International Applications of Ecosystem-based Disaster Risk Reduction in Coastal Areas
(Second Batch)

Ministry of Natural Resources of the People’s Republic of China
in collaboration with
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CONTENTS

Preface

Against the backdrop of global climate change, the risk of marine disasters such as storm surges, waves, and coastal erosion are intensifying, thus posing severe threats to human security and hindering the sustainable development of marine economy. At the third meeting in 2018 of the Central Financial and Economic Affairs Commission, General Secretary Xi Jinping emphasized the need to “implement coastal zone protection and restoration projects, build ecological seawalls, and enhance the capacity to withstand marine disasters such as typhoons and storm surges.” In response to the directives of the CPC Central Committee, the Ministry of Natural Resources has steadfastly deployed a series of protection and restoration projects in coastal areas, fully leveraging the natural wave attenuation functions of mangroves, coastal salt marshes, sandy shores, seagrass beds, and oyster reefs, in coastal erosion reduction and shoreline stabilization. These efforts aim to build a more resilient and safer coastal zone. The practices of coastal protection and restoration not only inherit the traditional Chinese ecological wisdom of “following the laws of nature,” but also closely align with the International Union for Conservation of Nature (IUCN)’s globally promoted concept of Nature-based Solutions (NbS), thereby achieving synergies between ecological conservation and disaster risk reduction.

In 2023, the Ministry of Natural Resources of China (MNR) and the International Union for Conservation of Nature (IUCN) jointly released the first batch of International Applications of Ecosystem-based Disaster Risk Reduction in Coastal Area (published in both Chinese and English) at the World Coastal Forum, providing valuable practical references for coastal regions seeking to balance ecological protection, safety, and economic development. In 2024 at the East Asian Seas Congress Ministerial Forum, the Xiamen Declaration adopted the practical experience of Eco-DRR synergies into regional coordinated action. In the same year, twelve Chinese cities, including Xiamen, jointly launched an initiative advocating for the in-depth study and application of Xi Jinping’s thought on Ecological Civilization through the “Xiamen Practice,” promoting Nature-based

Solutions, adopting context-specific and category-based measures, and exploring optimal pathways for ecological conservation and restoration.

To deepen international exchange and mutual learning, the MNR and IUCN once again in 2025 collaborated to select nine exemplary cases of coastal Eco-DRR and their synergistic benefits. These cases encompass ecosystem restoration initiatives involving mangroves, coastal salt marshes, and sandy shores, as well as ecologically enhanced seawalls. They also explore innovative mechanisms such as mobilization of private capital, fostering community engagement, and advancing carbon sink accounting and trading. Collectively, these initiatives have effectively delivered multiple benefits as well as co-benefits, including the prevention and mitigation of disasters, enhancement of ecosystem functions, climate change adaptation and mitigation, and socio-economic development.

By disseminating these cases, we aim to promote global knowledge sharing, build broad consensus, and contribute practical insights to the implementation of the UN Sustainable Development Goals (SDGs), the UN Decade on Ecosystem Restoration, and the Sendai Framework for Disaster Risk Reduction. Together, we strive to advance the philosophy of "ecological priority and green development" in coastal regions and work hard to forge a new paradigm of harmonious coexistence between humanity and the sea.

The compilation of this case study collection has been supported by the *l'Agence Française de Développement* (AFD) and the European Union (EU), to whom we express our heartfelt gratitude. We also extend our highest respect to all practitioners and scholars dedicated to advancing Eco-DRR in coastal zones.

Coastal zone Eco-DRR and its synergistic benefits remain in a pivotal phase of technological innovation and practical exploration. As such, this collection may inevitably include oversights or shortcomings. We sincerely welcome critique and suggestions from all sectors to collaborate on advancing the coastal zone governance on the global stage.

Editorial Committee
September 2025

PART I

Executive Summary

This collection presents nine exemplary cases from China, the Republic of Korea, Indonesia, and Spain. The cases represent practices of restoring critical ecosystems—including mangroves, coastal salt marshes, and sandy shores—as well as the ecological enhancement of seawalls. They demonstrate comprehensive benefits across multiple dimensions, including disaster prevention and mitigation, ecological function enhancement, climate change mitigation and adaptation, and socio-economic development, as detailed below.

1. Eco-DRR Case of Tianjiaoshan Coast, Huludao City, Liaoning Province, China

This case is located at Tianjiaoshan, Huludao City, Liaoning Province, characterized by a unique cape–bay landform and a natural coastline–coastal, wetland–tidal flat ecosystem. To address pressing issues such as encroachment on sandy coastlines, wetland degradation, and weak capacity for coastal disaster prevention and mitigation, a systematic land–sea coordinated governance was implemented in the region beginning 2020. Measures included restoring 12.1 hectares of vegetation, rehabilitating 1.8 hectares of beach, modifying 434 meters of ecological revetment, dismantling 564 meters of artificial dykes, and restoring 6.8 hectares of coastal wetlands. In the eastern section of the site, an "ecological safety barrier" comprising beach–revetment–shelterbelt was established, protecting the lives and property of 3,000 residents located behind it. In the central and western sections, multi-layered plant community structures were established, significantly improving the ecological environment while creating recreational coastal spaces that boosted cultural tourism revenue in the area. The case thus achieved synergistic benefits of strengthening ecological barriers, reducing disaster risks, and promoting green economic development, providing replicable and practical experience for ecological governance in northern coastal hilly regions.

2. Eco-DRR Case of Qilihai Lagoon, Qinhuangdao City, Hebei Province, China

This case is situated at Qilihai Lagoon, Qinhuangdao City, Hebei Province, the largest lagoon in North China and a critical node in the East Asian-Australasian Flyway for migratory birds. Since the 1980s, production activities such as embankment construction, land reclamation, and aquaculture had reduced the lagoon's area to just 14% of its historical maximum. Consequently, tidal prism sharply declined, tidal channels were heavily silted, water quality deteriorated, and biodiversity decreased, while risks of waterlogging and storm surges intensified. Since 2017, the region has implemented measures including the restoration of 818.35 hectares of wetlands through negotiated aquaculture withdrawal, dredging and clearing 1.59 million cubic meters of sediment, and restoring 29.33 hectares of tidal channels. These efforts expanded the lagoon area to three times its pre-restoration size, increased tidal prism by 2.82 times, and improved water exchange capacity by 30%. In addition, 610.52 hectares of microtopography were modified, 15.61 kilometers of shoreline rehabilitated, and a natural shoreline defense system was constructed using an earthwork self-balancing approach combined with a scientific “tree–shrub–grass” planting model. An integrated “air–space–land–sea” monitoring and early-warning platform was also developed, enabling marine disaster forecasting and enhancing intelligent management capacity. Today, the restored lagoon wetland features “clear waters, blue skies, and flocks of birds in flight,” significantly strengthening regional comprehensive disaster prevention and mitigation functions, and serving as a model for Eco-DRR wetland restoration in lagoon wetlands.

3. Eco-DRR Case of Haoyunjiao Coast, Weihai City, Shandong Province, China

This case is located at Haoyunjiao, Weihai City, Shandong Province, encompassing the Chaoyang Port Lagoon and sandy coasts. To address challenges including the shrinking lagoon area, reduced tidal prism on the inner side of Chaoyang Port, erosion of the outer sandy coast and the progressively weakened capacity to defend against storm surges and other marine hazards, restoration measures have been implemented since 2021. On the inner side, interventions such as aquaculture-to-sea conversion, dredging and channel clearance, and salt marsh rehabilitation have been carried out, resulting in an expansion of the lagoon wetland by 170 hectares and an increase of 33.5% in tidal prism. The restored salt marsh has continued to expand naturally year by year, with the number of bird species in the area increasing by 21% compared with pre-restoration levels. On the outer side, sandy coast restoration, ecological modification of seawalls, and the establishment of vegetative shelterbelts were undertaken. These actions naturally restored 6 kilometers of sandy shoreline, with an average beach width of about 30 meters. A total of 2,354 meters of artificial shoreline were recognized as ecologically restored coastline, with 16.7 hectares of vegetative shelterbelts planted to enhance coastal resilience against disasters. The restored high-quality space was further leveraged to vigorously develop coastal cultural and tourism industries, thereby realizing the value of ecological products. Through these measures, the region has markedly improved its ecological conditions, significantly strengthened disaster prevention and mitigation capacity, and stimulated sustained economic vitality. It vividly demonstrates harmony between people and the sea, offering a replicable and scalable model of ecological–disaster reduction–economic synergistic development.

4. Eco-DRR Case of Hua'ao Island, Ningbo City, Zhejiang Province, China

This case is located on Hua'ao Island, Xiangshan County, Ningbo City, Zhejiang Province—an area renowned for its majestic natural scenery and rich cultural heritage, widely known as the "Fairyland on the Sea, Paradise on Earth." Faced with intensified coastal erosion, heightened geological disaster risks, fragile ecosystems, and weak infrastructure, restoration efforts have been carried out since 2016. These measures included restoring 6.10 hectares of sandy beach and 1.98 hectares of pebble beach, reinforced 249 meters of seawall, rehabilitated 6.76 kilometers of coastal revetment, and remediated 2.3 hectares of abandoned mines, thereby establishing an Eco-DRR framework featuring a multi-tiered system of "beach buffering–shoreline protection–hillslope stabilization." In addition, an ecological greenway was constructed, a cultural park was established, and coastal recreational spaces were expanded to enhance the island's ecological vibrancy. The project revitalized distinctive cultural resources and promoted a diversified economy integrating "tourism–culture–fisheries." In doing so, it created pathways for translating ecological advantages into economic value—embodying the "Two Mountains" transformation principle. Hua'ao Island has thus explored a distinctive pathway that synergizes high-quality island development with Eco-DRR.

