participants take charge of design and digital marketing, forming an intergenerational knowledge community.

This dynamic broadly aligns with UNESCO's (2021) Creative Cities Network principles of cultural empowerment, which emphasize that local cultures should not merely be preserved but continuously regenerated through creative action. The Caota Sand Dunes exemplify this principle in practice, showing how cultural creation can reinforce environmental governance.

6.4.2. The Tension Between Commercialization and Cultural Authenticity

However, cultural creativity also entails inherent challenges. When landscape imagery becomes commodified, it risks falling into the traps of landscape consumption and cultural performativity. As MacCannell (1976)

cautions, touristic representation often leads to external simplification and objectification of local culture. In Caota, the challenge lies in balancing educational integrity with commercial viability in the process of branding.

To address this, the project team adheres to the principle of cultural authenticity, preserving local language, residents' stories, and native ecological motifs throughout the design process to prevent over-commercialization from eroding the depth of local knowledge. Cultural creativity, to be sustainable, must maintain equilibrium between authentic experience and public education, ensuring that branding remains a vehicle for knowledge rather than a form of superficial consumption.

The cultural and creative initiatives of the Caota Sand Dunes reveal that the regeneration of local knowledge depends not only on institutional frameworks or educational systems but also on aesthetic practices and narrative imagination that bring knowledge into lived experience. From mascot creation to product design, from photography exhibitions to comic publications, these multilayered processes of cultural translation have transformed the dunes into a site where emotion and knowledge intersect.

This story-centered landscape branding not only revitalizes the local economy but also establishes a sustainable model in which aesthetics functions as education. It demonstrates how citizen science and cultural creativity form complementary structures: the former provides the epistemic foundation, while the latter supplies emotional and symbolic momentum. Together, they propel the local community toward integrated practices of environmental governance, cultural memory, and social innovation.

7. Collaborative Governance and Social Networks

The governance experience of the Caota Sand Dunes Geopark illustrates a shift in Taiwan's local environmental management from a bureaucratic model toward collaborative governance (Ansell & Gash, 2008). Whereas coastal conservation was traditionally government-led, with residents positioned as passive recipients, the Caota case redefines governance as a process of co-production. Government institutions provide regulatory and policy frameworks, while civic organizations and residents contribute knowledge, labor, and emotional engagement, forming a cross-sectoral and trust-based network. Through this transformation, environmental protection evolves from a closed administrative mechanism into a public practice embedded in social and cultural relations.

According to official project reports (Taoyuan City Environmental Protection Bureau, 2025), the governance structure operates across three interconnected levels. The first is the policy and decision-making level, led by the Bureau and responsible for strategic planning and interdepartmental coordination. The second is the professional execution level, comprising consulting and creative teams organized by Heda International Management Consulting Group, which oversee research, design, and implementation. The third is the community participation level, including residents, volunteers, citizen scientists, schools, and local associations.

This vertically integrated yet horizontally connected framework enables institutional rationality and local affective attachment to coexist, thereby constituting the structural foundation of sustainable governance.

7.1. Institutionalizing Civic Participation and Cross-Sector Collaboration

At the core of Caota's collaborative governance is the institutionalization of citizen science, which formalizes civic participation in environmental monitoring. Through structured training programs, residents become "Dune guardians" capable of observing wind patterns, vegetation change, and geomorphological features, and of uploading data to the Digital Dune Management System to build a localized environmental database. By 2025, more than 100 individuals had participated in dune monitoring and cleanup actions, transforming local experience into public knowledge.

Citizen science is closely integrated with environmental education. Guided tours and exhibitions disseminate scientific knowledge while inviting residents to act as storytellers in shaping community narratives. Learning and practice thus intersect in what Freire (1970) describes as praxis—knowledge generated through the dynamic relationship between reflection and action.

Beyond volunteer participation, the Dune Guardian initiative also incorporates a public–private–people partnership. Aviation and logistics companies regularly engage in dune-cleaning programs, contributing manpower, financial resources, and technical expertise in waste classification, plastic recycling, and data analysis. These actors function not merely as sponsors but as collaborators in environmental governance, transforming corporate social responsibility from a branding strategy into a practice of shared social accountability.

7.2. Social Networks, Knowledge Flow, and Polycentric Governance

Through these practices, Caota has developed a multi-layered social network characterized by both horizontal linkages and vertical integration. Horizontally, community associations, schools, residents, and local artists are connected through walking tours, collective learning activities, and exhibitions. Vertically, governmental agencies, research institutions, and private enterprises constitute a support structure for policy coordination and resource mobilization.

This arrangement reflects the key elements of collaborative governance identified by Ansell and Gash (2008): trust-building, information sharing, and joint action. Roles and responsibilities are continuously negotiated among actors at different levels, resulting in a polycentric system of cooperation rather than centralized management.

Within this network, knowledge circulates bidirectionally. Residents contribute experiential observations of environmental change, while scholars and experts translate these insights into visualized materials and educational content that are subsequently returned to the community. For example, residents' observations of the southward retreat of windbreak forests were later corroborated through aerial imagery and topographic surveys, leading to the development of a Dynamic Dune Monitoring Map that was shared with the community.

This reciprocal exchange exemplifies Bourdieu's (1993) conception of the field as a space where professional and local knowledge are co-produced.

7.3. Challenges, Adaptation, and Sociocultural Effects

Despite these achievements, Caota's collaborative governance faces structural constraints. Taiwan lacks a unified legal framework for geoparks, resulting in fragmented jurisdiction across environmental, educational, land, and agricultural authorities. Annual budgeting further disrupts long-term initiatives, limiting continuity in knowledge accumulation and civic engagement.

In response, local teams have developed community-based self-management strategies that diversify financial resources by supplementing public funding with revenue from environmental education and cultural creative products. This internal circulation strengthens local autonomy and institutional resilience while reducing reliance on government subsidies.

Uneven participation remains a concern. Some elderly residents initially viewed the geopark as externally imposed rather than collectively shared. Project teams addressed this through storytelling sessions, old-photo exhibitions, and oral history projects that activated collective memory and fostered intergenerational ties, aligning with Healey's (1997) collaborative planning framework.

Beyond ecological restoration, Caota's governance has reshaped local social relations. Participation cultivates environmental knowledge and civic identity, enabling residents to shift from passive inhabitants to active guardians. Cross-sector collaboration has facilitated a transition from technocratic toward culturally embedded governance, where values are co-constructed through learning and affective engagement.

This experience situates Caota within broader sustainability discourses, particularly SDGs 11, 13, and 17. Consistent with Ostrom's (2010) polycentric governance framework, the case illustrates how institutional, social, and cultural forces converge to sustain collaborative governance as a dynamic local process.

8. Conclusion: Toward a Model of Cultural Sustainability

8.1. Research Review and Core Findings

This study takes the Caota Sand Dunes Geopark as a case to explore how a coastal landscape can become a site for the regeneration of local knowledge and sustainable practice. Through document analysis, policy review, and observation of community action, three key findings emerge.

First, the sustainable development of Caota Sand Dunes represents localized ecological governance. Anchored in citizen science, it links monitoring, education, and policy, with government as facilitator and residents as knowledge co-producers.

Second, the regeneration of local knowledge is a cultural act restoring both landscape and human–land relations. Through storytelling, design, and education, residents transform the dunes from an "othered" natural object into a lived environment with ethical and emotional meaning.

Third, the success of sustainability depends on cross-boundary integration. The Caota experience interweaves government policy, academic research, community action, and cultural creativity into a dynamic social network.

This interdisciplinary collaboration shows that sustainable development requires not only institutional support but also cultural energy and local trust.

In dialogue with recent studies on Caota Sand Dunes (V. M. van Onselen et al., 2025; V. V. van Onselen & Lin, 2022), this study further demonstrates how community-based knowledge practices can be institutionally embedded through governance frameworks rather than remaining at the level of perception or participation. It also extends Lin and Su's (2019) geopark framework by illustrating how cultural translation and pedagogical practices function as mechanisms linking geological conservation with social learning. From a broader perspective, the findings resonate with Berkes' and Ostrom's co-management scholarship by showing how local knowledge becomes durable when translated into shared practices and organizational routines rather than treated as informal or supplementary input.

8.2. Theoretical Reflections: From Landscape Politics to Cultural Sustainability

The governance and cultural practices surrounding the Caota Sand Dunes expose the deep interrelations among landscape, power, and knowledge. Foucault (1980) posits that knowledge is power, and the Caota case exemplifies the politics of local knowledge: as residents engage in dune governance through lived experience, they simultaneously challenge centralized professional authority and redefine the source of epistemic legitimacy.

From the perspective of landscape politics, the dunes are not merely a natural space but an arena of power relations, cultural representation, and social interaction. Through collaborative governance and citizen science, the local community redistributes both knowledge and discursive power, shifting landscape governance from being managed to being self-governed.

At the same time, the Caota Sand Dunes embody the concept of cultural sustainability. As Throsby (2001) argues, culture constitutes the fourth pillar of sustainable development—alongside the environmental, economic, and social dimensions—because it provides the foundation of meaning and value. In Caota, cultural memory serves as a medium through which sustainability becomes not only a policy goal but also an everyday ethic and aesthetic practice.

8.3. Institutional and Social Implications of the Caota Model

8.3.1. Institutional Innovation

The Caota case demonstrates how partnership-based governance between local government and community organizations can overcome bureaucratic limitations. Its governance structure shifts from vertical administration to horizontal collaboration, enhancing both local adaptability and social legitimacy of policy measures.

This institutional innovation offers a reference model for other coastal regions in Taiwan:

- Institutionalizing citizen science within governance processes to ensure sustained public participation.

- Transforming policy communication through environmental education, allowing local actors to comprehend and internalize policy logic.
- Supporting sustainable community economies through cultural branding to achieve self-sufficiency.

Together, these strategies exemplify a form of soft governance—centered on trust, learning, and collaboration—rather than rigid control through regulation and enforcement.

8.3.2. Social Significance

The Caota initiative has also generated structural transformation within local society. First, it has redefined local identity: residents engaged in environmental education, guided tours, and creative-cultural projects have evolved from passive observers into active participants, rebuilding community confidence through collective practice.

Second, it has strengthened social connectedness and public life. Through walking programs, dune-guardian activities, and community exhibitions, residents build affective networks grounded in shared experiences. This process contributes to the emergence of the community as a learning arena, echoing Lave and Wenger's (1991) notion of a community of practice, where learning arises through joint participation rather than unilateral instruction.

8.4. The Global Significance of Local Knowledge

Although rooted in a specific locality, the Caota Sand Dunes experience offers globally relevant insights. In an era of accelerating climate change and coastal erosion, communities worldwide face the challenge of localizing sustainability. Caota's experience suggests three universal principles:

1. Local knowledge is the core resource of sustainable governance. Residents' long-term observations of topography, climate, and ecology provide irreplaceable insights that complement scientific models.
2. Cultural action is the key pathway for social mobilization. When sustainability issues are expressed through stories and art, they resonate emotionally and inspire collective action.
3. Collaborative governance offers a viable model for cross-sector integration. Through public–private–community partnerships, local actors can create self-governing spaces within institutional interstices.

These principles extend beyond Taiwan, offering a replicable framework for other coastal communities, particularly within the East Asian maritime cultural sphere.

8.5. Limitations and Future Research

This study has several limitations that help clarify the scope of its scientific contribution and suggest directions for future research. First, as a qualitative case study focused on a single geopark, the analysis does not aim for statistical generalizability; rather, it offers analytically grounded insights that may inform understanding of similar coastal social–ecological–governance systems. Second, although triangulation was achieved through document analysis, participant observation, and semi-structured interviews, the empirical materials primarily reflect the perspectives of actively engaged actors; future studies could incorporate more

marginal, critical, or dissenting voices to further examine governance tensions. Third, the analysis prioritizes governance processes and knowledge practices rather than long-term ecological or quantitative outcomes; longitudinal research integrating ecological indicators would strengthen the empirical basis for assessing sustainability impacts. Finally, comparative studies across different geoparks or coastal regions would enable a more systematic examination of how institutional contexts shape the regeneration and institutionalization of local knowledge.

