

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

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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).

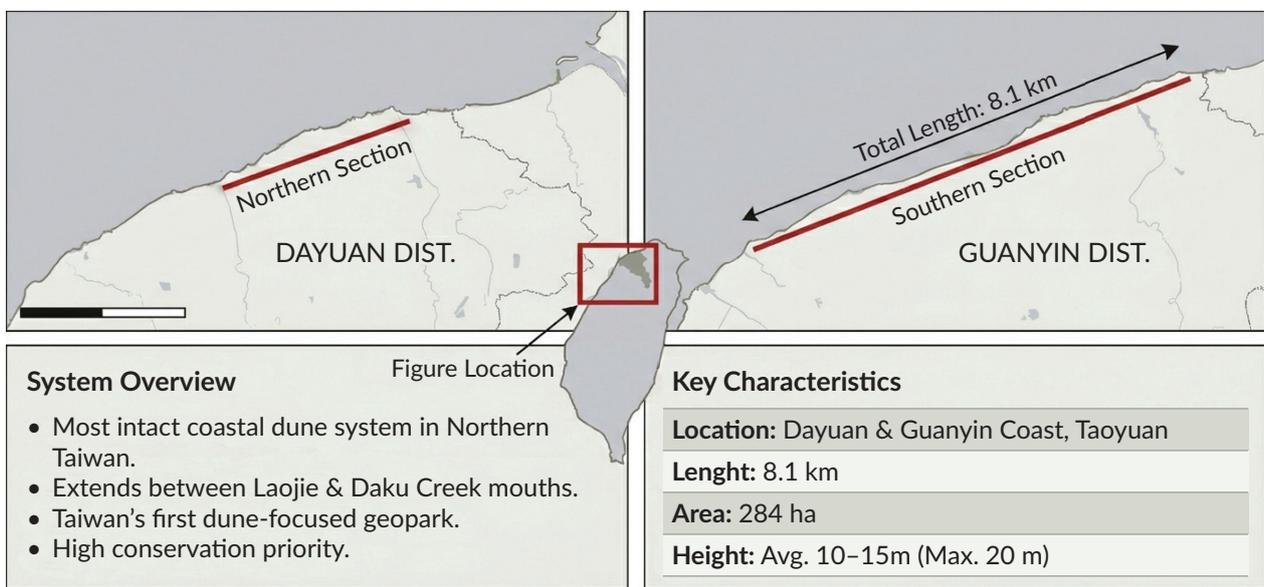


Figure 1. Overview of the Caota Dune System, showing its location across Dayuan and Guanyin Districts, with a context map of Taiwan, key geographical characteristics, and conservation status.

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.