5. Eco-DRR Case of Sandy Coast in Dongtou District, Wenzhou City, Zhejiang Province, China

This case is located on Dongtou Island, Wenzhou City, Zhejiang Province, which has a total coastline of approximately 50 kilometers. The island's sandy coasts—primarily distributed along Dong'ao, Dongsha, and the western side of Banping—hold significant ecological value. However, these sandy coasts have experienced erosion and degradation caused not only by natural disasters and illegal sand mining, but also by breakwater construction which led to siltation of nearby fishing port beaches. Since 2017, restoration measures have included dredging 1.57 million cubic meters of sediment from fishing ports, reusing dredged sediments, and reshaping beach surfaces to restore 3.2 kilometers of sandy shoreline. A multi-level long-term management and protection mechanism was established, incorporating social capital and community participation in protection and restoration. The rehabilitated Dong'ao Beach has successfully withstood multiple severe typhoons, maintaining overall equilibrium and stability, while recovering its natural functions of wave dissipation and current attenuation for disaster mitigation. The improved ecological environment has expanded coastal recreational spaces, stimulated growth in the regional tourism industry, and fostered a virtuous cycle of "ecological restoration – enhanced disaster risk reduction – industrial revitalization." This case provides a valuable practical reference for Eco-DRR on sandy coasts.

6. Eco-DRR Case of Coastal Bays of Qinzhou City, Guangxi Zhuang Autonomous Region, China

This case is located in Qinzhou Bay, Qinzhou City, Guangxi Zhuang Autonomous Region, within the China–Malaysia Industrial Park, adjacent to Qinzhou Port and at the heart of the New Western Land–Sea Corridor. Restoration efforts commenced in 2020 to address issues of fragmented mangrove habitats, reduced seawater exchange and self-purification capacity, damaged coastal defense barriers, and severe beach erosion in the region. These included restoring 512.99 hectares of mangroves, rehabilitating 33.94 kilometers of shoreline, dredging 2.9664 million cubic meters of tidal channels, nourishing beaches with 369,300 cubic meters of sand, and restoring 3.25 hectares of psammophyte vegetation. An integrated bay-wide Eco-DRR system was established, featuring an outer bay structure of "beach–eco-revetment–shelterbelt" and an inner bay structure of "mangrove–eco-revetment." After restoration, the beach width increased by 15–30 meters, with the maximum average wave height attenuation rate reaching 63.7%. Biodiversity in the restored mangrove areas has significantly improved. In addition, 2,162.2 meters of artificial shoreline was ecologically remodified and recognized as restored ecological shoreline. Furthermore, approaches included graded utilization of dredged materials for beach formation and afforestation, and the use of discarded oyster shells for constructing ecological revetments, achieving optimal resource allocation and promoting circular resource utilization. The project monetized the ecological value of mangroves through Guangxi's first-ever blue carbon trading. These ecological dividends have fueled the flourishing development of the coastal cultural tourism industry, providing a replicable and scalable demonstration for integrated bay governance.

7. Eco-DRR Case of Coastal Dune Restoration and Disaster Mitigation in Taeanhaean National Park, South Korea

This case is located in South Chungcheong Province, South Korea, which is renowned for its unique coastal dune system, forming the most critical natural disaster buffer along the country's western coast. This system effectively maintains coastline stability, prevents wind erosion and sand encroachment, mitigates seawater intrusion, and provides habitats for rare psammophytes and birds. However, since the 1970s, large-scale coastal development, unregulated sand mining, and artificial structures like breakwaters have led to systemic degradation.

In response, the Korea National Park Service (KNPS) initiated a disaster prevention-oriented dune restoration project in 2001. This project not only reduced storm surge damage but also reconstructed disaster-resilient dune plant communities while enhancing coastal carbon sequestration. The practice successfully restored the coastline's natural disaster buffer function and innovatively integrated ecological restoration with disaster risk reduction, offering a replicable Nature-based Solution (NbS) model for global coastal areas facing climate hazards.

8. Eco-DRR Case of Coastal Mangrove Restoration in Demak District, Indonesia

The case is located in Demak, Indonesia, a coastal district in Central Java province that has been plagued by erosion, flooding and devastating land loss that in some places extends for several kilometres inland. When “hard” infrastructure such as seawalls and mangrove planting failed to stop land loss, Wetlands International and Ecoshape, in collaboration with the Indonesian government, initiated an ecological restoration project centered on the Building with Nature approach. Through integrated mangrove restoration efforts, the construction of permeable structures, and the promotion of sustainable land use, the project successfully restored 20 kilometres of coastline, rehabilitated 119 hectares of mangroves, and improved the protection of an additional 60 hectares, promoting natural sedimentation and mangrove regeneration while improving the livelihoods of local communities, and was recognised through international awards. Its outcomes have been incorporated into both local and national development plans, fully demonstrating the potential of multi-stakeholder collaboration in building coastal resilience.

9. Eco-DRR Case of Beach-Dune-Lagoon Restoration and Disaster Mitigation in La Pletera, Spain

The case is located on the Costa Brava in Catalonia, Spain, is part of the Montgrí Natural Park and the European Natura 2000 protected area network, possessing high biodiversity value. To address issues such as habitat fragmentation, hydrological disruption, and increased flood risk, the site implemented ecosystem-based measures. These included demolishing unfinished urban infrastructure, restoring the original salt marsh hydrological system, and rebuilding coastal dunes. These actions not only effectively restored ecosystem functions but also provided solutions for adapting to climate change, protecting biodiversity, and promoting local socio-economic sustainable development. These ecological restoration measures were rated as "Best Practice for NbS in the Mediterranean Region" by IUCN, offering an implementation pathway of "Ecological Engineering - Policy Integration - Community Participation" for Nature-based Solutions (NbS) in similar areas.

PART II

CASE STUDIES

Eco-DRR Case of Tianjiaoshan Coast, Huludao City, Liaoning Province, China

I Information

Tianjiaoshan is located in the eastern part of Longgang District, Huludao City, adjacent to the urban built-up area, and is surrounded by Zhaolitou Fishing Port, Hulu Ancient Town, the coastal highway, and the bay. On the eastern side lies a semi-enclosed shallow bay, which once contained the scarce resources of sandy coasts, bedrock shores, and gravel beaches within the built-up area of Huludao City. The central part of Tianjiaoshan is a bedrock headland protruding into the sea, hosting the rare bedrock coastlines of western Liaoning. Relatively gentle sandy coasts are distributed along its eastern and western sides. The total coastline within the area is about 6 km, with a permanent population of around 3,000 people. Its distinctive coastal erosion landforms, where mountains and sea intertwine, make it a treasured coastal resource of Huludao City and an important asset for the development of the city’s coastal cultural tourism industry.

Figure 1. Schematic map of the Tianjiaoshan coast case area

Since 2020, targeted restoration measures have been implemented to address issues such as the encroachment and degradation of sandy beaches on the eastern and western sides of Tianjiaoshan due to human activities, the functional decline of wetlands and shoreline ecosystems in the central part, and the weakening of disaster prevention and mitigation capacity. Measures included vegetation and beach restoration on the eastern side, wetland restoration and slope protection in the central part, and vegetation restoration and beach remediation on the western side. In total, 12.1 hectares of vegetation have been restored, 1.8 hectares of beaches rehabilitated, 434 meters of revetment ecologically remodeled, 564 meters of artificial embankments removed, and 6.8 hectares of coastal wetlands restored [1].

Following restoration, Tianjiaoshan's coastal "protective shield" has become more robust, with disaster prevention and mitigation capacity significantly enhanced. The regional ecological environment has continued to improve, with vegetation cover reaching nearly 90%. Flocks of seagulls skim over the beaches, complementing the azure sea and sky. Newly built coastal promenades and high-quality beaches meet residents' needs for seaside leisure and recreation, while also promoting the vigorous development of the coastal cultural tourism industry.

II Issues

In the 1980s, influenced by coastal development activities such as "reclaiming land from the sea," the natural shoreline of the Tianjiaoshan area in Huludao City was encroached upon and degraded. Illegal excavation and unregulated mining caused surface fragmentation and frequent geological hazards, posing a serious threat to the integrity and stability of the regional ecosystem. This, in turn, disrupted the balance of the integrated "land–sea–beach" ecosystem [2]. The main problems can be summarized as follows:

First, the eastern sandy coastline has long been subjected to encroachment and degradation (Figure 2), resulting in insufficient disaster prevention and mitigation capacity. Severe loss of sand sources and morphological changes to the beach have greatly reduced its ability to storm surge defense and wave energy, thereby exposing the lives and property of approximately 3,000 permanent residents in the immediate hinterland to marine hazards. In 2021, the "210918" extratropical storm surge caused severe damage across Liaoning Province, with Huludao City suffering losses of 672 million yuan [3]; seawalls within the area were heavily damaged.