8.6. Future Outlook: The Enduring Life of Local Knowledge

The regeneration of the Caota Sand Dunes remains an ongoing endeavor, with future challenges centered on sustaining continuity of action and transmission of knowledge. This study proposes three directions:

1. Establish a local knowledge database and landscape archive by systematically collecting residents' observational data, oral histories, and cultural imagery to support long-term research.
2. Deepen school–community collaboration by integrating the geopark into local curricula to strengthen environmental literacy and civic engagement.
3. Promote a cultural-ecological governance network by connecting other coastal settlements, such as Xinyu Okan, Yong'an Fishing Port, and Zhunan Haikou, into an inter-coastal knowledge alliance.

Through these actions, the Caota model can extend beyond its local stage and inform sustainable coastal governance in Taiwan. More broadly, the Caota case demonstrates that sustainability is not solely a technological challenge but a cultural process grounded in everyday practice and ethical coexistence.

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Conflict of Interests

The author declares no conflict of interests. The empirical cases discussed in this study are derived from the author's professional practice experience; however, no external entity had any role in the research design, analysis, interpretation, or writing of this manuscript.

Data Availability

The data presented in this study are available from the corresponding author upon reasonable request. Due to the qualitative and community-based nature of the research, some materials are not publicly available to protect participants' privacy and community confidentiality.

LLMs Disclosure

The author declares that large language models (LLMs) were used to assist in language editing, structural refinement, and manuscript preparation. All conceptual framing, analysis, interpretation, and final writing decisions were made solely by the author.

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About the Author

Wan-Lin Chang holds a PhD in literature from National Taiwan University and has conducted research in Germany and the Czech Republic as a DAAD and Erasmus Mundus fellow. Her work theorizes practice-based cultural governance and sustainability, reframing local knowledge systems within transregional social ecology frameworks.

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Cross-Cultural Collaborative Learning and Regional Revitalization: A Taiwan–Japan Case Study

Hsiao-Chien Lee [1], Shingo Akaike [2], Yi-Juen Chen [3], Yi Tsai [1], Ay-Ling Huang [4], Kenji Okamura [5], and Wen-Hong Liu [1]

[1] Department of Fisheries Technology and Management, National Kaohsiung University of Science and Technology, Taiwan
[2] Organization for Promoting Regional and International Cooperation, Kochi University, Japan
[3] Department of International Business, National Kaohsiung University of Science and Technology, Taiwan
[4] Department of Applied Japanese, National Kaohsiung University of Science and Technology, Taiwan
[5] Innovation Center, Kochi University, Japan

Correspondence: Wen-Hong Liu (andersonliu@nkust.edu.tw)

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Abstract

This study examines how short-term, cross-cultural experiential programs support sustainability learning in higher education. The focus is on a case analysis of two Taiwan–Japan regional revitalization workshops held in 2024 and 2025. This research uses a qualitative-dominant mixed-methods design. Methods used include interviews, participant observation, instructor reflections, course artifacts, and post-program surveys. This research investigates how Taiwanese and Japanese students interpret local issues, negotiate intercultural collaboration, and develop practical, feasibility-oriented thinking during field immersion. Findings show that students deepened their understanding of sustainability by comparing revitalization contexts in both countries. The study recognizes how demographic trends, cultural identity, and institutional histories shape community development. Both groups improved their intercultural communication skills. Students learned to adjust language use, manage differing teamwork norms, and navigate trilingual communication. Field engagement strengthened the students' sense of place and improved their ability to assess community needs and the proposal's feasibility. Instructor reflections revealed the challenges of cross-cultural facilitation, such as language imbalance and varied student preparedness. The reflections also underscore the value of long-term institutional partnerships for meaningful engagement. This study contributes to sustainability education research by illustrating how comparative, community-based immersion can cultivate action competence, ethical awareness, and cross-cultural understanding within international higher education.

Keywords
cross-cultural experiential learning; intercultural communication; regional revitalization; sustainability education; university social responsibility

1. Introduction

In recent years, universities across Asia have been advancing their contribution to regional sustainability agendas through community engagement, knowledge co-production, and collaborative problem-solving. Taiwan and Japan, facing similar demographic and structural challenges—such as population aging, rural decline, and uneven regional development—have each promoted higher-education policies that encourage universities to participate in regional revitalization. In Taiwan, national initiatives such as the Ministry of Education's University Social Responsibility (USR) program and the National Science and Technology Council's Humanities Innovation and Social Practice program emphasize the importance of active engagement with local communities. Japan has also prioritized regional revitalization (*chiiki sōsei*) as a national priority, urging universities to collaborate with local governments and community organizations. Within this context, cross-border partnerships have emerged as a vital mechanism for strengthening universities' capacities to address sustainability challenges while developing students' global and civic competencies.

The Taiwan–Japan Alliance (TJA) for Regional Revitalization and Social Practice, established in 2021, represents one such institutionalized platform for long-term collaboration. Initiated through the joint efforts of Taiwan's USR Center and the Humanities Innovation and Social Practice Office, the alliance formalized partnerships among universities in both countries to promote cross-campus teaching, faculty student mobility, and community-engaged action (Humanity Innovation and Social Practice, 2021; TJA for Regional Revitalization and Social Practice, n.d.). Through regular forums, co-teaching initiatives, field-based courses, and shared communication channels, the TJA aims to strengthen knowledge exchange and support regional sustainability through higher education.

Short-term, intensive field-based programs—such as cross-cultural workshops on regional revitalization—have become a core pedagogical strategy within this alliance. These workshops situate students in real community settings, require them to work in mixed-nationality teams, and encourage them to co-design responses to local needs. For Taiwanese students, the experience provides exposure to Japan's long-term, community-driven revitalization practices; for Japanese students, it offers firsthand engagement with Taiwan's SDG-focused coastal communities. Despite their benefits, these programs also present challenges related to language use, cultural norms, compressed timelines, and differing institutional expectations across the two countries.

Although cross-cultural service learning and regional revitalization programs have expanded in East Asia, empirical research on how students learn, negotiate meaning, and design action in cross-national, community-engaged sustainability courses remains limited. Few studies have examined how students from different cultural backgrounds jointly interpret local issues, navigate cross-cultural teamwork, or reflect on feasibility and community expectations in short-term international programs. Further research is needed to understand how such programs shape the students' sustainability attitudes, sense of place, and intentions for future community engagement.

To address this gap, this study examines two Taiwan–Japan cross-cultural regional revitalization workshops conducted in 2024 (Japan) and 2025 (Taiwan), respectively. Using a mixed-methods case study design—including qualitative interviews, participant observation, faculty reflections, and post-program surveys—this research investigates how students understand local contexts, collaborate across cultures, and transform their perspectives through experiential learning. By situating the analysis within the broader institutional efforts of the TJA, this study provides empirical insights into how universities can cultivate sustainability competencies through international community-engaged programs.

Specifically, this study addresses the following questions:

1. How do students make sense of local sustainability issues through experiential and community-engaged learning in an international context?
2. What similarities and differences emerge between Taiwanese and Japanese students in their approaches to collaboration, problem analysis, and action design?
3. How do short-term international field programs influence students' sense of place, sustainability attitudes, and intentions for future community engagement?
4. What understandings of regional development and feasibility are reflected in students' proposed action plans?
5. What challenges do faculty encounter when jointly designing and facilitating cross-cultural sustainability learning programs?

By answering these questions, this study contributes to the literature on sustainability education, international experiential learning, and USR. It offers insights into how universities can enhance cross-national sustainability curricula, how community-engaged programs can foster students' action competence, and how institutional partnerships can support long-term regional revitalization efforts across Taiwan and Japan.

2. Literature Review

2.1. Taiwan–Japan University Collaboration and the Development of Regional Revitalization Education

Taiwan and Japan have faced similar demographic and structural challenges in recent years, including population aging, regional imbalance, and shifting roles for higher education. These factors have encouraged universities in both countries to take on more active roles in supporting regional development and addressing community needs, a trend also noted in broader discussions of sustainability-oriented higher education and civic engagement (Saltmarsh et al., 2009; Wiek et al., 2011). In this context, cross-national partnerships have become a crucial strategy for sustaining local engagement and expanding educational innovation.

The TJA for Regional Revitalization and Social Practice was formally launched in 2021 by Taiwan's USR Center and the Humanities Innovation and Social Practice Office. Official reports show that the alliance aims to establish long-term, structured cooperation through joint teaching, faculty and student exchanges, collaborative research, and community-engaged field programs (Humanity Innovation and Social Practice, 2021; TJA, n.d).

Scholars have noted several characteristics of this growing collaboration: increasingly institutionalized mechanisms, diverse curricular models, interdisciplinary integration, and reciprocal policy influence (Wang, 2020). These developments align with Japan's Center of Community Plus initiative, which promotes university–local government collaboration to address the decline of regional communities (Tsai, 2023). Taiwan's USR framework similarly emphasizes social practice, needs-based engagement, and long-term partnership building, while encouraging universities to widen their global linkages as part of community revitalization efforts (Kuo, n.d.).

Overall, Taiwan–Japan collaboration has evolved from informal exchanges toward structured, sustained cooperation linked to regional revitalization. Research suggests that such partnerships not only strengthen local problem-solving capacity but also cultivate cross-cultural competencies essential for future talent development (Wang, 2020).

2.2. The Role and Functions of International Linkages in Regional Revitalization Education

International linkages within regional revitalization initiatives usually take the form of academic partnerships, field-based experiential learning, and digital or interdisciplinary innovations (Chen et al., 2025). Such experiential approaches have been widely recognized as effective in supporting applied learning and reflection in real-world contexts (Eyler & Giles, 1999; Kolb, 1984). These forms of cooperation broaden learning resources, enhance students' global awareness, and create opportunities for universities to address sustainability challenges jointly.

In Taiwan, recent examples include cross-border revitalization workshops hosted by the National Taiwan Ocean University (2025) and the collaboration between National Pingtung University and Hirosaki University, which introduced Japanese regional revitalization texts to Taiwan for the first time (National Pingtung University, n.d.). These initiatives demonstrate how international collaboration can expand the scope of local revitalization education by introducing diverse development models, community engagement approaches, and cross-cultural communication practices.

Scholars have also shown that student participation in international cultural or community-based events can deepen their understanding of intangible heritage, cultural identity, and place-based social issues (K.-W. Lin, 2022). At the same time, digital tools—including location-based media used in remote communities—have been shown to strengthen students' engagement and enhance the sustainability of community–university partnerships (Her, 2022).

Taken together, these studies indicate that international linkages support regional revitalization by providing new resources, broadening students' perspectives, and fostering innovative approaches to community engagement.

2.3. Educational Aims and Learning Outcomes in Regional Revitalization Practice

Regional revitalization education emphasizes cultivating students' ability to understand local issues, collaborate with community actors, and engage in problem-solving rooted in real-world contexts. These aims align with broader sustainability education frameworks, which emphasize key competencies such as systems

thinking, collaboration, and action-oriented learning (Wiek et al., 2011). In the Taiwanese context, such educational directions are also reflected in policy discussions on regional revitalization and talent cultivation (Shang, 2022).

However, scholars have also noted that universities must carefully manage their role when entering local communities. As C. Y. Lin (2021) argues, while university participation can support community development, it may also unintentionally cause disruption if institutional needs overshadow local priorities. This underscores the need for respectful, long-term collaboration that prioritizes community perspectives and ensures mutual benefit.

Empirical studies of classroom-based and field-based USR programs demonstrate that students often gain a deeper understanding of social issues, empathy, and problem-solving abilities through direct engagement (Hung, 2022). Cross-campus and cross-national initiatives—such as the Excellent Neighbor Fishermen program reported by National Kaohsiung University of Science and technology (Lee et al., 2024)—also illustrate how collaborative community engagement can enhance students' motivation, awareness of local industries, and ability to design actionable proposals for regional development.

In summary, the literature suggests that regional revitalization education aims to cultivate socially responsible, community-engaged learners. Through sustained partnerships and experiential learning, universities can help students develop both the competencies and the ethical awareness required to contribute meaningfully to local sustainability issues, particularly through direct engagement with real-world contexts and community interaction (Kolb, 1984; Wiek et al., 2011).

3. Methodology

3.1. Research Context

This study was conducted within the framework of the TJA for Regional Revitalization and Social Practice, which supports long-term cross-border collaboration in community-engaged education. Two intensive field-based programs served as the primary research settings: the 2024 summer workshop in Japan and the 2025 spring workshop in Taiwan.