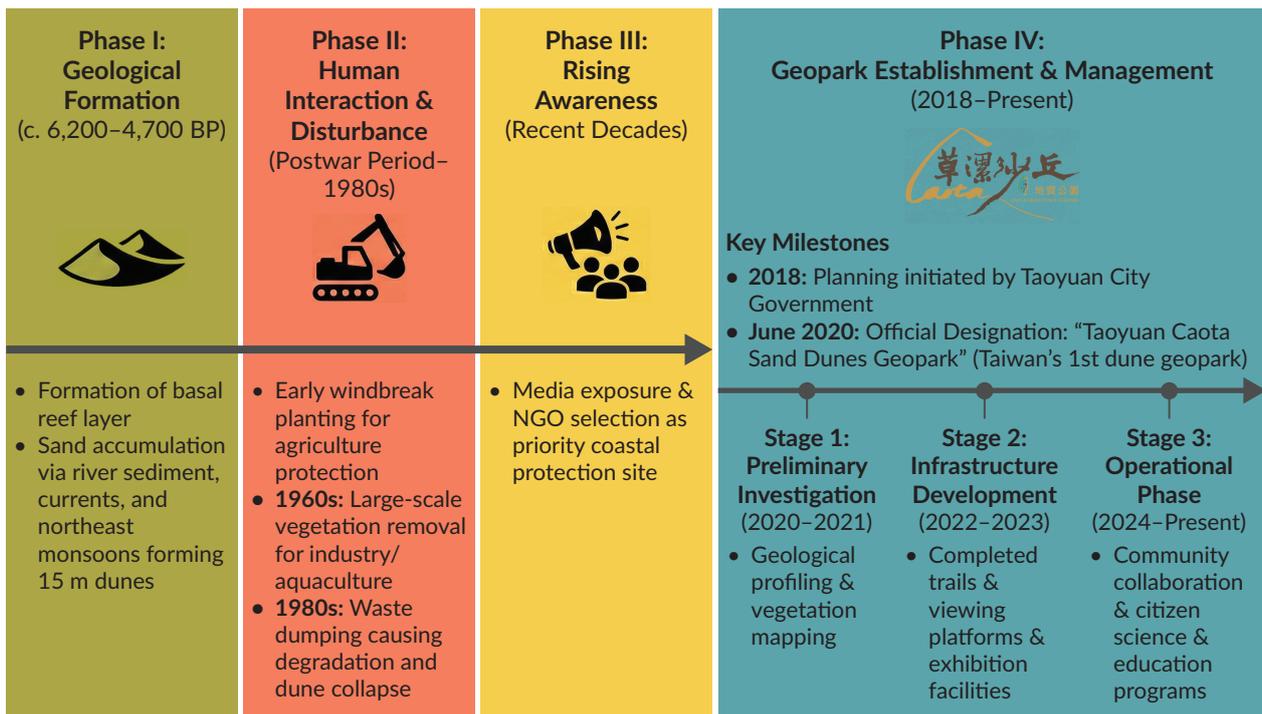


Figure 2. Timeline of the development of Taoyuan Caota Sand Dunes Geopark.

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.

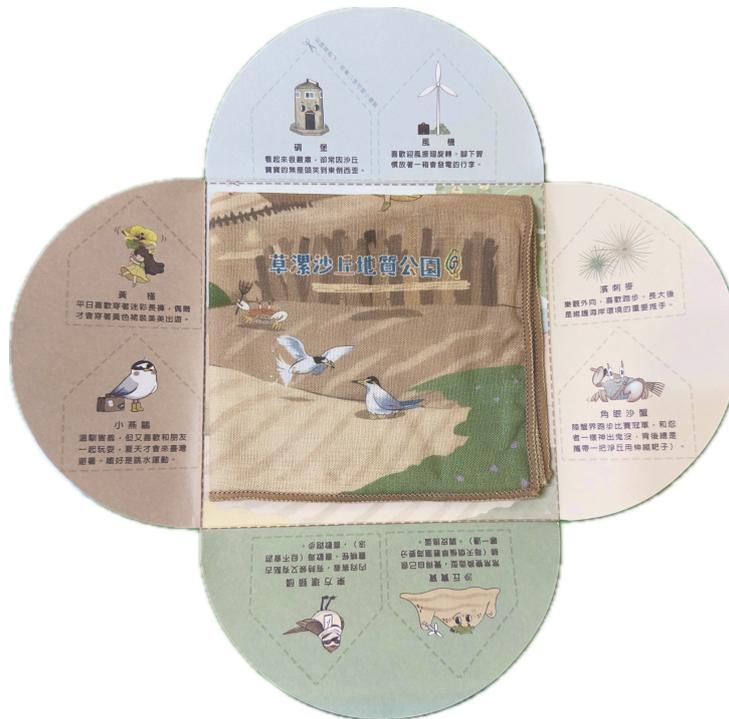


Figure 4. The rich geomorphology and biodiversity of the Caota Sand Dune coastal settlement are translated into mascot figures, each endowed with a distinct personality. Note: Through collaborative comic creation, these narratives are rendered in comic form, and mascot-introduction scarves are produced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