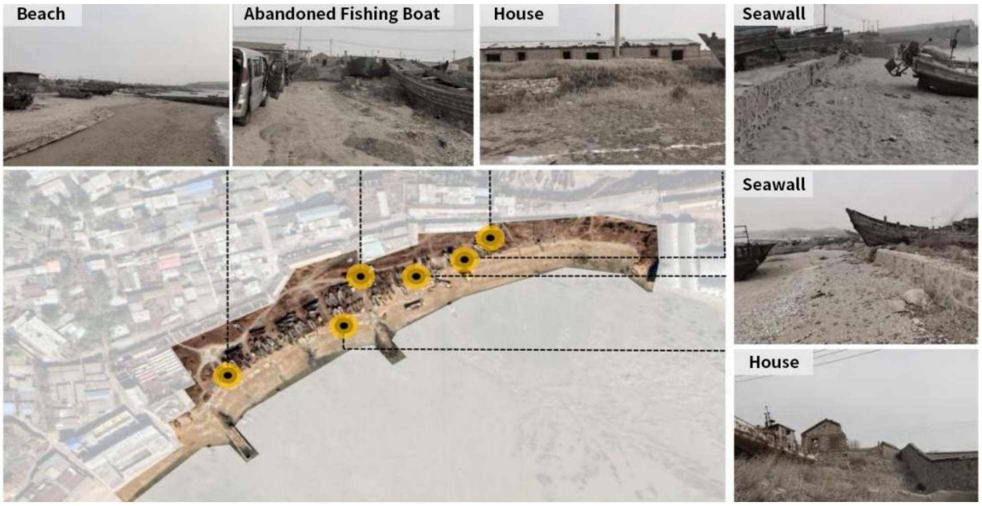

Figure 2. Encroachment and degradation of the eastern sandy coastline
(Longgang District People's Government, 2020)

Second, in the central coastal section, mountain excavation and indiscriminate mining led to extensive deforestation, surface fragmentation (Figure 3), and heightened risks of geological hazards such as landslides. The construction of artificial embankments disrupted hydrological connectivity, resulting in weakened regional hydrodynamics and degradation of wetland ecosystem functions.

Figure 3. Surface fragmentation in the central area caused by illegal excavation and mining
(Longgang District People's Government, 2020)

Third, the western beach has been occupied by abandoned fishing vessels, while surface fragmentation and severe damage to the shelterbelts behind the beach (Figure 4) have undermined the ecological integrity of the area, accelerating ecosystem degradation.

Figure 4. Encroachment and erosion of the western sandy coastline
(Longgang District People's Government, 2020)

III Approaches

(1)Scientifically Building an Ecological Safety Barrier of "Beach–Revetment–Shelterbelt"

Studies have shown that beach width, slope, and sediment characteristics significantly influence the capacity to resist storm surges and wave impacts. Wider beaches with gentler slopes are more effective in dissipating wave energy [4]. Based on underwater topographic survey results of the restoration area and adjacent waters, a scientifically designed restoration plan was formulated. Sand with particle sizes ranging from 0.48 mm to 0.81 mm (mean particle size: 0.71 mm) was selected for beach nourishment, extending the average beach width from 20 m to 50 m and reducing the slope, thereby enhancing its buffering capacity. Three damaged wave-resistant seawalls were dismantled, and the original vertical concrete revetments were replaced with ecologically engineered sloping revetments along a 434 m stretch of coastline. Rock blocks and gravel were used for reinforcement to improve permeability and reduce hydraulic impacts. A layer of coir fiber mat was applied for soil stabilization, followed by the planting of salt-tolerant herbaceous species to increase stability and durability. Behind the revetments, more than 1,000 trees and shrubs, including Amorpha fruticosa and Pinus thunbergii, were planted, thereby forming an integrated "beach–revetment–shelterbelt" ecological safety barrier (Figure 5) and comprehensively strengthening disaster prevention and mitigation capacity.

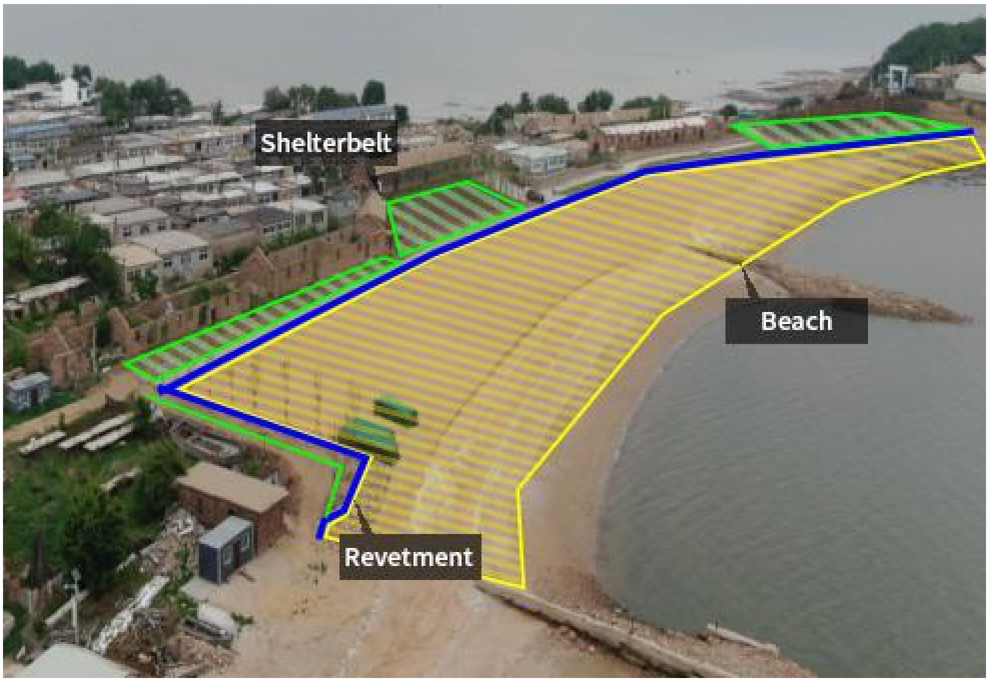

Figure 5. Post-restoration establishment of an ecological safety barrier on the eastern beach (Longgang District People's Government, 2022)

(2)Habitat Reconstruction to Restore Coastal Ecosystem Functions

A total of 564 meters of artificial dykes were dismantled in the central area to restore the original hydrodynamic environment (Figure 6). In the central and western regions, surface gravel was removed, sites were leveled, and 38,000 m³ of soil was backfilled. Twelve salt- and alkali-tolerant as well as drought-resistant plant species—including Ulmus pumila (white elm), Pinus thunbergii (black pine), Prunus sibirica (Siberian apricot), Acer negundo 'Aureomarginatum' (golden-leaf boxelder), Sabina chinensis (Chinese juniper), Ulmus pumila 'Aurea' (golden-leaf elm), Prunus cerasifera (myrobalan plum), Populus alba var. pyramidalis (white poplar), Sophora japonica (Chinese scholar tree), Forsythia suspensa (forsythia), Sorbaria sorbifolia (false spiraea), and Amorpha fruticosa (false indigo)—were interplanted to establish a multi-layered plant community structure (Figure 7). For potentially unstable mountain slopes within the area, protective reinforcement measures were implemented, followed by hydroseeding with an eco-substrate slurry composed of organic fertilizer and local herbaceous seeds. Vegetation-based slope protection reduced soil erosion, maintained slope stability, and effectively mitigated geological hazards such as landslides (Figure 8). Through these measures, coastal ecosystem functions were restored and the natural ecological barrier was reconstructed.

Figure 6. Dismantling of embankments in the central area (left: before restoration; right: after restoration) (Longgang District People's Government, 2022, 2025)

Figure 7. Establishment of a multi-layered plant community structure in the central area (Longgang District People's Government, 2025)

Figure 8. Ecological slope protection on mountain slopes (red-circled area)
(Longgang District People's Government, 2025)

(3)Positioning the Area as a Recreational and Leisure-Oriented Coastal Space

A public fitness park was established in the central and western restoration zones (Figure 9), equipped with sports and leisure facilities such as a football field, tennis courts, and a coastal wooden boardwalk. In the western area, 0.87 hectares of beach was remediated by removing abandoned fishing vessels and beach debris, thereby enhancing the coastal environment. These improvements attracted private investment for the construction of facilities include pavilions, leisure huts, swings, and photo hotspots (Figure 10). Following the environmental enhancement, rare bird species—including ruddy shelducks (Tadorna ferruginea), common cranes (Grus grus), whooper swans (Cygnus cygnus), and tundra swans (Cygnus columbianus)—returned to the area for roosting, foraging, and breeding, transforming it into a new hidden gem for coastal exploration and birdwatching (Figure 11). Today, Tianjiaoshan has evolved into a recreational coastal space that integrates eco-tourism, sports and fitness, and seaside leisure, becoming one of Huludao's newly emerging "social media-famous" destinations.

Figure 9 Public fitness park (Longgang District People’s Government, 2025)

Figure 10. Newly emerging “social media-famous” attraction (Longgang District People’s Government, 2025)

Figure 11. Hidden gem for coastal exploration (Longgang District People's Government, 2025)

IV Accomplishment

(1)Enhancing Regional Disaster Defense Capacity to Safeguard Residents' Lives and Property

This case follows a people-oriented principle by establishing an ecological safety barrier consisting of "beach–revetment–shelterbelt" through measures such as beach restoration, ecological revetment modification, and vegetation rehabilitation (Figure 12). These interventions safeguard the lives and property of approximately 3,000 residents in the hinterland. Since 2022, the Tianjiaoshan area has successfully withstood multiple storm surges and other marine disasters. In October 2024, abnormal tide levels triggered storm-surge-induced seawater intrusion in many regions of China. At Huludao Station, the maximum tide level reached 486 cm, exceeding the red-alert threshold by 42 cm and setting a new historical record. Nevertheless, no casualties or major economic losses occurred in the Tianjiaoshan area [6].