The 2024 workshop, held in Kuroshio Town and Yasuda Town in the Kochi Prefecture, introduced Taiwanese students to Japan's long-standing models of community-centered revitalization. Students visited community-run facilities, interacted with local government officers, observed heritage preservation and coastal development initiatives, and worked in mixed groups to examine issues such as depopulation, aging, and youth outmigration.

The 2025 workshop, implemented in Kaohsiung and Pingtung's coastal communities, engaged Japanese students in Taiwan's fisheries culture, cultural diversity, and SDG-oriented community practices. Students visited local associations, elementary schools, and cultural practitioners, and developed bilingual proposals focusing on marine education, cultural identity, sustainable tourism, and community development.

Together, these two workshops provided a comparative, cross-cultural environment for examining how students from different backgrounds interpret local issues, collaborate across languages and cultures, and develop understandings of regional revitalization.

To support student engagement and intercultural readiness, both workshops were structured with pre-departure preparation, field-based activities, and post-field reflection. Before departure, students participated in orientation sessions introducing basic cultural norms, local etiquette, and contextual information about the host communities. Faculty members from Taiwan and Japan also conducted joint online briefings to explain learning objectives, field tasks, and expectations. In some cases, preparation extended to practical arrangements; for example, Taiwanese students traveling to Japan prepared basic food ingredients and seasonings in response to local living conditions and planned group cooking activities.

During the workshops, learning extended beyond field visits to include stakeholder interviews, group discussions, and collaborative analysis. Students worked in mixed-nationality teams to identify local issues, interpret community needs, and co-develop context-sensitive proposals. At the conclusion of each workshop, teams presented their proposals in a formal setting, outlining problem identification, analysis of local conditions, and suggested action plans. These presentations were shared with instructors and, in some cases, community stakeholders, allowing students to receive feedback and reflect on the feasibility of their ideas.

The workshops were open elective courses offered at the university level, with students recruited through an application and selection process. Priority was given to students who had previously taken courses related to regional revitalization or community-based learning. Applicants were further evaluated through interviews, including assessments of their language abilities and learning motivations to ensure their readiness for cross-cultural participation.

Participants came from diverse academic disciplines and year levels. A total of nine Taiwanese and nine Japanese students participated in the Japan workshop (2024), which was held over nine days. The Taiwan workshop (2025) involved eleven Taiwanese and nine Japanese students and lasted for seven days. Among the participants, five students (three Taiwanese and two Japanese) were selected as focal interview participants in this study. All five had participated in both the Japan and Taiwan workshops, allowing for comparative reflection across the two contexts.

3.2. Research Design

This study adopted a qualitative-dominant mixed-methods approach to gain a comprehensive understanding of students' learning processes within short-term, cross-cultural experiential programs (Creswell & Plano Clark, 2018). Data sources included interviews, participant observation, instructor reflections, course artifacts, and post-program surveys. Both workshops required students to participate in field visits, conduct stakeholder interviews, collaborate in mixed-nationality teams, and present community-based action plans, providing multiple points of observation for the research.

3.3. Data Collection and Analysis

Data were collected from multiple sources to ensure depth and credibility. Semi-structured interviews with five students (three Taiwanese and two Japanese) explored their motivations, intercultural experiences, perspectives on revitalization, and reflections on collaboration. Faculty members who co-designed and facilitated the workshops provided written reflections and teaching journals documenting pedagogical decisions, instructional challenges, and observations of student engagement. Field notes were compiled during community visits, team discussions, and proposal development, capturing real-time interactions and cultural negotiation. Post-program surveys yielded 21 valid responses from the Taiwanese participants in the 2025 workshop, assessing environmental action intention, community responsibility, and intercultural attitudes. Course artifacts—including worksheets, proposal drafts, and presentation slides—were analyzed to understand students' conceptualization of local issues and feasibility.

All interviews were audio-recorded with participant consent and transcribed. A thematic analysis approach was used to code the qualitative data. Codes were developed inductively and refined through constant comparison across Taiwanese and Japanese participants to identify similarities and differences in learning processes, communication strategies, and interpretations of local development. Survey findings were summarized descriptively to complement the qualitative analysis. The triangulation of interviews, field observations, instructor reflections, and course products enhanced the trustworthiness of the findings.

To further clarify the mixed-methods approach, additional details on data collection and analysis are provided. The semi-structured interview protocol was developed based on the study's research questions and relevant literature on sustainability learning and intercultural collaboration. Interview guides included open-ended questions exploring students' motivations, perceptions of local issues, intercultural experiences, and reflections on collaboration. While a flexible format was maintained to allow participants to elaborate on their experiences, all interviews followed a common thematic structure to ensure comparability across cases.

Qualitative data were analyzed using an inductive thematic analysis approach. The research team manually coded the transcripts without the use of specialized qualitative analysis software. Codes were developed through careful reading and comparison of interview data to identify recurring patterns and themes across participants.

The survey instrument was designed to assess students' environmental attitudes, community responsibility, and intercultural learning outcomes, drawing on established constructs in sustainability education and experiential learning research. The research team reviewed the survey items to ensure clarity and relevance. Responses were analyzed using descriptive statistics to identify general trends in students' learning outcomes.

Due to ethical considerations and the qualitative nature of the study, full interview transcripts and raw survey data are not publicly available. Findings are presented in an anonymized and synthesized manner, and the authors may provide additional information upon reasonable request.

3.4. Research Limitations

Several contextual factors influenced the research process. The short duration of the workshops constrained the depth of students' community immersion, and the small number of interview participants reflected the exploratory nature of the study. Trilingual communication (Mandarin–Japanese–English) shaped how students articulated their experiences. The dual roles of instructors as both facilitators and researchers may have influenced data interpretation; this issue is further addressed in the positionality statement Section 3.5. To mitigate these constraints, the analysis incorporated multiple data sources, reflective documentation, and methodological triangulation. Despite these limitations, the rich qualitative data and comparative cross-national context provide meaningful insights into students' learning within international regional revitalization programs.

3.5. Positionality of the Researchers

The researchers in this study were directly involved in the design and implementation of the workshops, serving as course instructors and facilitators who guided students during field activities and interacted with community partners. In addition, the cross-institutional research team had several years of prior collaboration, including co-teaching and joint course delivery across Taiwan and Japan.

This insider position enabled the researchers to gain in-depth, process-oriented insights into students' learning experiences, but also required careful reflexivity in data interpretation. To enhance the credibility of the findings, the study employed methodological triangulation by integrating multiple data sources, including interviews, participant observation, instructor reflections, and course artifacts.

4. Findings

The findings of this study draw from interviews, field observations, instructor reflections, and students' written work generated during the 2024 Japan and 2025 Taiwan regional revitalization workshops. Analysis revealed several interconnected themes concerning (a) Taiwanese students' learning experiences, (b) Japanese students' interpretations and cross-cultural engagement, (c) shared learning patterns across both groups, and (d) instructors' observations regarding team dynamics and pedagogical implications. Together, these themes illustrate how short-term, cross-cultural experiential programs shape students' understanding of regional revitalization, sustainability, intercultural communication, and community engagement.

4.1. Taiwanese Students' Learning Experiences

4.1.1. Motivations and Expectations

Taiwanese students expressed diverse motivations for joining the workshop. Many reported an interest in understanding Japan's revitalization practices, particularly the long-term community–government collaborations characteristic of Japanese regional planning. Others viewed the workshop as an opportunity for cultural exchange, personal growth, or exploration of potential future study paths. For several participants, the workshop represented their first experience participating in an intensive international field program.

Despite these varied motivations, students shared a common expectation: to compare the revitalization practices of Taiwan and Japan, and to gain insights applicable to Taiwan's own community development challenges. They hoped to observe concrete strategies implemented in Japan—such as heritage preservation, local industry branding, and population retention—and evaluate whether similar approaches could be adapted to Taiwanese contexts.

4.1.2. Awareness of Sustainability and Local Issues

Field immersion in Kuroshio and Yasuda towns prompted Taiwanese students to reflect on the differences between Taiwanese and Japanese approaches to regional development. Students noted Japan's strong emphasis on long-term planning, institutional stability, and the preservation of local culture. They observed that many revitalization projects in Japan were designed to operate over decades rather than short funding cycles, contributing to a sense of continuity and community trust.

Through interactions with local officials and community practitioners, Taiwanese students also became aware of the complexity of sustainability issues. While they initially assumed that revitalization could be understood primarily through economic or tourism-focused strategies, they came to recognize the importance of cultural identity, community participation, and intergenerational collaboration. Several students commented in interviews that "revitalization goes beyond increasing tourist numbers" and instead requires "building long-term relationships and strengthening local pride."

In comparing the two contexts, several students felt that the revitalization challenges they encountered in Taiwanese coastal communities—such as cultural preservation or local participation—seemed less structurally complex than the issues observed in Japan, where population aging, labor shortages, and multi-stakeholder coordination required long-term planning. This contrast helped students more clearly distinguish between short-term community projects and the long-term institutional systems necessary for sustaining revitalization efforts.

4.1.3. Intercultural Challenges and Communication Growth

Working in mixed-nationality teams presented both challenges and growth opportunities for Taiwanese students. Some reported communication difficulties in interviews, either due to language barriers or differences in discussion styles. Taiwanese students described their Japanese peers as more reserved in group settings, which initially made collaboration on idea generation difficult. However, as the workshop progressed, they learned to adapt their communication strategies, slow down discussions, and use non-verbal cues or simple English to bridge gaps.

Several Taiwanese students also found themselves taking on informal translation or cultural mediation roles during field visits and team discussions. They noted that this responsibility required them not only to translate words, but also to interpret cultural cues and contextual meanings for their Japanese peers. While demanding, this role strengthened their leadership and attentiveness, and deepened their understanding of both community narratives and team dynamics.

Several students also noted that Japanese teammates tended to be more cautious and detail-oriented, whereas Taiwanese students were more comfortable proposing creative or broader conceptual ideas. These

differences sometimes led to negotiation but ultimately contributed to deeper reflection, as students learned to articulate their perspectives more clearly and consider alternative viewpoints.

4.1.4. Teamwork and Leadership Development

Many Taiwanese students experienced personal growth through team collaboration. Some stepped into leadership roles, guiding discussions or facilitating communication among team members. Others learned to work more collaboratively, respecting each member's strengths and adjusting to diverse working paces. Students repeatedly emphasized in interviews that the most valuable learning was not just "about Japan" or "about revitalization," but about "learning how to work with people from different cultural backgrounds."

The co-design process of community proposals also encouraged students to consider feasibility. Whereas initial ideas were broad or idealistic, discussions with community stakeholders compelled students to revise their proposals and incorporate practical considerations. This shift from abstract brainstorming to context-sensitive problem solving was a major learning outcome.

In reflecting on the workshop structure, Taiwanese students also offered several practical suggestions for improvement. Some felt that the lack of shared accommodation reduced opportunities to build group cohesion, especially compared to the Japan workshop, where living together accelerated team bonding. Others noted that uneven language proficiency occasionally hindered participation, indicating the need for stronger translation support or bilingual materials. Students also felt that the tight schedule limited the time available for deeper reflection or integrating stakeholder feedback into their proposals. Several expressed a desire for more sustained post-workshop activities or follow-up guidance to continue developing their ideas beyond the short program.

4.2. Japanese Students' Learning Experiences

4.2.1. Encountering Taiwan's Coastal and Cultural Diversity

Japanese students participating in the 2025 Taiwan workshop were deeply impressed by the cultural richness and diversity of Taiwan's coastal communities. The close relationships between schools, community organizations, and fisheries-based industries impressed them the most. Many participants expressed surprise at the warmth, openness, and hospitality shown by local residents, which helped them feel welcomed and comfortable despite the language barriers.

Through field visits, Japanese students gained exposure to the lived experiences of Taiwanese coastal communities, including the challenges of sustaining traditional industries, maintaining cultural identity, and navigating the complexities of rural education. These observations allowed them to compare Taiwanese contexts with those of rural Japan, prompting reflection on similarities and differences in community needs.

4.2.2. Shifts in Cultural Perspective and Self-Understanding

Several Japanese students reported in interviews that their experiences in Taiwan challenged preconceived notions about cultural differences. They initially assumed that Taiwanese and Japanese revitalization

contexts would be similar due to shared demographic challenges. Still, they soon realized that Taiwan's local culture, community structures, and educational systems introduced unique dynamics. Students commented that Taiwan's revitalization efforts appeared more closely tied to school programs and youth engagement, whereas Japan's model emphasized long-term community governance and municipal planning.

These insights led students to reflect on their own communities back in Japan. Some mentioned that their hometowns faced similar issues but lacked the strong partnerships between schools and community organizations seen in Taiwan. This comparative perspective strengthened students' sense of place and heightened their awareness of regional assets and challenges within their home contexts.

4.2.3. Intercultural Collaboration and Adaptation

Japanese students also encountered communication challenges. Many expressed initial hesitation speaking English, Mandarin, or even simplified Japanese to their Taiwanese peers. However, they found that Taiwanese students were supportive and encouraging, which eased their anxiety. Over time, Japanese students became more willing to express their ideas and take initiative in team discussions.

Several Japanese students, in interviews, reflected that they had initially relied too heavily on Japanese during group work, unintentionally limiting opportunities for Taiwanese students to practice English. This realization made them more conscious of adjusting their communication strategies, and they began making efforts to use simpler English or slower speech so that both sides could participate more equally in discussions. Students noted that this awareness was an important form of self-growth, as it helped them recognize the need for mutual accommodation in cross-cultural teamwork.

Some Japanese participants also mentioned that while the structured schedule provided helpful guidance, they would have liked more unstructured time to engage in deeper group discussions. They felt that additional space for peer-to-peer negotiation would have allowed them to explore ideas more fully, integrate diverse viewpoints, and take greater ownership over the proposal development process. This reflection highlighted their desire for a balance between instructor-led activities and student-driven collaboration.

Team collaboration highlighted cultural differences in working styles. Japanese students tended to prefer structured planning and incremental progress, while Taiwanese students were more comfortable generating multiple options quickly. Despite these contrasts, students agreed that the combination created productive synergy, with each group contributing complementary strengths.

4.2.4. Learning from Community–School–Industry Linkages

Japanese students found Taiwan's "community–school linkage model" particularly inspiring. They noted that local elementary schools served as centers of cultural preservation and community engagement, and that teachers played active roles in connecting students to the local traditions. This approach broadened Japanese students' understanding of how education can contribute to regional revitalization, and they expressed interest in learning how similar collaborations might strengthen their home communities.

They were particularly impressed by how Taiwanese elementary schools collaborated closely with community elders, local artisans, and cultural practitioners to co-design learning activities. Students observed classes in

which children learned local history directly from community members, participated in traditional craft making, or engaged in place-based environmental projects. These experiences demonstrated to Japanese students how schools in Taiwan function not only as educational institutions but also as hubs that sustain cultural transmission and strengthen community identity.

4.3. Shared Learning Themes Across Taiwanese and Japanese Students

4.3.1. Mutual Recognition of Cultural Differences and Similar Challenges

A major theme emerging across both groups was the recognition that Taiwan and Japan face similar revitalization challenges—aging populations, declining industries, and youth outmigration—yet approach them through different cultural lenses. Rather than remaining at an abstract level, students articulated how these differences were reflected in practice. For instance, Taiwanese communities were often described as prioritizing industrial development and tourism as key drivers of revitalization, whereas Japanese contexts emphasized population sustainability and the maintenance of community relationships. These differences were further reflected in students' approaches to action, with Taiwanese participants tending to propose more economically oriented strategies. In contrast, Japanese participants focused more on resident-centered and relational approaches. Students from both countries commented in interviews that comparing the two contexts deepened their understanding of sustainability and broadened their awareness of alternative development models.

4.3.2. Growth in Intercultural Communication Competence

Both Taiwanese and Japanese students experienced noticeable growth in their ability to communicate across languages and cultural norms. They learned to navigate misunderstandings, adjust communication strategies, and interpret non-verbal cues. Students repeatedly emphasized that intercultural competence was one of the most significant learning outcomes of the workshops. Quantitative results from the Japanese cohort also supported these reflections. Post-program surveys showed the largest gains in interpersonal interaction, collaborative planning, reflective thinking, and the intention to take concrete action. These improvements suggest that the workshop's cross-cultural structure created meaningful opportunities for Japanese participants to expand their communication skills and deepen their engagement in community-based problem-solving.

4.3.3. Increased Awareness of Feasibility and Community Realities

Through field interactions, students from both countries developed a stronger sense of feasibility. Initial proposals were often creative but unrealistic; for example, some groups initially suggested large-scale tourism marketing campaigns or infrastructure upgrades that exceeded the community's financial and organizational capacity. After conversations with community stakeholders, these ideas were revised into more feasible, small-scale actions—such as designing locally guided walking tours, developing simple educational activities for elementary school students, or proposing community-based storytelling materials that could be implemented with existing resources.

This shift from abstract and idealized solutions to context-sensitive and actionable plans demonstrated their growing ability to connect theory with practice, a core competency in sustainability education.

Despite these gains, Taiwanese students scored lower on survey items related to responsibility toward unfamiliar communities. Several students explained in interviews that the short duration of the workshop limited their ability to build trust and sustained relationships with residents, making it difficult to develop a deeper sense of long-term community obligation. This suggests that certain civic dispositions may require extended engagement beyond a brief field immersion.

4.3.4. Enhanced Sense of Place and Community Connectedness

Experiencing real communities—walking through towns, meeting local leaders, and participating in cultural activities—strengthened students' emotional connection to place. Many expressed a deeper appreciation of coastal environments, traditional industries, and the value of community resilience. This enhanced sense of place contributed to their motivation to engage in future community-oriented work.

4.4. Instructor Observations

4.4.1. Observations on Student Growth

Instructor reflections provided further insight into how students progressed throughout the workshops. Teachers reported that students demonstrated significant improvement in communication, adaptability, and critical thinking. They observed that, over time, students became more willing to take risks, ask questions, and participate actively in mixed-nationality discussions. Cross-cultural teamwork functioned as both a challenge and an opportunity: although linguistic and cultural differences occasionally slowed progress, they ultimately contributed to richer dialogue and deeper learning.

Instructors from Taiwan and Japan also noted meaningful differences in their pedagogical orientations. Taiwanese instructors tended to adopt a more interventionist approach—providing direct guidance during field visits and team discussions. In contrast, Japanese instructors favored a facilitative, observation-based role that encouraged students to explore issues independently. Combining these approaches enriched the learning experience by exposing students to multiple modes of engagement.

4.4.2. Pedagogical Challenges in Cross-Cultural Facilitation

Teachers also highlighted the complexities of facilitating cross-cultural programs. Full English instruction was demanding for many students, requiring additional visual aids, simplified explanations, and repeated clarification. Instructors noted that translation between English, Mandarin, and Japanese occasionally produced subtle meaning gaps that affected how well students understood community histories or local concerns.

Differences in students' language proficiency and prior knowledge further contributed to uneven participation during team tasks, prompting instructors to adjust lesson pacing, scaffold group work, and provide differentiated support throughout the workshop.

4.4.3. Challenges in Recruiting Rural Students and Instructor Reflections

Both workshops were conducted in rural areas characterized by geographic remoteness and limited economic development. While the program aimed to engage with such communities, one instructor emphasized the

challenges of recruiting students from rural backgrounds. As the workshops were offered as elective courses, participation required additional time commitment beyond regular academic responsibilities.

In practice, students from rural areas were less likely to enroll, often due to competing responsibilities such as family obligations, academic workload, or the need for part-time employment. This highlighted the structural barriers that can limit participation in community-based learning, particularly for those who may already be closely connected to similar contexts.

Despite these difficulties, instructors agreed that the workshops successfully strengthened Taiwan–Japan higher education collaboration and provided meaningful, context-rich experiences that deepened students' understanding of sustainability and regional revitalization.

4.5. Summary

Overall, the findings reveal that cross-cultural field-based workshops can significantly deepen students' understanding of sustainability, community development, and intercultural collaboration. Both Taiwanese and Japanese students gained valuable insights through direct engagement with local communities, collaborative problem solving, and comparative reflection across national contexts. The workshops not only facilitated cognitive learning but also fostered personal transformation, enhanced communication competence, and strengthened students' sense of responsibility toward regional revitalization.

5. Discussion

Through field engagement in Taiwan and Japan, students developed a more nuanced appreciation of local contexts, community needs, and the constraints and possibilities of revitalization initiatives. These outcomes highlight the value of structured experiential learning situated within long-term partnerships between higher education institutions, consistent with established theories of experiential learning and sustainability competencies (Kolb, 1984; Wiek et al., 2011).

5.1. Cross-Cultural Experiential Learning and Sustainability Competencies

Students' reflections show that direct engagement with Taiwanese and Japanese communities helped them connect demographic changes, cultural identity, and local development issues to broader sustainability concerns. This learning pattern aligns with research emphasizing the effectiveness of experiential and place-based pedagogies in fostering systems thinking and environmental responsibility (Sipos et al., 2008; Sterling, 2010). Survey results also reveal strong environmental action, which echoes findings in the community-engaged learning literature (Ash & Clayton, 2009).

However, students' lower scores in areas such as family discussions on the environment and responsibility toward unfamiliar communities suggest that certain civic dispositions may require more sustained interaction to develop fully—a dynamic often observed in short-term sustainability programs (Brundiers & Wiek, 2017). Notably, the cross-cultural structure of these workshops contributed an added layer rarely emphasized in single-country studies: Students developed sustainability competencies not only through

local immersion but also by comparing how different socio-cultural systems shape sustainability challenges and responses. This comparative dimension represents an important contribution to sustainability pedagogy.

5.2. Intercultural Negotiation and Communication

Intercultural communication emerged as a core aspect of students' learning. Participants encountered linguistic imbalance, differing communication styles, and unfamiliar team norms. These challenges encouraged greater attention to turn-taking, clarity, and mutual respect—behaviors associated with the development of intercultural competence (Deardorff, 2006; Vande Berg et al., 2012). The trilingual environment added complexity but also promoted deeper cultural awareness as students adjusted their pace, clarified meanings, and distributed communicative responsibilities.

Consistent with relational perspectives on intercultural learning, competence in this study emerged through sustained negotiation and adaptation rather than immersion alone (Bennett, 2013; Hung, 2022). As students learned to bridge cultural gaps, they also developed trust and stronger collaborative relationships within mixed-nationality teams.

5.3. Cross-National Perspectives on Regional Revitalization

The workshops enabled students to compare revitalization practices across Taiwan and Japan, prompting them to reconsider assumptions about community development. Observations in Japan highlighted the value of long-term partnerships, gradual progress, and community autonomy, while field visits in Taiwan emphasized cultural identity, school–community collaboration, and SDG-oriented planning. These contrasting experiences reflect broader research showing how policy histories and cultural norms shape revitalization trajectories (Akaike, 2019; C. Y. Lin, 2021; Tsai, 2023).

Students also voiced concerns about tourism pressure, community consent, and the feasibility of externally designed proposals—issues commonly raised in critiques of revitalization efforts that fail to incorporate local priorities (Her, 2022; Liu, 2019).

Unlike conventional revitalization research that addresses policy or institutional perspectives, this study demonstrates how student-led field immersion can surface ethical considerations—such as community voice and feasibility—at an earlier stage of learning. This highlights the pedagogical potential of cross-national immersion for developing more socially responsible understandings of revitalization.

This may also reflect a change in how students approach these issues. Instead of focusing mainly on proposing solutions, many students placed more emphasis on listening to the community and adjusting their ideas based on local feedback.

5.4. Faculty Collaboration and Pedagogical Considerations

Faculty members navigated institutional differences, curricular timelines, and cultural norms while facilitating the workshops—experiences consistent with scholarship on transdisciplinary and community-engaged sustainability education (Brundiers & Wiek, 2017; Pless et al., 2011). Coordination across national systems

required attention to language balance, preparatory scaffolding, such as structured guidance and support to help students engage with complex tasks, and communication with community partners, patterns frequently observed in global service-learning and cross-border teaching initiatives (Crabtree, 2008; Lee et al., 2024).

These pedagogical demands emphasize the need for intentional instructional design, including pre-departure briefings, bilingual materials, and structured reflection activities that help students navigate compressed timelines and cross-cultural environments. Faculty reflections in this study demonstrate that well-designed supports can reduce barriers and enable students to engage more meaningfully with community contexts.