Figure 12. Restored eastern section (Source: Longgang District People's Government, 2022)

(2) Continuous Improvement of the Ecological Environment and Significant Enhancement of Ecosystem Functions

The project has completed ecological restructuring of 18 hectares of coastal zone in the Tianjiaoshan area, including the restoration of 6.8 hectares of coastal wetland and 12.1 hectares of vegetation, resulting in nearly 90% vegetation cover across the region (Figure 13). The marine ecological environment continues to improve, with the stability and resilience of the ecosystem steadily enhanced. Its functions in windbreak, sand fixation, and water conservation have been significantly reinforced. With sustained ecological improvement, the area has attracted a growing number of bird species for roosting and breeding. In 2024, over 30 rare bird species—including ruddy shelduck (*Tadorna ferruginea*), common crane (*Grus grus*), tundra swan (*Cygnus columbianus*) , and whooper swan (*Cygnus cygnus*)—were observed in the region, with populations continuing to increase annually.

Figure 13. Vegetation cover after restoration in the central section (Source: Longgang District People's Government, 2025)

(3) Continuous Improvement of the Living Environment with Remarkable Social and Economic Benefits

The restored Tianjiaoshan now integrates ecological sightseeing, sports and fitness, and coastal leisure, while also recovering two high-quality beaches and creating a new hidden gem for coastal exploration and birdwatching (Figure 14). A 6,000-meter coastal wooden boardwalk and a public fitness park have been constructed, transforming the area into a newly emerging "social media-trending" attraction. The project has stimulated tourism development in surrounding scenic areas: in 2024, the nearby Hulu Ancient Town received more than 750,000 visitors, generating tourism revenue exceeding 70 million yuan—representing a substantial increase compared with pre-restoration levels—thus achieving a win–win outcome of ecological restoration and economic growth. At the same time, the improved ecological environment has attracted greater investment. Between 2022 and 2024, Longgang District introduced 15 investment projects with a total value of 1.885 billion yuan, injecting new vitality into the region's sustainable economic development [7].

Figure 14. Post-restoration Tianjiaoshan with clear waters, clean beaches, and flocks of seagulls wheeling over the waves (Source: Longgang District People's Government, 2025)

V Alignment with IUCN Nature-based Solution Global Standard

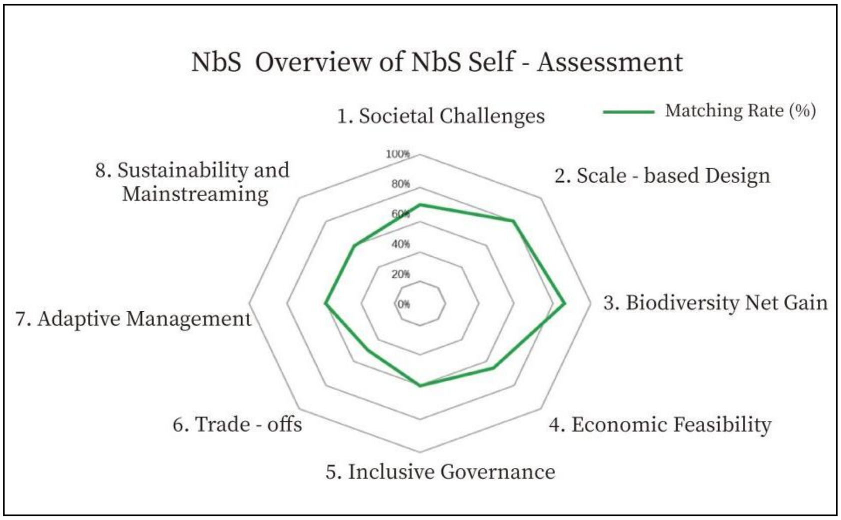

Figure 15. Radar chart of NbS self-assessment for this case

The Tianjiaoshan Coastal Zone Project in Huludao City effectively identified and addressed challenges related to disaster prevention and mitigation, economic and social development, environmental degradation, and biodiversity loss. The project perfectly assessed the living and production needs of local communities, aligning closely with established social challenge criteria. Stakeholders—including government departments, nearby residents, and research institutions—were clearly identified. Through consultations, public disclosures, and collection of public opinions, residents' production and livelihood needs were fully incorporated. In terms of improving well-being, the project not only enhanced the living environment and surrounding ecology but also created higher-quality waterfront spaces for residents and visitors, thereby significantly increasing their sense of happiness (Criterion 1).

The project fully integrated the interactions among the regional economy, society, and ecosystems. Holistic design measures included the planting of native vegetation, restoration of natural sandy beaches, and rehabilitation of bedrock shorelines, closely aligning with the requirements of Criterion 2. Furthermore, the project proactively assessed external risks common to coastal zones—such as extreme weather events and marine hydrodynamic forces—and strengthened shoreline resistance to erosion. A cross-departmental collaboration mechanism was also established, with research institutions providing technical support and consulting agencies optimizing the restoration plan (Criterion 2).

The project evaluated ecological degradation mechanisms caused by human disturbances and land reclamation in adjacent areas. While considering the habitat requirements of fish, birds, and terrestrial wildlife, it optimized ecological safety barriers, established ecological corridors, and developed a biodiversity conservation network. These measures provided high-quality ecological spaces and habitats for biodiversity, in close alignment with Criterion 3. Baseline surveys of ecosystems and species—including fisheries, birds, and terrestrial fauna—were conducted in the early stages. Long-term monitoring during and after restoration, compared against the baseline data, demonstrated significant ecological recovery, with several indicators showing net increases. Potential negative impacts—such as vegetation disturbance and wastewater pollution during construction—were anticipated and mitigated through restricted work zones, timely vegetation restoration, and the installation of wastewater treatment facilities. In addition, illegal barriers were dismantled, intertidal wetlands were restored to reconnect fragmented habitats, and native plants were established in the land–sea transition zone to form continuous vegetation belts, thereby strengthening ecosystem integrity and connectivity (Criterion 3).

Although the project was relatively modest in investment scale and funded entirely by government finance—thus generating no immediate economic return—it produced significant ecological benefits, fully meeting the core requirements of Criterion 4. Furthermore, the project is expected to yield future economic returns through the development of eco-tourism, supporting sustainable development and providing a practical pathway for benefit transformation, as required by Criterion 4.

During implementation, the project actively sought input from local residents, government departments, and business stakeholders, including operators of the nearby Hulu Ancient Town, involving them in planning and post-restoration management. This participatory approach was highly consistent with Criterion 5. A cost–benefit analysis was carried out, and by optimizing construction methods and integrating resources, the limited budget was used with maximum efficiency, further satisfying Criterion 5.

In project design, the docking needs of local fishing boats were respected through the retention of the old pier. Citizens' waterfront recreational demands were also incorporated with the construction of an open-access bathing beach. This reflected a careful balance between social needs and ecological protection. Potential benefits were identified, and assurance measures were periodically reviewed to maintain ecosystem stability in accordance with the principle of benefit trade-offs. From a cost–benefit perspective, retaining the old pier avoided the dual costs of demolition and reconstruction while meeting residents' production needs and reducing potential hidden social costs linked to restricted livelihoods. Although the creation of an open-access bathing beach increased both initial construction and long-term maintenance costs, it enhanced the public value of the coastal space, delivering long-term social and ecological benefits and thereby achieving a balance between investment and multiple benefits (Criterion 6).

Throughout its entire implementation cycle, the project developed and executed a robust monitoring and evaluation program, fully aligning with the requirements of adaptive management (Criterion 7).

Overall, the project contributes to global goals of enhancing human well-being, addressing climate change, and conserving biodiversity, while also meeting mainstream regional standards for sustainable development (Criterion 8).

Recommending Institution: Department of Natural Resources of Liaoning Province

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Eco-DRR Case of Qilihai Lagoon, Qinhuangdao City, Hebei Province, China

I Information

Qilihai Lagoon is located in Beidaihe New District, Qinhuangdao City, Hebei Province. As the largest lagoon in northern China, it serves as a critical node along the East Asian–Australasian Flyway for migratory birds. The regional coastline extends approximately 82 kilometers and contains high-quality tourism resources, including the ocean, beaches, forests, hot springs, and wetlands. Qilihai Lagoon plays an important role in disaster prevention and mitigation as well as water conservation, while also serving triple ecological functions as the 'green lung' of the city, a stopover site for migratory birds, and a habitat for lancelets (*Branchiostoma lanceolatum*). However, with the continued expansion of aquaculture, rice-field development, and other agricultural and fishery activities, the lagoon area rapidly shrank to just 286 hectares. As a result, water exchange capacity declined, biodiversity decreased, and disaster prevention capacity was gradually weakened.

To enhance regional ecosystem services and coastal disaster prevention capacity, Qinhuangdao City launched two phases of Eco-DRR and restoration of the Qilihai Lagoon Wetland (Figure 1) beginning in 2016. Measures included the negotiated withdrawal of aquaculture and wetland restoration across 818.35 hectares, micro-topographic remodeling of 610.52 hectares, and 15.61 kilometers of shoreline restoration [1][2]. These actions expanded the lagoon wetland to three times its original size. By adopting self-balancing earthwork techniques and a scientific "tree–shrub–grass" planting model, ecological functions were enhanced and a natural shoreline protection system was established. In addition, an integrated "air–space–land–ocean" marine disaster monitoring and early-warning system was developed, based on real-time data from oceans, wetlands, and meteorological observations. This system employed satellite remote sensing, unmanned aerial vehicle (UAV) inspections, land-based monitoring stations, offshore buoys, numerical modeling, and artificial intelligence to improve forecasting and management. Following restoration, ecosystem functionality was significantly enhanced, and disaster prevention and mitigation capacity was strengthened. The Qilihai Lagoon Wetland Eco-DRR project has since been selected as both a "Exemplary Case of Marine Ecological Conservation and Restoration in 2023" and a "Practical Case of Building a Beautiful China" [2].