5.5. Implications for Higher Education and Sustainability Practice

The study illustrates how short-term, well-structured cross-cultural workshops can advance sustainability learning by helping students develop environmental awareness, civic responsibility, and intercultural communication skills. These outcomes align with sustainability education frameworks that emphasize experiential pedagogies and competencies for action (Brundiers et al., 2020; Sterling, 2010).

The findings also underscore the value of embedding experiential programs within longstanding institutional partnerships. The stability, shared objectives, and ongoing collaboration within the TJA helped create conditions that enhanced learning and community engagement—a trend consistent with studies examining international networks for regional revitalization (Tsai, 2023; Wang, 2020).

Furthermore, students' reflections on feasibility, community consent, and the risks of tourism-driven development highlight the importance of ethical engagement. These concerns echo scholarship warning against extractive approaches to community-based initiatives, particularly those involving external actors or students (Her, 2022; C. Y. Lin, 2021). Facilitated reflection played a crucial role in helping students critically engage with these issues and develop more context-sensitive understandings of community-based sustainability practice.

Finally, the workshops demonstrate how universities can function as intermediaries in sustainability transitions by linking international partners, local communities, and academic programs. This role aligns with theoretical perspectives positioning higher education institutions as key actors capable of bridging knowledge systems and fostering multi-stakeholder collaboration for sustainable development (Goddard et al., 2013; Trencher et al., 2014).

6. Conclusion

This study examined how two Taiwan–Japan cross-cultural regional revitalization workshops supported students' learning in sustainability, intercultural communication, and community engagement. Using interviews, observations, and course artifacts, the research traced how students interpreted local issues, navigated cultural differences, and developed feasibility-oriented thinking during intensive field immersion.

Across both workshops, students demonstrated the capacity to connect local experiences with broader sustainability questions. Rather than focusing solely on tourism or economic development, they learned to recognize the social, cultural, and institutional conditions that shape revitalization efforts. Team-based

work in mixed-nationality groups further encouraged students to negotiate meaning, coordinate responsibilities, and adapt communication strategies, deepening their understanding of collaboration in multicultural settings.

The workshops also highlighted the importance of long-term institutional partnerships in supporting effective international experiential programs. Faculty coordination, community engagement, and curricular alignment were essential to enabling students to engage meaningfully within compressed timeframes. These findings illustrate how universities can function as relational bridges—linking local communities, international collaborators, and sustainability-oriented educational practices.

Several implications emerge from this study. For higher education, the results suggest that structured cross-cultural field programs can effectively cultivate place-based awareness and action-oriented competencies, particularly when supported by reflective scaffolding and sustained institutional collaboration. For community partners, the workshops demonstrate how international student engagement—when approached respectfully and collaboratively—can generate new perspectives on local challenges. More broadly, the study emphasizes the value of comparative field immersion for helping students understand the diversity of revitalization pathways across cultural and policy contexts.

This research is not without limitations. The short duration of the workshops restricted the depth of community immersion, and the small number of interview participants limits the generalizability of the findings. Linguistic differences and the trilingual learning environment also influenced how students expressed and interpreted their experiences. Future studies could adopt longitudinal designs, expand to additional institutions, or examine how sustained participation in transnational programs shapes students' long-term civic engagement and sustainability practices.

Overall, this study contributes to growing scholarship on sustainability education by showing how international, community-based learning environments can foster both comparative understanding and intercultural competence. As universities increasingly engage with regional revitalization and cross-border collaboration, such models offer valuable insights into how higher education can support more inclusive, context-sensitive approaches to sustainable development.

This study contributes to the literature in both theoretical and practical ways. Theoretically, it extends existing research on sustainability education and experiential learning by demonstrating how cross-cultural, community-based immersion can support the development of action competence, feasibility awareness, and ethical engagement. Practically, the findings offer insights for educators and institutions designing short-term international programs, highlighting the importance of structured support, cross-cultural facilitation, and sustained institutional partnerships to enhance student learning and community engagement.

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Conflict of Interests

In this article, editorial decisions were undertaken by Kuei-Chao Chang (National Academy of Marine Research).

Data Availability

The data is not publicly available due to privacy and ethical considerations.

LLMs Disclosure

Large language model (LLM) tools (e.g., ChatGPT) were used for language editing and translation support.

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About the Authors

Hsiao-Chien Lee is a professor at National Kaohsiung University of Science and Technology, Taiwan. Her research focuses on university social responsibility, regional revitalization, ocean sustainability, and fishery literacy education, with an emphasis on place-based learning and international collaboration.

Shingo Akaike is a Regional Coordinator at Kochi University, Japan, where he manages university collaboration initiatives. His research interests include forest policy, regional revitalization, and environmental conservation in Japan and Taiwan. He is actively engaged in Japan–Taiwan regional revitalization partnerships through international collaborative projects.

Yi-Juen Chen is an assistant professor in the Department of International Business at National Kaohsiung University of Science and Technology, Taiwan. Her research interests include technology management, regional revitalization, and the application of design thinking in education.

Yi Tsai is a master's student at National Kaohsiung University of Science and Technology, Taiwan. His research focuses on CoralWatch workshops and ocean literacy. He has actively participated in regional revitalization projects and Taiwan–Japan collaborative workshop exchanges.

Ay-Ling Huang is an associate professor in the Department of Applied Japanese at National Kaohsiung University of Science and Technology, Taiwan. She received her PhD in Japanese Language and Culture from Osaka University. Her research interests include Japanese linguistics, cognitive semantics, bilingual education, and project-based learning.

Kenji Okamura is an associate professor at Kochi University, Japan. His research focuses on cross-sector partnerships, social management systems, and traffic engineering.

Wen-Hong Liu is a Distinguished Professor at National Kaohsiung University of Science and Technology, Taiwan. His research focuses on ocean governance, fisheries sustainability, and marine technology applications, with recent work on coral monitoring, smart ocean technologies, and offshore wind energy development.

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Higher Education as Coastal Community Development: Lessons Learned From the University Centre of the Westfjords, Iceland

Peter Weiss, Catherine Chambers, and Matthias Kokorsch

University Centre of the Westfjords, Iceland

Correspondence: Catherine Chambers (cat@uw.is)

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Abstract

Theoretical and applied scholarship examines the role of educational institutions as a rural and regional development tool. In this article, we use the 20-year history of the University Centre of the Westfjords (UW), located in Ísafjörður (population 2,700), as a case study in university education as a community development tool. Close to 300 graduates from UW's two coastal-themed master's programs, plus countless study abroad and guest students and researchers, have contributed significantly to the region's cultural and economic revitalisation. Many graduates choose to stay in the Westfjords, supporting community development through innovative projects, entrepreneurship, and social engagement. This retention of talent has been crucial in addressing demographic challenges such as outmigration and gender imbalances. The authors use methods from insider research in higher education to reflect on lessons learned about the role of universities in small-scale societies, using data on local economic impact and the immeasurable cultural impact of university institutions in rural coastal communities. We examine how UW has acted as a policy tool for societal transformation, enabling the region to move beyond economic, educational, and demographic stagnation. In this way, UW serves as a model for the concept of universities as collaborative platforms for promoting sustainable development in coastal communities through education and research grounded in local economic and cultural connections to the sea. By sharing these insights, this work contributes to the broader discussion on the unique challenges and opportunities of how university activities in coastal communities can serve as engines for regional development.

Keywords

community capital; community development; higher education institutions; Iceland; societal impact

1. Introduction

The growing literature on the civic university and the third mission of higher education institutions (HEIs) emphasises that universities are not only producers of teaching and research but also civic and cultural actors with explicit responsibilities to their surrounding societies (Benneworth et al., 2024; Carlsen et al., 2013; Hedin, 2009; Tomasi et al., 2020). Nordic universities, for example, are increasingly tasked with supporting rural and regional development through adapted education and lifelong learning, entrepreneurship and business formation, and applied R&D collaboration with local industry, often organised through networked triple helix arrangements that connect universities, firms, and public actors (Berlina, 2025; Hedin, 2009). Similarly, the concept of universities as anchor institutions has gained prominence in rural and peripheral settings, capturing their role as long-term, place-bound organisations whose decisions around employment, curricula, and engagement significantly shape local development trajectories (Berlina et al., 2025; Orphan & McClure, 2019). In many rural regions, a single HEI may be the only nearby provider of higher education and a major employer, making the sustainability of communities heavily dependent on its presence and orientation (Orphan & McClure, 2019; Raghavan, 2019). A civic university provides direct inputs to regional development (expenditure, human capital, knowledge services), makes developmental contributions by upgrading elements of the regional economic structure, and plays a transformative role in creating new paths and futures (Atterton & Thompson, 2010; Keerberg, 2018; Salomaa, 2019; Tomasi et al., 2020).

A core mechanism through which universities can address depopulation and skill shortages in peripheral regions is the provision of locally accessible and flexible higher education, including distance and blended learning. Using the term "peripheral higher education institutions" (PHEIs), Berlina et al. (2025) note that PHEIs serve as pillars of regional development by functioning as cultural and civic hubs and sustaining local public spheres and community events. PHEIs' primary contributions are in the areas of social, civic, and territorial cohesion, as well as resilience and identity, by widening access for non-traditional and place-bound students and tailoring programmes to local labour markets. Such an expanded purpose and definition of PHEIs therefore leads to demands for funding and evaluation models that extend beyond research rankings and limited economic indicators often used to evaluate HEIs (Berlina et al., 2025). Similarly, from a community development perspective, Orphan and McClure (2019) document how a rural university systematically invests in different forms of community capital, i.e., human, cultural, social, political, financial, and built. Raghavan (2019) similarly finds that PHEIs can be powerful catalysts of rural development when they engage proactively with their communities, with residents perceiving university outreach as improving infrastructure, access to finance, and interactions with government agencies, ideally helping to fight out-migration.

In coastal rural regions, where the industrial base is often dominated by fisheries and related activities, these insights highlight the importance of aligning university education and research with both existing sectors and emerging opportunities in, for example, maritime economies, sustainable tourism, coastal planning, and environmental management. Universities may help regions branch into related or new paths, such as marine innovation, environmental services, or knowledge-intensive public services by training skilled graduates, undertaking applied research, and facilitating partnerships (Keerberg, 2018; Kurikka et al., 2020). Yet, this potential depends on governance arrangements, funding, institutional culture, and the ability to balance local embeddedness with global academic standards (Benneworth et al., 2024; Berlina, 2025; Hedin, 2009).

While this literature is generally optimistic about the potential of universities in peripheral development, it also highlights important tensions and risks. Policy makers often place high expectations on universities as transformative agents, sometimes without providing the necessary resources, autonomy, or supportive ecosystems. Academic drift towards research excellence, institutional mergers, and centralisation can undermine the capacity of peripheral campuses to maintain strong regional engagement, as investment and prestige concentrate in a few centres (Benneworth et al., 2024).

This article draws on 20 years of PHEI experience in a remote coastal community, reflecting on the role of the University Centre of the Westfjords (UW) in Ísafjörður, Iceland (Figure 1). In Iceland, research on Icelandic higher education shows that regional universities can significantly increase the supply and retention of qualified professionals in their immediate micropolitan centres, but that on-campus provision alone tends to have limited reach into more remote rural communities (Bjarnason & Thorarinsdottir, 2017). When students must relocate to study, they are less likely to return to the smallest and most remote settlements after graduation, thereby contributing to ongoing rural depopulation and urban concentration of human capital (Bjarnason & Edvardsson, 2017). In contrast, distance education, delivered by universities in ways that allow rural students to remain in their communities while studying, emerges as a key mechanism for strengthening educational levels and professional capacity in remote regions (Bjarnason & Edvardsson, 2017). Although there are other political, social, or economic drivers that may play a role in demographic changes (Bjarnason & Thorlindsson, 2006), rural academic opportunities still increase the chances that graduates stay in or return to their home communities, especially in welfare professions such as teaching and health care that are critical for sustaining basic services in small settlements (Berlina et al., 2025; Bjarnason & Thorarinsdottir, 2017). For coastal regions facing depopulation and ageing populations, this has direct implications for the viability of schools, health services, and local administrations.

Figure 1. Location of UW in Ísafjörður, with the school building circled in the foreground, and student housing in the background.

Upon its founding in 2005, UW was therefore tasked with the purpose of community development and the goal to respond to and balance the local needs for distance education, in-person education, research, and other educational services. The remote Westfjords of Iceland had experienced a transformational shock in their mainstay maritime industry and a related significant population decline from the early 1990s until 2015. These conditions are similar in many Nordic and European peripheries where HEIs are increasingly tasked with supporting regional resilience and transformation (Berlina, 2025; Hedin, 2009). In coastal settings, this implies that universities must engage with the dual challenges of socio-economic restructuring and environmental change, i.e., climate impacts on fisheries, marine ecosystems, coastal infrastructure, and hazard risk, while also addressing demographic decline and social inequalities. The call for neo-endogenous, place-based, and sustainable development (see e.g., Benneworth et al., 2024) provides a conceptual entry point to understand how universities like UW can function as collaborative platforms in such contexts.

This longitudinal case study on UW contributes to a thematic issue that stresses the need for transformative, socially just, and environmentally sustainable development in marine and coastal regions and explicitly foregrounds universities as platforms that connect science, policy, and communities. Universities can host forums that bring together different stakeholder groups to deliberate on issues such as marine spatial planning, aquaculture development, coastal hazards, and climate adaptation. They can co-design student projects and research that address real-world challenges and produce tangible benefits for communities and ecosystems. In doing so, they embody the role of collaborative platforms, translating science and engagement into lasting social impacts. This article examines how UW has developed from a distance-learning hub into an international teaching and research institution, and how it contributes to community and regional development in the Westfjords. The discussion links this empirical case to debates on universities in peripheral regions and the balance between regional development and academic missions. In this way, the case study of UW links together concepts of the civic university and third mission in the unique context of the broader sustainability challenges facing coastal and marine communities.

2. Theoretical Framework and Methods

This article is situated at the intersection of debates on coastal peripheries, regional development, and the evolving role of universities as civic and collaborative actors. In response, we conceptualise UW as a PHEI embedded in a remote coastal region undergoing long-term socio-economic restructuring, demographic decline, and environmental change. Our theoretical framework brings together several strands of literature: work on peripheral and coastal regions, depopulation, and path dependency; neo-endogenous development and the role of PHEIs in regional transformation; research on universities as anchor institutions, social rural campuses, and providers of accessible higher education; and the civic university and third mission debates, including critical reflections on the tensions and limits of university-led development (Table 1). This work is a reflexive, longitudinal case study of a single HEI. We collected and triangulated multiple data sources (e.g., institutional documents such as annual reports, internal reviews, and board minutes) that document how UW has evolved, how it has been perceived locally, and how it has interacted with wider regional dynamics. Our approach follows work on insider research in higher education, which highlights both the value and the challenges of researching one's own institution (Healey, 2016; Savvides et al., 2014; Trowler, 2011). Therefore, the results and discussion sections are combined and reflect on the various concepts overviewed in Table 1.

Table 1. Overview of UW's contributions to peripheral coastal development through different theoretical lenses.

Theoretical lens/concept	UW role/practice	Main type of impact	Example/indicator
Neo-endogenous development (Benneworth et al., 2024)	Founding of UW as locally rooted but externally connected PHEI	Demographic, knowledge, institutional	Shift from distance hub to international master's and visiting field schools
Social rural campus/anchor institution (Benneworth et al., 2024; Berlina et al., 2025)	UW as demographic and cultural anchor in Ísafjörður and surrounding villages	Demographic, social, cultural, identity	Missing age group filled; student-led cultural events
Access & demographic sustainability (Bjarnason & Edvardsson, 2017)	Offering local higher education access + attracting students from outside the region	Demographic, skills, welfare services	Number of local residents graduating from UW programmes
Civic university/ collaborative platform (Tomasi et al., 2020)	Co-produced theses and research projects with municipalities, NGOs	Knowledge, policy, practice	Share of theses with local partners; funded adaptation projects
Community capitals (Orphan & McClure, 2019)	Investments in student housing, entrepreneurship, and cultural activities	Built, financial, social, cultural	Student housing units; number of graduate-led ventures
Tensions and limits (Benneworth et al., 2024; Keerberg, 2018; Pinheiro, 2020)	Limited Icelandic enrolment; uneven regional reach; resource constraints	Governance, institutional, scalar	Share of Icelandic vs. international students; spatial concentration of impacts

We first conducted a systematic review of institutional documents produced since UW's establishment. This includes a comprehensive collection of founding documents, strategic plans, annual reports, board minutes, programme descriptions, external evaluations, and reports. These materials were used to trace UW's development, priorities, funding base, and regional role over time, where each document was reviewed systematically, noting similarities, differences, and omissions/changes over time. Similar document-based institutional case studies have been used to understand how universities enact regional sustainability roles (Radinger-Peer et al., 2021; Sedlacek, 2013). We also analysed internal student data and teaching- and curricula-related records, including enrolment and graduation statistics, student origin, stays in the region after graduation, and current career status (where possible). This allowed us to examine who UW has attracted and where students have contributed to the Westfjords labour market and community life.

Next, we undertook a review of all completed master's theses and funded projects associated with UW. For theses, we coded broad themes, empirical foci, and connections to the Westfjords and coastal Iceland more generally in order to assess how student research has engaged with local and regional challenges. For funded projects, we mapped thematic focus, partnerships (e.g., municipalities, agencies, NGOs, private sector), and geographical distribution to understand how UW's research and outreach have evolved. This broad institutional mapping reflects earlier case studies where universities are examined as regional sustainability actors through projects, teaching, and outreach activities (Radinger-Peer et al., 2021; Sedlacek, 2013).

We then linked internal data to official statistics and secondary sources on demographic change, labour markets, and education in the Westfjords and Iceland as a whole. This provided a contextual baseline against which to interpret UW's activities and potential contributions to regional development. Additionally, we draw on ongoing communication with local stakeholders, both formal and informal. Over two decades, UW's director and staff have maintained regular contact with municipal representatives, local as well as national politicians, private companies, NGOs, and community organisations through board meetings, project collaborations, public events, and everyday encounters. Although these interactions are not formally documented as interview data, they offer valuable qualitative insights into how UW is viewed and its significance in local discussions about the region's future. This attention to relational dynamics and shifting insider/outsider positions resonates with methodological reflections on negotiating such roles in educational research (Savvides et al., 2014).

Finally, for the 20-year period we are reviewing, UW has had the same director, first author P. W., while second and third authors C. C. and M. K. have worked at UW for 11 years and 7 years, respectively. Therefore, this is explicitly insider research. We consider this internal perspective as a valuable source of practical knowledge regarding decision-making, limitations, conflicts, and crucial moments in UW's development and continuous growth. Following the insider-research literature, we recognise both the advantages of intimate contextual knowledge and the risks of bias, power asymmetries, and selective memory (Fleming, 2018; Healey, 2016; Trowler, 2011). To address risks, we systematically cross-check personal recollections against documentary evidence and statistical records, and we make our positionality explicit throughout the article. Across these data sources, our analysis is interpretive and iterative. We identify key moments and patterns in UW's 20-year trajectory and relate them to wider processes of coastal depopulation, regional policy, and changing expectations of universities. In doing so, our design parallels other longitudinal institutional case studies of universities' regional sustainability roles that combine institutional data, policy documents, and stakeholder perspectives (Radinger-Peer et al., 2021; Sedlacek, 2013). The goal is not to provide a comprehensive evaluation of UW, but to use this unusual depth of access to explore how a small coastal PHEI can function as a collaborative platform for sustainable development in a remote coastal region.

3. Results and Discussion

3.1. Founding Rationale and Regional Context

3.1.1. Coastal Peripheries, Depopulation, and Regional Lock-In

UW was founded in a context that closely resembles what Keerberg (2018) describes as a "periphery of the periphery": a remote coastal region on a remote island, characterised by long-term demographic decline, limited higher-education provision, and concerns about brain drain. The Westfjords region combines characteristics of remoteness, small-scale societies, and a high degree of economic and demographic vulnerability (Kokorsch & Benediktsson, 2018a). Peripheral regions such as the Westfjords often face structural disadvantages rooted in long-term dependence on a monotonous industrial structure, a limited institutional landscape, and path-dependent development trajectories in which past decisions constrain present and future options (Benneworth et al., 2024; Carlsen et al., 2013; Kokorsch et al., 2018b; Kyllingstad, 2021). In such contexts, economic restructuring, the decline or closure of key employers, and demographic

shifts, including youth out-migration and gender imbalances, can lead to lock-ins or even path exhaustion, where the dominant development path no longer provides adaptive capacity for new challenges (Carlsen et al., 2013; Kurikka et al., 2020).

Coastal peripheries are particularly exposed to these dynamics. They are often specialised in fisheries and related marine industries, which are vulnerable to policy changes, such as quotas and other forms of ocean privatisation (Chambers et al., 2017; Kokorsch & Benediktsson, 2018b), technological change (Skaptadóttir, 2000), global market shifts, and climate change (Wilke & Kristjánsdóttir, 2023). When these sectors restructure or decline, the consequences for small communities can be drastic in terms of employment, population loss, and local revenue (Kohoutek et al., 2017; Kurikka et al., 2020). Such transformation is not only economic. It is also institutional and cultural, reflecting governance routines, power relations, and expectations about the local place identity and what futures are imaginable (Benneworth et al., 2024; Kokorsch et al., 2018b; Kyllingstad, 2021). Such has been the experience in the Westfjords, where population numbers dropped from around 10,479 in 1980 to 6,746 in 2016 (lowest population) before rebounding slightly to 7,176 in 2025 (Statistics Iceland, 2025).

3.1.2. Neo-Endogenous Development and Universities in Peripheral Regions

Neo-endogenous development emphasises locally grounded strategies that are driven by regional actors but draw selectively on external knowledge, networks, and resources (Benneworth et al., 2024). This approach stands in contrast to both purely exogenous growth models and simplistic self-help narratives that ignore structural constraints (Kokorsch, 2022). For peripheral regions with thin institutional landscapes and limited innovation capacity, universities can become crucial agents and hubs, connecting local stakeholders to wider circles of expertise, funding, and policy while simultaneously nurturing local capabilities and leadership (Atterton & Thompson, 2010; Berlina, 2025; Hedin, 2009). Nordic and European case studies demonstrate that regional universities and colleges can contribute to upgrading local skills and economic structures, but that this is highly dependent on their embeddedness and the presence of complementary actors. In Tromsø, for example, a research base in marine and Arctic sciences did not automatically translate into a vibrant regional industry because of a lack of engineering capabilities, weak company–university linkages, and thin local markets (Carlsen et al., 2013). In Telemark, by contrast, the expansion of a university college was seen as an opportunity to challenge the region's low-skill equilibrium, provided that teaching and research could be aligned with new industrial trajectories and not only reinforce existing patterns (Kyllingstad, 2021). Similar strains are visible in the Ústí region in Czechia, where universities play an important role in personal, relational knowledge exchange but face weak incentives for lifelong learning and limited scope to reshape industrial structures without supportive funding and policy frameworks (Kohoutek et al., 2017). However, such development can also lead to a "cathedrals in the desert" problem, where universities produce academic knowledge that is poorly aligned with regional needs, or where politically motivated investments create PHEIs with weak local linkages (Benneworth et al., 2024).

To counteract the development of a "cathedral in the desert," UW was conceived as a locally embedded institution explicitly tasked with community development, in line with neo-endogenous development ideas that emphasise locally grounded initiatives which selectively draw on external knowledge and networks. The idea of founding a university centre was very much a bottom-up initiative, initiated by local politicians and other community leaders and companies. This was partially due to the experience of shifting national

goals over time related to education, universities, and research centres. Initially, UW served primarily as a distance-learning centre for residents of the community and the wider Westfjords, filling a regional gap in university-level provision. Over time, however, it became evident that servicing only existing residents would not be sufficient to significantly alter demographic trajectories. The strategy therefore shifted towards a dual role: enabling local people to study without leaving, while also attracting new residents, i.e., students, staff, and visiting academics, to a region that had long lacked a university presence. This was done by the establishment of a master's program in 2008, developed and operated through UW, but accredited through and in close collaboration with the University of Akureyri. As of 2025, UW has around nine core positions, including 1.25 full-time research positions (Figure 2). The steady growth in staff is expected to continue, with the strategic plan aiming for five full-time research positions by 2030. In addition, UW has outsourced or co-organised shared positions throughout the years, such as bookkeeping, cleaning, technical services, and exam proctoring. The visiting instructors for the master's programs and the permanent partner programs (such as study abroad programs hosted at UW) make up another five and two positions, respectively. In parallel, UW's role needed to be differentiated from that of the local adult continuing education provider, which was not equipped at the time to handle activities such as proctored university examinations or advanced academic programmes. This division of labour between adult learning and university-level education became part of the regional education landscape.