Figure 1. Schematic diagram of the overall case layout
(Qinhuangdao Municipal Bureau of Ocean and Fisheries, 2025)

II Issues

Since the 1980s, human activities such as dyke construction, land reclamation, and aquaculture in the Qilihai Lagoon wetland have drastically reduced the lagoon's area to only 286 hectares—just 14% of its historical maximum. As a result, tidal prism declined from 48.6 million cubic meters to 10.85 million cubic meters by 2015 [3] . The loss of wetland ecological space weakened the lagoon's climate regulation and flood storage functions, heightening the risk of regional waterlogging and posing serious threats to surrounding farmland and local property security.

Domestic wastewater from surrounding residents and wastewater from aquaculture effluent, were discharged directly into Qilihai lagoon, leading to water quality. Siltation of tidal channels further obstructed water exchange, aggravating eutrophication and degrading aquatic habitats. Intensive human activities encroached upon ecological space, causing habitat fragmentation, sharp declines in biodiversity, and a diminished capacity for natural ecosystem self-recovery.

III Approaches

(1)Aquaculture withdrawal and wetland restoration to recover lagoon space

To address shrinking lagoon area, poor water exchange, and reduced tidal prism, 818.35 hectares of aquaculture ponds were withdrawn through negotiated agreements and restored as wetlands. Aquaculture infrastructure—including farmhouses and dykes—was dismantled, expanding the lagoon area to 853.47 hectares (Figure 2).

By dredging 1.59 million cubic meters of silt and modifying 29.33 hectares of tidal channels [1], the channel depth was increased, and after restoration, the average residence time of every 10,000 cubic meters of water was reduced by more than 30%.

Figure 2. Comparison before and after aquaculture withdrawal and wetland restoration
(left: before; right: after; Qinhuangdao Municipal Bureau of Ocean and Fisheries, 2025)

(2)Balanced earthwork and layered planting for ecological restoration

A total of 2.817 million cubic meters of earth, originating from dismantled aquaculture pond embankments, was reused in situ for land leveling and micro-topographic shaping, creating naturally undulating terrain. This approach both reduced transportation costs substantially and achieved a win–win outcome of ecological restoration and resource utilization (Figure 3). On the basis of micro-topographic remodeling, soil physical and chemical properties were adjusted to support plant survival and growth. Measures included backfilling with suitable planting soil, applying decomposed organic fertilizer, and regulating soil pH to ensure balanced nutrient supply. According to topographic features and soil–salinity dynamics, a layered "tree–shrub–grass" planting model was implemented from shoreline to sea. Specific actions included planting 28,998 arbor trees (*Robinia pseudoacacia, Salix matsudana*), 108,113 shrubs (*Amorpha fruticosa, Malus 'Radiant'*), 37.27 hectares of aquatic vegetation (*Phragmites australis*), and hydroseeding 66.39 hectares of salt-tolerant grasses such as *Suaeda salsa* [1] (Figure 4). Together, these measures effectively restored the ecological environment and significantly enhanced Eco-DRR functions.

Figure 3. Comparison of Micro-Topography Before and After Modification (Left: Before Modification; Right: After Modification; Qinhuangdao Bureau of Ocean and Fisheries, 2025)

Figure 4. Vegetation restoration effects (Qinhuangdao Municipal Bureau of Ocean and Fisheries, 2025)

(3)Smart monitoring defense line for strengthened disaster early warning capacity

An integrated "air–space–land–ocean" monitoring system was established in Qilihai Lagoon and adjacent sea waters, combining satellite remote sensing, UAV patrols, land-based monitoring stations, and offshore buoys. The system incorporates multi-dimensional land–sea ecological monitoring platforms, meteorological eddy covariance smart monitoring, and marine biological–environmental monitoring (Figure 5). This framework enables continuous, all-weather observation of multiple variables, including wind direction and speed, rainfall, temperature, humidity, air pressure, solar radiation, soil moisture and temperature, water nutrient concentrations, radioactivity, carbon flux, and biodiversity [1].

Figure 5. Offshore buoys and onshore monitoring stations of the early-warning and monitoring system (Qinhuangdao Municipal Bureau of Ocean and Fisheries, 2025)

Leveraging precise monitoring data, the system integrates numerical modeling with artificial intelligence technologies to forecast marine hazards such as high waves, storm surges, and harmful algal blooms (red tides), thereby strengthening regional marine disaster early-warning capacities (Figure 6).

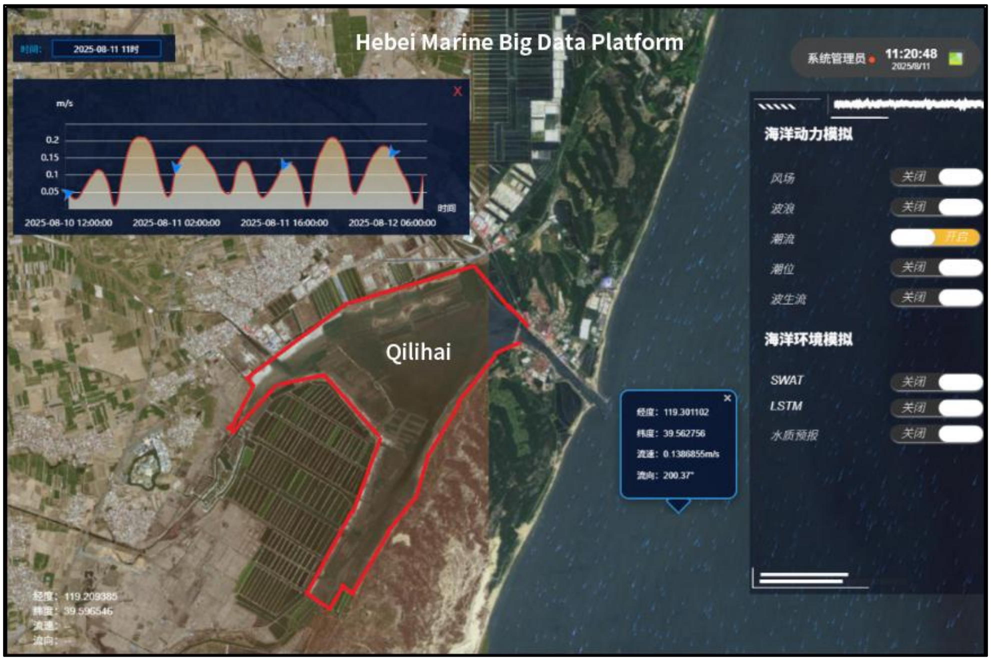

Figure 6. Big Data Platform for Real-Time Monitoring of the Early Warning System (Qinhuangdao Municipal Bureau of Ocean and Fisheries, 2025)

IV Accomplishment

(1)Tripling the Lagoon Area and Enhancing Regional Ecological Functions

The Qilihai Lagoon expanded to 853.47 hectares [4], with tidal prism increasing by 2.82 times to approximately 30.69 million m³ [2]. Water exchange capacity per unit of time improved by more than 30%, substantially enlarging the wetland's ecological space. Furthermore, the average density of macrobenthic organisms rose from 20.71 individuals/m² before restoration to 60.83 individuals/m² afterward. The number of water quality monitoring sites meeting standards increased from 5 to 11, while avian species diversity grew from 85 species (13 Orders, 26 Families) to 165 species (15 Orders, 29 Families) [5], including 50 species under Class I and II national protection. The lagoon has thus regained its pristine ecological landscape of "blue seas, clear skies, and flocks of birds in flight" (Figure 7).

Figure 7. Significant increase in bird species in the Qilihai Lagoon wetland (Fei Minjian, President of the Beidaihe New District Photographers' Association, 2025)

(2)Establishing a Dual System of Natural Protection and Intelligent Early-warning to Enhance Regional Disaster Prevention and Mitigation Capacity

Micro-topographic modifications were carried out over 610.52 hectares to shape near-natural coastal landforms. Through vegetation planting, 15.61 kilometers of artificial shoreline were transformed into ecologically restored shoreline (Figure 8), thereby reconstructing a natural ecological safety barrier. In parallel, an integrated "Sky–Space–Land–Sea" early-warning and monitoring platform was developed (Figure 9). Based on real-time monitoring data from marine, wetland, and meteorological systems, the platform enables early warning of marine hazards such as high waves, storm surges, and harmful algal blooms (red tides).

Figure 8. Shoreline after ecological restoration
(Qinhuangdao Municipal Bureau of Ocean and Fisheries, 2025)

Figure 9. Illustration of Dual System Implementation Effects
(Qinhuangdao Municipal Bureau of Ocean and Fisheries, 2025)

(3)Attracting High-End Investment and Boosting Tourism Development in the Surrounding Areas

The restored shoreline of Qilihai Lagoon now accounts for 18.6% of the total shoreline length of Beidaihe New District. With its widened water surface, improved water quality, flourishing benthic communities, thriving bird populations, and naturally rehabilitated shoreline, the lagoon has become a strong magnet for high-end investment projects. Over ten major tourism and resort projects—each with investments exceeding RMB 10 billion—have been launched in Beidaihe New District. The district has accelerated the establishment of a Demonstration Zone for Comprehensive Tourism Reform (Figure 10), forming integrated development models such as “Tourism + Marine Sports” and “Tourism + Health and Wellness.” In 2024, the number of tourists reached 11.74 million, with total tourism revenue of RMB 15.3 billion.

Figure 10. Qilihai Lagoon driving surrounding tourism development
(Qinhuangdao Municipal Bureau of Ocean and Fisheries, 2025)

(4)Ecological Transformation Gaining Broad Social Recognition

A total of 15.61 km of ecologically restored shoreline has been established in the Qilihai Lagoon area, expanding public access to the sea and attracting large numbers of bird photographers, who have witnessed the lagoon's ecological transformation. The case has demonstrated remarkable ecological and disaster-mitigation benefits, and has been successively selected as a "Exemplary Case of Marine Ecological Protection and Restoration in 2023" and a "Practical Case of Building a Beautiful China." The outcomes provide a practical reference for ecological restoration and sustainable development, while also receiving extensive attention and coverage from national, provincial, and municipal mainstream media, generating positive societal responses (Figure 11) and widespread acclaim.