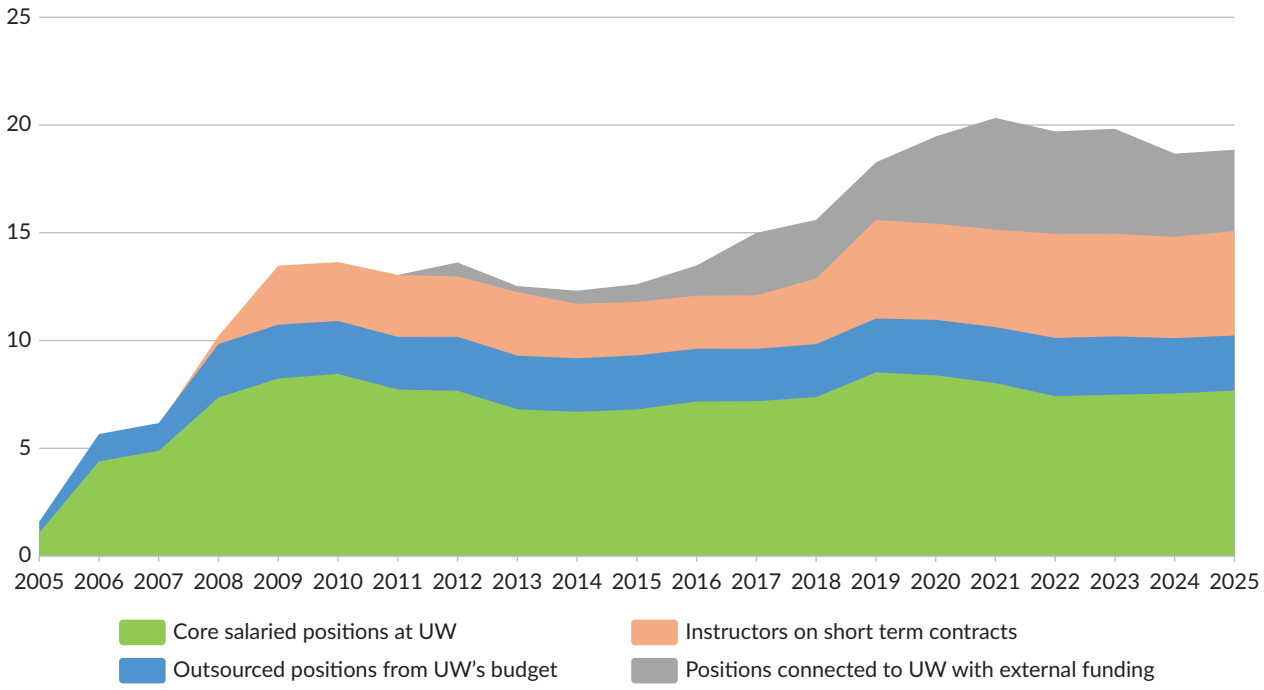

Figure 2. UW staff positions 2005–2025 in full-time equivalents.

This neo-endogenous orientation needs to be understood against the backdrop of national industrial policy debates. The founding context was also shaped by national debates on industrial development. While large industrial projects were being developed in other parts of the country (e.g., an aluminium smelter in the East of Iceland), municipalities in the Westfjords explicitly decided against encouraging heavy industry (Fjórðungsþing Vestfjarða, 2006). UW thus became part of an alternative development trajectory: Instead of relying on a single large employer, regional stakeholders invested in a knowledge-intensive, educational anchor that would bring skills, diversity, and new forms of innovation to a then vulnerable coastal

economy/community. Universities do not bring the same sheer numbers of jobs as heavy industry, but they can contribute a different quality of development: knowledge, skills, diversity, cultural life, and new forms of innovation. UW was established as a non-profit entity, supported by a core annual contribution from the Ministry of Education and Culture (now called the Ministry of Culture, Innovation, and Higher Education), complemented by self-generated income through teaching and projects. Notably, although the funding stream is "educational," the founding documents clearly frame community development as a central goal. This duality—being a HEI funded by the education sector while simultaneously serving as a community-development instrument—is a recurring theme throughout UW's history. The close relationship with the University of Akureyri also shows how larger universities can partner with PHEIs that have a separate funding source for mutual benefit.

3.2. Logistics of a Rural PHEI

Given the small population of Ísafjörður (around 2,700 inhabitants, and less than 5,000 inhabitants within a driving distance of 200 km), it is not realistic to maintain a large permanent academic staff. Instead, UW has developed a block-teaching model in which the master's courses are offered as intensive modules, typically lasting 2–3 weeks. The majority of instructors (75%) are invited from universities and organisations in Iceland and abroad, complemented by practitioners, such as managers, consultants, and public officials, who provide hands-on perspectives. The remaining 25% are instructors from within the Westfjords or UW staff. This model offers several advantages, such as the exposure of students to a highly international and diverse faculty and the flexibility to quickly incorporate emerging global trends in teaching topics. Students generally report that this format works well at the master's level: focusing intensively on one topic allows them to engage in deep, critical learning. Some traditional academic tasks (e.g., extensive term papers) are almost impossible within such short blocks, but this is compensated for by the master's thesis and the overall programme design. Furthermore, the decision was made from the outset to teach courses in English, with students bringing experiences from different countries and opening up for larger student numbers.

In addition to the intensive block course model, a strategic choice has been to prioritise in-person teaching, even when many universities elsewhere move towards online or hybrid models (Berlina et al., 2025; Laterza et al., 2023). Apart from the exceptional and comparatively short period during the Covid-19 pandemic, UW has consistently insisted on students physically attending courses in Ísafjörður. This reflects the conviction that certain forms of learning, especially at the master's level, depend on experiencing a coastal community first-hand. In almost every course, there are guest lectures or field components involving the local community or the wider Westfjords region. Students learn about challenges and opportunities directly from people on site, not only from books and lectures, and they participate in field visits, excursions, and company visits, including to other coastal communities, fisheries, aquaculture sites, municipal offices, and other local institutions (Figure 3).

Furthermore, being exposed to local weather, darkness, and logistical challenges (including flight cancellations, storms, and long travel times) helps the students develop practical problem-solving and conflict-resolution skills that are only achieved through experiential learning. Similarly, group work is also central to many courses. Two cohorts of around 20 first-year students mean that roughly 40 master's students live and study together through the winter, in addition to the second-year students and visiting students. This shared experience contributes to personal development and to the formation of a strong peer network, which is part of the professional identity of future coastal and regional practitioners.

Figure 3. Students visiting local aquaculture sea pens during a field trip.

The choice of coastal and marine management as the first master's programme was deliberate and closely aligned with the identity and needs of the region. The commercial fishing industry has long been a backbone of the Westfjords' economy and history, making it logical that the academic offer would connect with this maritime identity. However, the programme was not framed narrowly as fisheries management. Instead, it was conceived as an interdisciplinary coastal and marine management programme with a much broader purpose: to address environmental, social, economic, and governance dimensions of coastal areas. This aligns with international debates on integrated coastal zone management and sustainable development while simultaneously engaging with the lived realities and ongoing transformations of the nearby communities of the Westfjords. The courses also are forward-looking, exploring how coastal communities and marine industries might change under climate, policy, and market pressures rather than only documenting past trajectories. This design reflects the idea that universities in peripheral regions should not simply replicate urban universities but instead build on local strengths while engaging with global debates.

Finally, the construction of student housing in Ísafjörður is an important material expression of UW's development and impact. In the beginning, the decision was made to forego student housing, and rather connect the students to the local rental market, thereby providing economic input into the community rather than internal to UW. Since the socio-economic and demographic decline that started in the early 1990s, Ísafjörður saw almost no new residential construction. But in the mid 2010s, the housing market tightened due to modest population growth, second home ownership, and growth in tourism, and it became clear that a dedicated student housing would benefit the local community. The student housing project, initiated in 2022 to secure accommodation for incoming students, addresses this practical constraint while signalling that higher education is a long-term fixture in the town's built and social landscape. This was challenging in a context where external developers were reluctant to invest; however, the development was supported by the

municipality in terms of the building plot and a loan from the national Housing and Construction Authority. The student housing now functions both as essential infrastructure and as a symbol of local development.

3.3. Community Impacts

3.3.1. Demography and the "Missing Age Group"

Consistent with research on PHEIs as demographic anchors, UW has contributed to altering the age structure and demographic dynamics of Ísafjörður. Each year, UW brings approximately 30–40 full-time students and 100 international exchange students, in a missing age cohort that had largely left the town and region for education and work opportunities elsewhere. Since UW was founded in 2005, Ísafjörður's population initially continued to decline, reaching a low of 2,492 inhabitants in 2015, before gradually increasing to 2,723 as of 2025 (Statistics Iceland, 2025). This reflects also local developments in R&D as well as rapid growth in the fish farming industry. Over this period, the 20–29 age group has grown from 13% to 15% of the population, and the number of women in this age group has risen from 157 to 205, with the gender ratio in this cohort shifting from 56% to 49% male (Statistics Iceland, 2025, authors' own calculation). Thus, Ísafjörður is running counter to the still male-skewed pattern in the overall Westfjords. While Iceland overall, and the capital region, have experienced strong overall growth and broadly balanced gender ratios, Ísafjörður now slightly exceeds the national average share of 20–29-year-olds, suggesting a modest but notable strengthening of young adult presence in town. Even when the absolute numbers are relatively small, in a town with around 2,700 inhabitants and a region with roughly 7,000 residents, each student and each graduate can have disproportionate local impact.

While many students leave after graduation, a growing number stay in the region, start businesses, or remain somehow connected (i.e., as PhD students who eventually teach or supervise thesis research). Importantly, students are not drawn away from other Westfjords communities or struggling rural areas of Iceland; most arrive from outside the region and often from outside Iceland (Figure 4). UW thus adds to the regional population base rather than merely redistributing it, an important consideration in regional development.

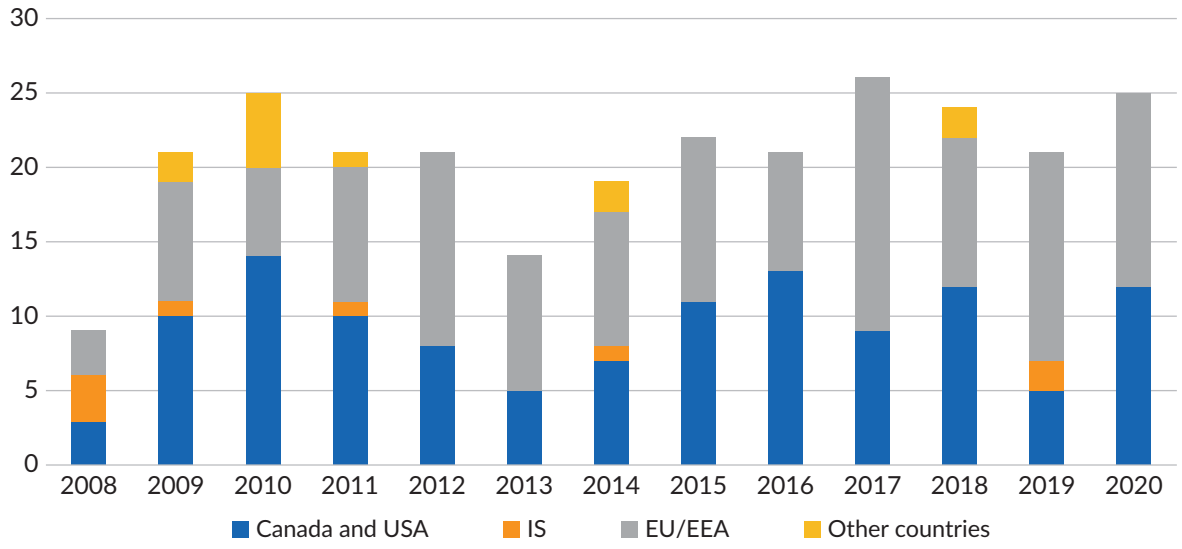

Figure 4. Number of students according to country of origin, 2008–2020. Note: IS = Iceland.

3.3.2. Cultural Life and Intangible Contributions

UW also functions as a hub for learning communities and communities of practice that extend beyond formal degree programmes. Local narratives emphasise that students and staff contribute significantly to cultural and social life: running cafés, joining cultural groups, organising events, and participating in local associations and sports clubs. These activities strengthen several forms of community capital, i.e., human, cultural, social, and political (Table 2), contributing to a sense of vibrancy and diversity in Ísafjörður. Even residents who are not directly involved with UW often express pride in hosting an international university centre that carries the name of the Westfjords. This symbolic presence shapes local identity and external perceptions of the region.

Table 2. Community capital examples of UW students while enrolled in master's studies.

Community capital form	UW example
human	Sports teachers, business developers, tour guides, social service workers
cultural	International bike race and cultural events like Halloween, joining choirs and orchestras, running and working at the café, open mic nights and pub quizzes
social	Knitting, learning Icelandic, international networks
political	Management and development recommendations through thesis research
financial	For every kronur of government support, there are 2 kronur left behind in the local society (Þórisson, 2010)
built	Largest renter in shared office space, student housing

As evidenced by the UW experience, recent work suggests that the impacts of such institutions are often more social and civic than captured by common economic indicators. Benneworth et al. (2024) argue that small rural campuses operate primarily as social rural campuses, acting as hubs for local learning communities and communities of practice rather than simply generating agglomeration effects via spin-offs or high-tech clusters. These campuses act as sites where global knowledge is translated into local solutions, where students, staff, and residents co-produce new practices, and where social infrastructure, identity, and long-term assets are built (Benneworth et al., 2024).

In coastal and marine contexts, such anchoring roles gain added importance. They can strengthen local identity and attachment to place in areas experiencing depopulation and economic instability. Furthermore, there is a growing trend of graduates staying in the area to pursue entrepreneurial or social innovation activities in the Westfjords. Local job creation includes one UW graduate as a founder of a seaweed farming venture, one as a founder of a cycling-related tourism/sports initiative, and others deeply involved in other small business start-ups, while still others were hired as experts in local companies and research institutions.

3.3.3. Research Projects and Local Case Studies

Outside of the teaching activities, master's students' thesis research and research by UW staff comprise an important part of UW's impact on the local communities. UW's knowledge production is shaped by its embeddedness in a thin institutional landscape where it often acts as the main local knowledge actor. Roughly half of the master's theses focus on Iceland and many specifically on the Westfjords. These projects frequently originate from questions raised by local municipalities, companies, NGOs, or residents. These

stakeholders are then involved in data collection, reviewing results, and public communication, illustrating the co-production of regionally relevant knowledge. Therefore UW serves as a low-threshold interface between academia and community, with about half of the theses produced by each graduating cohort being co-produced in some way. Thesis topics often address practical issues such as fisheries and coastal management, tourism development, climate change adaptation, transport accessibility, and community resilience (Figure 5). Comparative theses, in which international students examine both an Icelandic and a home-country case, contribute additional value by situating Westfjords experiences within broader coastal and marine debates. For local stakeholders, these comparisons can be particularly useful in terms of policy recommendations.

Figure 5. Major research topics in students' master's theses and research projects at UW.

Beyond student theses, UW has expanded its externally funded research activities since 2016, securing grants from local and regional bodies, national R&D funds, and Nordic and international programmes. These projects frequently involve students as research assistants or as thesis writers embedded within project frameworks, giving them early exposure to international research networks and applied research practice. Many of these projects focus on climate change adaptation and sustainable development in coastal and remote communities, thereby reinforcing UW's role as a civic university institution and collaborative platform.

3.4. Challenges

Despite its regional embeddedness, UW faces several tensions that reflect wider debates about the limits of university-led development in peripheral regions. One recurring issue is the limited number of Icelandic students in the master's programmes; some cohorts include no Icelanders at all. While all programmes are taught in English, this alone does not fully explain the pattern; many Icelanders who are comfortable with English might prefer to study abroad rather than in a small domestic town. This leads to perceptions elsewhere in Iceland that UW is "for foreigners," raising the question about *for whom* UW primarily operates. Politicians often ask how many Icelandic students are enrolled. Theoretically, this is interesting because universities are often conceptualised as international spaces by design. The case therefore raises questions about what counts as "serving the national interest": Is educating non-Icelandic students about Icelandic coastal challenges, who

later work abroad, a public good? Or should the benchmark be the number of Icelandic students enrolled? In theoretical terms, this tension reflects different understandings of the public good provided by a PHEI: Is the benchmark national human-capital formation, local community development, or contributions to global knowledge on coastal and marine issues?

Another challenge is how to better integrate international students and graduates into the Icelandic labour market and society. Many students engage in local life and learn Icelandic, but structural barriers, e.g., language requirements, recognition of foreign qualifications, and labour-market regulations, limit long-term retention. This challenge is not unique to the Westfjords; it reflects a broader Icelandic and Nordic debate about how to retain international graduates and migrants, at a time when 17% of Iceland's population has a migrant background. UW's students thus embody wider opportunities and tensions in the country's migration and integration policies.

As mentioned previously, operating a PHEI in a remote coastal town entails substantial logistical transportation and infrastructure constraints. Flights can be cancelled due to weather, leading to delays in the arrival of instructors and sometimes forcing short-notice course adjustments. Roads and power supply can be affected by storms or avalanches, and the winter darkness affects daily life and study routines. These conditions demand continuous flexibility from staff and students, but they also reinforce UW's identity as an institution that both experiences and studies peripherality. These frictions reflect broader concerns about the sustainability of small, specialised institutions: Limited size, constrained resources, and national performance metrics geared towards research excellence may undermine long-term engagement capacity unless supportive multi-scalar frameworks are in place (Berlina et al., 2025; Kyllingstad, 2021; Pinheiro, 2020). Paradoxically, these challenges are also part of the learning experience: Students gain a grounded understanding of what it means to live and work in Arctic and sub-Arctic coastal communities.

From the perspective of Ísafjörður, UW is likely a clear success story in terms of community development and demographic stabilisation. However, when looking at the larger Westfjords region, the picture is more nuanced. Municipalities located further away from Ísafjörður still face many of the same challenges they experienced in the 1990s and 2000s, including ongoing out-migration of young people. UW does not "take away" residents from these municipalities; rather, it draws in new people to the region. Yet the direct spatial impact is strongly concentrated in and around Ísafjörður. This raises questions about the distinction between community development and regional development, and about how development is measured: by population numbers, by economic indicators, or by broader concepts such as well-being and cultural vitality. At the same time, there is a growing awareness of potential research fatigue in small communities as more research projects target the same villages. These projects could cause research fatigue, but results from projects that align with local priorities could also lead to increased momentum for development. Therefore UW recognises the sometimes conflicting responsibility to engage in local projects while also ensuring that projects do not overburden local communities.

Finally, there is an inherent tension in UW's dual role as both a university-level institution and a community-development tool. University institutions are, by design, selective: They admit applicants who meet certain criteria and then sort among them based on academic performance, and funding regimes emphasise research rankings over engagement (Berlina et al., 2025; Keerberg, 2018). Provision of lifelong learning and informal knowledge exchange, which are often most important for rural SMEs and civic actors,

can be discouraged by funding formulas that prioritise degree programmes (Kohoutek et al., 2017). If the sole aim were to maximise population numbers in the region, other policy instruments, such as large industrial employers or direct relocation incentives, would arguably be more efficient. Yet UW's funding derives from the education sector, while its founding documents emphasise regional development goals, placing it at the intersection of different policy logics. Balancing these two missions, academic excellence and inclusive regional development, requires constant negotiation and reflection. On the one hand, such institutions are often deeply embedded in local contexts and responsive to regional needs; on the other hand, their limited size, narrower disciplinary base, and constrained resources can make it difficult to sustain broad engagement portfolios, secure external research funding, or influence national policy debates (Keerberg, 2018; Kyllingstad, 2021). Their success depends not only on internal leadership and institutional culture, but also on supportive multi-scalar policy frameworks and stable funding that values engagement alongside teaching and research (Benneworth et al., 2024; Berlina, 2025; Berlina et al., 2025).

4. Conclusion: A Peripheral but Connected Coastal University Centre

As of 2025, 297 students have graduated from the master's programmes, accredited through the University of Akureyri and hosted at UW, with 150 instructors over the years, and countless guest students and researchers. From smaller cohorts in the first few years, to two master's programs and larger cohorts since 2020, UW has evolved over 20 years from a small distance-learning hub into an internationally recognised centre for teaching and research on coastal management and regional development. Its trajectory illustrates how a HEI in a doubly peripheral region can attract new residents in a missing age group, contribute to cultural vitality and community well-being, support local, regional, and international research on pressing issues such as climate change adaptation in coastal communities, enable student entrepreneurship and innovation, and act as a bridge between global research trends and very local needs. With just over half of the total institutional income coming from the government, UW is an example of how a PHEI can use government funds to meet the simultaneous needs of providing quality education while supporting community development.

At the same time, the case highlights persistent challenges, including the limited number of Icelandic students, the integration of international graduates, concentrated local (rather than regional) benefits, potential research fatigue of the local residents, and the tension between being a selective academic institution and serving as a community-development tool. Universities can promote revolutionary repertoires and new future pathways, but they can also inadvertently reinforce unsustainable trajectories if engagement is not reflexive, inclusive, and justice-oriented (Benneworth et al., 2024; Hedin, 2009). Widening participation in rural regions requires programmes that fit around family and employment responsibilities, address cultural barriers to higher education, and provide strong local support structures (Hedin, 2009). By attracting and retaining students, and offering pathways for local residents to upskill, a coastal PHEI can contribute directly to demographic stabilisation, gender balance, and community resilience. In the context of UW, these insights suggest that PHEIs are not only tools for individual career mobility, but also key components of a regional demographic and skills strategy. UW's role as a provider of international programmes further positions it as an opportunity for in-migration and cultural diversification in a small-scale coastal society.

The Westfjords can be described as a remote region of a remote island, a kind of double periphery. Previously, the region had not had the best reputation within Iceland and was largely unknown internationally. UW's teaching model, with its revolving international faculty and student body, has helped insert Ísafjörður and the Westfjords into global academic and professional networks. Over time, more and more external partners actively seek collaboration with the Centre in teaching and research. In this sense, the institution is both deeply peripheral and strongly globally connected. Furthermore, as global attention to climate impacts on coastal communities increases, UW's ability to respond flexibly with new courses and research has become a core strength that will aid in community resilience.

Overall, UW offers a rich practical case study of how university institutions can function as collaborative platforms for promoting sustainable development in marine and coastal regions, while navigating the complexities and contradictions inherent in such a role. In the paradox of the "universality" of universities, higher education administrations must ask the question of the purpose of HEIs, and particularly of PHEIs, with relation to regional development. In the trend of consolidation of university services in both Iceland and abroad, UW serves as a reminder of the importance of place-based learning, both for the responsibility that universities have to the general public, and in terms of the experiences of students.

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Conflict of Interests

All three authors are employees of the institution in the case study. As outlined in the methods, these affiliations do not affect the content of the article.

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About the Authors

Peter Weiss served as the director of UW from its founding in 2005 until March 2026. Expertise areas include Icelandic as a second language and community development. He was awarded the Knight's Cross of the Icelandic Order of the Falcon in 2023 for pioneering work in Icelandic higher education.

Catherine Chambers was the research manager at UW before taking over as director in April 2026. She has over 15 years of experience in knowledge co-production, focusing on coastal cultural heritage, ocean governance, and fishers' knowledge. She teaches social science research ethics and serves in many professional service roles.

Matthias Kokorsch is a research specialist at UW, previously involved in developing the master's program in coastal communities and regional development. His work focuses on community development and societal transformation, with research interests in (remote) community resilience, climate change, natural hazards, and disaster risk management.

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