Figure 11. Qilihai Lagoon receiving extensive mainstream media attention at national, provincial, and municipal levels

V Alignment with IUCN Nature-based Solution Global Standard

In accordance with the IUCN Global Standard for Nature-based Solutions officially released in 2020, a self-assessment of this case was conducted, with the following results.

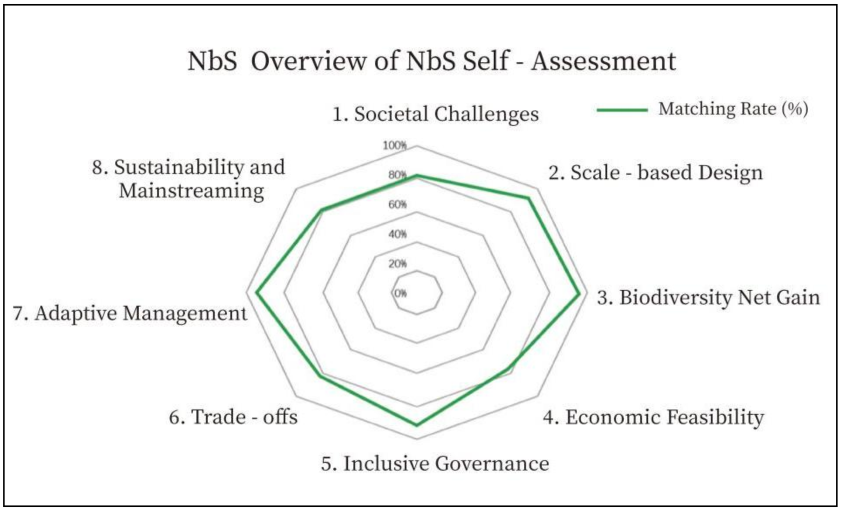

Figure 12. Adaptive management Radar chart of NbS self-assessment for this case

The case directly addressed core challenges such as ecosystem degradation, biodiversity loss, and weakened disaster resilience resulting from land reclamation and aquaculture. By converting aquaculture ponds back into wetlands and restoring shorelines, the ecological structure of Qilihai was reconstructed, creating a coastal space where people and nature coexist harmoniously—thus showing strong alignment with Criterion 1: Effectively addressing societal challenges.

The case delivered significant ecological, social, and economic benefits. Coordination with the Hebei Provincial Department of Ecology and Environment, the Management Center of Hebei Changli Gold Coast National Nature Reserve, and the Qinhuangdao Water Resources Bureau facilitated environmental impact assessments, protected-area impact evaluations, flood-risk assessments, and emergency response planning—thus strongly aligned with Criterion 2: Design at scale.

Through tidal channel modification and aquaculture withdrawal, ecosystem integrity and connectivity were enhanced. After restoration, recorded bird species increased from 85 species (13 Orders, 26 Families) to 165 species (15 Orders, 29 Families), while average macrobenthic density rose from 20.71 individuals/m^2 to 60.83 individuals/m^2. In addition, 25 long-term monitoring stations were established for biodiversity assessment—highly consistent with Criterion 3: Biodiversity net gain.

As a non-profit marine Eco-DRR project, it did not generate direct economic revenue but indirectly boosted ecotourism and created jobs. Long-term funding mechanisms such as blue carbon trading are under exploration, and a diversified financing system led by public investment has been established—demonstrating basic compliance with Criterion 4: Economic feasibility.

The case adhered to an inclusive, transparent, and participatory governance process, with a regular consultation mechanism enabling both direct and indirect stakeholders to express their needs and suggestions. Original aquaculture operators received economic compensation, and a joint coordination mechanism was established with the Hebei Changli Gold Coast National Nature Reserve. Decision-making was clearly documented, and a long-term framework was developed for government, enterprises, NGOs, and the public to jointly participate in nature conservation—strongly aligned with Criterion 5: Inclusive governance.

Ecological restoration served as an ecological compensation mechanism, supported by cost–benefit analysis, environmental impact assessments, and mitigation measures for protected areas. Qualified institutions were commissioned to conduct follow-up monitoring, with progress reporting and acceptance mechanisms established—well aligned with Criterion 6: Balancing trade-offs.

The case established a comprehensive monitoring and evaluation program, with follow-up assessments conducted every six months before, during, and after restoration, for a total of six rounds. Based on observed social, economic, and ecological impacts, the monitoring scheme was continuously refined and adjusted. For example, when localized vegetation survival rates were found to be low, analyses of water–salinity dynamics were undertaken, and corresponding management measures were revised accordingly. Through this process of iterative optimization, the distribution of 25 long-term monitoring stations was adjusted, demonstrating strong conformity with Criterion 7: Adaptive Management.

The project expanded waterfront accessibility, strengthened biodiversity conservation, contributed to national goals for carbon peaking and carbon neutrality, and enhanced disaster resilience. Recognized as both a "Exemplary Case of Marine Ecological Protection and Restoration" and a "Practical Case of Building a Beautiful China", it has been promoted for nationwide application. The introduction of drone patrols and smart monitoring systems significantly reduced management costs and improved efficiency—well aligned with Criterion 8: Mainstreaming and sustainability.

Recommending Institution: Hebei Provincial Department of Natural Resources

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[1] Qinhuangdao Municipal People's Government. Implementation Plan for the Qinhuangdao Marine Ecological Protection and Restoration Project [R]. 2021.

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Marine Ecological Protection and Restoration Project [R]. 2023.

[5] Qinhuangdao Municipal Bureau of Ocean and Fisheries.. 2021 Follow-up Monitoring and Effectiveness Evaluation Report of the Qilihai Marine Ecological Protection and Restoration Project in Qinhuangdao [R]. 2025.

Eco-DRR Case of Haoyunjiao Coast, Weihai City, Shandong Province, China

I Information

Haoyunjiao is located at the easternmost tip of the Shandong Peninsula in Rongcheng City, Weihai. It includes the Chaoyanggang Lagoon and adjacent sandy coastal areas, where the upstream Bailong River discharges into the sea. The lagoon is well developed, covering a total area of approximately 580 hectares. The inner lagoon of Chaoyang Port and the outer sandy shoreline coexist in dynamic interaction, making it an important convergence zone of marine resources. Since the expansion of coastal aquaculture in the last century, although it contributed to local economic development, large-scale reclamation for aquaculture has also caused the shrinkage of the inner lagoon, reduction of tidal prism, deterioration of water exchange, and destruction of the natural sandy shoreline outside the lagoon. From 2019 to 2021, the area was affected by 11 storm surges and 28 destructive wave events [1], with average annual disaster losses of about RMB 10 million. These disasters further accelerated erosion of the outer sandy coast, leading to degradation of the regional ecosystem and a year-by-year decline in the overall capacity to defend against marine hazards such as storm surges and waves.

Figure 1. Overall layout of the case area

Guided by the concept of ecological civilization, and in line with the vision that "Weihai should develop toward a well-designed and high-quality city," Weihai has responded to the urgent need to restore severely degraded marine ecosystems and to promote a green ocean economy in the new era. Since 2021, restoration efforts have been undertaken in the Chaoyang Port area through 'inner' lagoon system restoration and 'outer' sandy coastline rehabilitation (Figure 1). Measures have included the removal of aquaculture ponds to restore wetlands, natural beach rehabilitation, ecological modification of seawalls, and vegetation planting. In total, 18.75 kilometers of shoreline and 35 hectares of coastal wetlands have been restored, forming a lagoon shoreline Eco-DRR system composed of "sandy coast – ecological seawall – vegetative buffer zone." Following restoration, the regional ecological environment has continued to improve, disaster prevention and mitigation capacity has been effectively enhanced, and extensive high-quality space has been created for coastal tourism development—driving socio-economic growth in surrounding areas and charting a new blueprint for harmony between people and the sea.

II Issues

Since the 1980s, large-scale reclamation and factory-style aquaculture have rapidly expanded in Chaoyang Port (Figure 2). At its peak, there were more than 200 aquaculture enterprises and households, with a total farming area exceeding 300 hectares. This led to shrinkage of the inner lagoon, reduction of tidal prism, and deterioration of water exchange of the inner Chaoyang Port. Severe sediment siltation occurred inside the port, while the outer coast lost its sediment supply, disrupting the balance of sediment transport. The lagoon ecosystem degraded, biological communities were damaged, food resources for birds declined, and the security of terrestrial ecosystems behind the lagoon was put at risk.

Figure 2. Large-scale aquaculture ponds occupying the lagoon
(Administrative Committee of Haoyunjiao Tourist Resort, Rongcheng City, 2021)

Historically, the outer Chaoyang Port featured a high-quality beach. However, reclamation for aquaculture occupied large sections of the sandy coast, altering hydrodynamic conditions and causing beach loss. In some sections, vegetation was sparse, leaving the beaches unprotected. Under the impact of storm surges and waves, the natural shoreline was severely damaged (Figure 3); sand from the backshore migrated seaward, and the width of the beach ridge decreased significantly year by year.

Figure 3. Partial degradation of coastal vegetation, reducing disaster resilience (Administrative Committee of Haoyunjiao Tourist Resort, Rongcheng City, 2021)

III Approaches

(1)Implementation of "Returning Aquaculture Ponds to Beaches" and Naturally Recover 18 Hectares of Beach

To address problems such as the encroachment and destruction of the outer beach of Chaoyang Port and severe coastal erosion, the principle of "natural restoration as the primary approach, supplemented by artificial intervention" was adopted. Without artificial beach nourishment, the project implemented the measure of "returning aquaculture ponds to beaches" to restore favorable hydrodynamic conditions for beach formation and enabling natural recovery. Specifically, the project dismantled 10.2 hectares of aquaculture ponds and 16.5 hectares of aquaculture greenhouses on the sandy coast, and removed 30,000 cubic meters of shoreline waste. Approximately 6,000 meters of sandy shoreline were naturally restored, with an average beach width of about 30 meters, totaling 18 hectares (Figure 4). Following natural restoration, 13.52 kilometers of ecological seawalls were reconstructed, and 1.7 hectares of vegetation such as *Tamarix chinensis* were planted behind the seawalls, thereby establishing an "ecological disaster mitigation system" composed of "sandy coast–ecological seawall–vegetation shelterbelt" (Figure 5). By leveraging the natural wave-dissipating capacity of the sandy shoreline and the ecological connectivity provided by the seawalls between marine and terrestrial systems, the ecological functions of the coastline and its resilience to marine disasters were effectively restored, while also enhancing the appeal of Weihai's "Thousand-Mile Coastal Line" brand.

Figure 4. Comparison of the outer shoreline of Chaoyang Port (Above: before restoration; Below: after restoration; Administrative Committee of Haoyunjiao Tourist Resort, Rongcheng City, 2021, 2023)

Figure 5. Schematic diagram of the "Sandy Coast–Ecological Seawall–Vegetation Shelterbelt" Eco-DRR System

(2)Adhere to Land-sea Coordination, Restore the Lagoon Ecosystem

To address issues such as reduced tidal prism and wetland degradation in the inner lagoon of Chaoyang Port, the project focused on "returning aquaculture ponds to the sea" and dredging the bay. Specifically, 176.7 hectares of aquaculture ponds were removed, and 1 million m^3 of silt was dredged (Figure 6). Pollution discharge from the upstream Bailong River was controlled through the dredging of 15 hectares of river channel, thereby greatly enhancing the lagoon's tidal prism and self-purification capacity. Through micro-topographic modifications, habitat space was expanded for native wetland plants such as *Suaeda salsa, Phragmites australis,* and *Zostera marina*, leading to the restoration of 35 hectares of salt marsh wetlands and the recovery of coastal wetland habitats.

Figure 6. Returning aquaculture ponds to wetlands in the inner lagoon of Chaoyang Port
(Left: before restoration; Right: after restoration; Administrative Committee of Haoyunjiao Tourist Resort, Rongcheng City, 2021 & 2023)

(3)Upgrading the Cultural and Tourism Industry to Unlock the Value of Ecological Products

In response to the challenge of insufficient industrial support caused by the removal of aquaculture facilities in Chaoyang Port, the project leveraged the high-quality development space created by ecological restoration and carried out detailed planning aligned with market demand. A 7.5-kilometer coastal greenway was constructed, and two leisure experience spaces were developed: the Ring-Sea Road Recreation and Sports Park and Haiyun Park (Figure 8). Clear development pathways were established for recreational fishing (Figure 9), tidal flat shellfish gathering, water-based recreation, and seaside markets. These initiatives were integrated with surrounding attractions such as Naxianghai, the "Blue Ways" shipwreck, and the Intercontinental Beach Resort, effectively filling gaps in coastal tourism offerings and revitalizing the regional marine cultural tourism sector[4].

Figure 7. Restored salt marsh in the inner lagoon of Chaoyang Port
(Administrative Committee of Haoyunjiao Tourist Resort, Rongcheng City, 2025)

Figure 8. Ring-Sea Road Recreation and Sports Park
(Administrative Committee of Haoyunjiao Tourist Resort, Rongcheng City, 2023)

Figure 9. Sea Fishing Base
(Administrative Committee of Haoyunjiao Tourist Resort, Rongcheng City, 2023)

IV Accomplishment

(1)Continuous Improvement of the Ecological Environment and Significant Enhancement of Disaster Prevention and Mitigation Capacity

Chaoyang Port has undergone a remarkable transformation—from a coastline once dominated by aquaculture and ecological degradation to an ecologically restored "golden coastline" with green shores, clear tidal flats, and abundant biodiversity. Following restoration, 2,354 meters of artificial shoreline were recognized as ecologically rehabilitated coastline (Figure 10). The inner lagoon area expanded by 170 hectares, and the tidal prism increased by up to 33.5%. On the seaward side, 18 hectares of natural sandy beach was restored. Populations of foraging bird species such as the Black-tailed Gull (*Larus crassirostris*), Great Egret (*Ardea alba*), and Whooper Swan (*Cygnus cygnus*) (Figure 11) increased by 21% compared with pre-restoration levels. The density of large benthic organisms rose from 821 individuals/m² to 973 individuals/m². Salt marsh vegetation such as *Suaeda salsa* and *Phragmites australis* expanded naturally year by year (Figure 12), while seagrass beds flourished, significantly improving regional ecological conditions and ecosystem stability. Since restoration, the area has withstood four typhoon-induced extreme storm surge events. Notably, around October 20, 2024, when many coastal areas across China experienced extreme storm surge anomalies—and sections of Weihai's coastline suffered severe damage—the Chaoyang Port shoreline remained intact, safeguarding the lives and property of inland communities.

Figure 10. Ecologically restored coastline
(Administrative Committee of Haoyunjiao Tourist Resort, Rongcheng City, 2023)

Figure 11. Increasing diversity and abundance of bird species
(Administrative Committee of Haoyunjiao Tourist Resort, Rongcheng City, 2025)

Figure 12. Thriving growth of salt marsh vegetation such as *Phragmites australis and Suaeda salsa*
(Administrative Committee of Haoyunjiao Tourist Resort, Rongcheng City, 2025)

(2)New Momentum for Industrial Development and a Revitalized Regional Economy

The co-benefits of ecological restoration and cultural–tourism development have been striking (Figure 13). Annual tourist arrivals rose from 3.87 million before restoration to

9.86 million afterwards, while tourism revenue increased from RMB 2.12 billion to RMB 3.11 billion. The improved ecological environment, combined with a stronger industrial development foundation, has attracted substantial investment from state-owned enterprises and leading private companies, with project investment exceeding RMB 30 billion. Since 2023, twelve star-rated hotels and boutique homestays have opened along the Chaoyang Port coastline. More than 20 new tourism formats have emerged, including low-altitude aerial tourism, nighttime cultural tours, digital VR experiences, and tidal flat foraging activities. During peak season, average daily traffic now exceeds 30,000 vehicles. At the same time, the growth of cultural and tourism industries has created new sales channels for local agricultural products such as figs and sweet potatoes, benefiting farmers in surrounding villages. Hotels and homestay projects have generated substantial employment opportunities, with more than 200 rural households achieving annual income increases of over RMB 30,000 each.

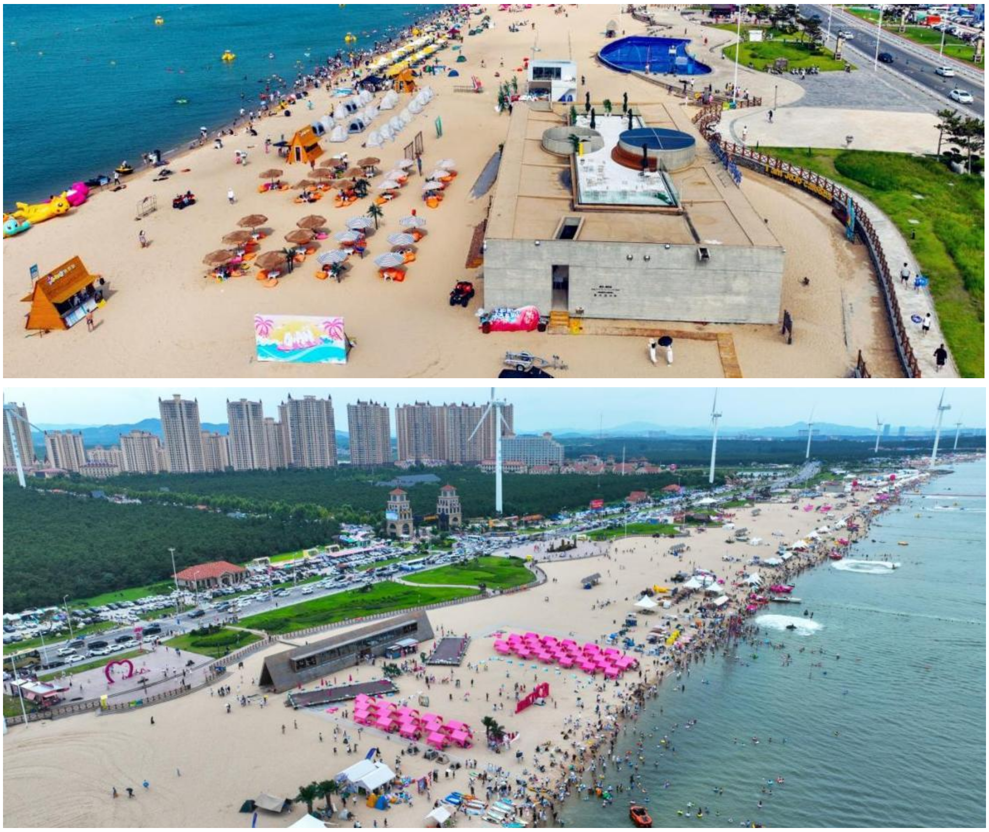

Figure 13. Flourishing development of cultural and tourism industries at the Haoyunjiao Tourism Resort (Administrative Committee of Haoyunjiao Tourist Resort, Rongcheng City, 2024)

(3)Demonstrating Human–Nature Harmony and Generating Significant Social Benefits

The restoration has effectively improved the surrounding living environment. More than 18 km of accessible coastal shoreline and 18 hectares of recreational beach have been added, greatly enhancing residents' and visitors' sense of well-being, fulfillment, and satisfaction. Public complaints concerning environmental degradation and aquaculture-related odors have decreased by over 90%. The Chaoyang Port restoration has also catalyzed broader social development in surrounding areas. The Haoyunjiao Tourism Resort in Rongcheng was recognized as a national-level "Lucid Waters and Lush Mountains Are Invaluable Assets" Practice and Innovation Base. The coastal attraction "Blue Ways" shipwreck became a popular social media check-in destination (Figure 14). The Chaoyang Port section of "Weihai Yinshan Bay to Malan Bay" was included in the first group of provincial-level Beautiful Bay exemplary cases. Nearby Xiaoxi Village in Gangxi Town was designated a "Traditional Chinese Village." The Chaoyang Port restoration provides compelling evidence for a new development pathway: enhancing natural landscapes through ecological restoration, strengthening service provision through infrastructure development, and consolidating industrial foundations through investment promotion. It stands as a vivid practice of the contemporary "Two Mountains" philosophy. Related experiences have been published in China Ecological Civilization and promoted nationwide (Figure 15).

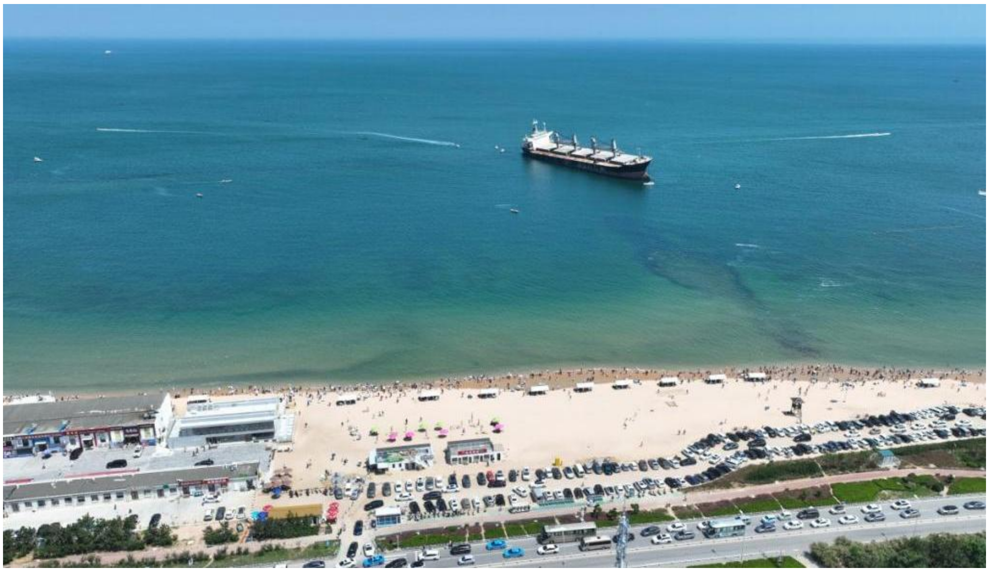

Figure 14. The "Blue Ways" check-in attraction trending online
(Administrative Committee of Haoyunjiao Tourist Resort, Rongcheng City, 2024)

06 地方读本
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责编:陈媛媛
电话: (010)67113382
传真: (010)67113772
E-mail:fz@cenews.com.cn

中国环境报

生态环境部公布第六批"绿水青山就是金山银山"实践创新基地名单

好运角旅游度假区榜上有名

2022年11月18日，生态环境部公布了第六批"绿水青山就是金山银山"实践创新基地名单，好运角旅游度假区榜上有名。好运角旅游度假区曾在2020年获山东省首批"绿水青山就是金山银山"实践创新基地称号，此次入选国家级"两山"实践创新基地名单，是对好运角旅游度假区近年来生态环境建设工作的更高肯定。

好运角旅游度假区位于山东半岛最东端，2012年底设立，总面积280平方公里，拥有112公里海岸线、30公里原生态沙滩、7万亩黑松林。依托良好的自然生态资源和深厚的历史文化资源，好运角旅游度假区在成立之初，就确立了以滨海旅游、文旅康养为主导的产业发展定位，经过近10年的蓄势发展，走出了一条生态效益、经济效益、社会效益多赢的发展之路。

近年来，好运角旅游度假区深入学习贯彻习近平生态文明思想，坚持"绿水青山就是金山银山"理念，把良好的生态、优质的岸线作为发展最大的优势、最宝贵的资源，注重保护与开发并重、生态效益与经济效益兼顾，打通了"绿水青山"向"金山银山"的转化通道，跑出了滨海文旅产业高质量发展"加速度"。

筑牢海岸带生态屏障，促进自然资本保值增值

大力推进乡村振兴，实现生态美百姓富有机统一

好运角：讲好"两山"创新故事

好运角2012年底设立，总面积280平方公里，下辖成山、港西、埠柳三镇。区内"岛、滩、礁、湖、林"广布，112公里海岸线上分布着五大海湾、30公里原生态沙滩、7万亩黑松林。依托良好的自然生态资源和深厚的历史文化资源，好运角确立了旅游、文化、健康、体育、养老五大幸福产业融合发展，着力打造中国北方知名滨海度假目的地、争创国家级旅游度假区的目标定位。

近年来，好运角始终坚持生态立区、绿色发展，深入贯彻落实习近平生态文明思想，牢固树立"绿水青山就是金山银山"理念，把良好的生态、优质的岸线作为最大的发展优势、最宝贵的资源，把生态环境的好坏作为决定好运角品质优劣的关键因素，秉持"生态自然，少做加法、多做减法"的原则，统筹推进生态环境保护和旅游产业发展，实行了最严格的环境保护，切实打造出了"水清、滩净、岸绿、湾美、岛靓"的生态环境，走出了一条生态效益、经济效益、社会效益共赢的发展之路。

一是岸线整治修复实现全覆盖

在环海一线，沿沙滩岸线200米、沿礁石岸线50米范围内只拆不建，累计投资6亿多元，拆除沿海参池、养殖房、看护房等设施300多处，约100万平方米，清理海上养殖1.5万亩，恢复沙滩60多万平方米；新建滨海步道22.4公里，打造绿化景观、口袋公园30多处，新增绿化

的白龙河休闲观光生态走廊、30公里自行车慢行系统和20多处观海观景平台，完成北环海港西虎头角至成山小五队段18公里岸线修复项目，打造的小五队·抱海驿站房车营地投入使用，成为新的网红打卡地。

大力推进荣成湾北岸综合整治提升，拆除沿线13万平方米老旧建筑、

Figure 15: Haoyunjiao Tourism Resort Selected as National-Level "Lucid Waters and Lush Mountains Are Invaluable Assets" Practice and Innovation Base

V Alignment with IUCN Nature-based Solution Global Standard

In accordance with the IUCN Global Standard for Nature-based Solutions released in 2020, a self-assessment of this case was conducted, with the following results.

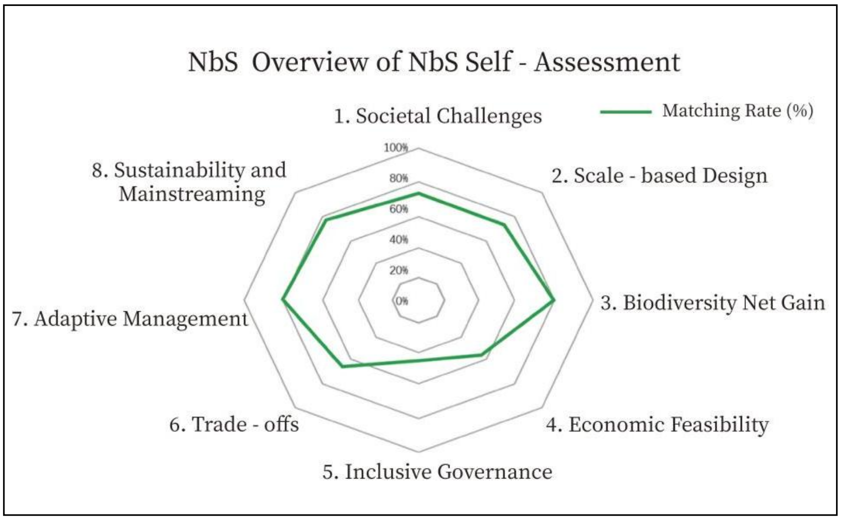

Figure 16. Radar chart of NbS self-assessment for this case

The case demonstrated a clear understanding and diagnosis of spatial needs for ecological disaster risk reduction and economic development. It thoroughly examined and identified the impacts of ecological degradation on disaster prevention and mitigation, conducted detailed surveys on regional demographics and socio-economic conditions, and assessed ecological issues and resilience gaps. Comprehensive evaluations were carried out across all relevant social dimensions within the influence area of the restoration zone. Measures were taken to improve living environments, increase local employment, and achieve both industrial development and household income growth. These outcomes show a high level of alignment with Criterion 1: Societal Challenge.

From the perspective of integrated ecological disaster risk reduction, the case combined economic, ecological, and social benefits through collaborative design. A multi-layered coastal-to-inland ecological disaster reduction system was established, achieving coupled marine–terrestrial coordination that extended from coastlines to estuaries and inland urban areas. By adopting a holistic land–sea planning approach, priority was given to addressing external risks such as waves and storm surges that threaten coastal ecosystems, thereby forming a land–sea ecological linkage mechanism. A cross-departmental coordination team led by the Rongcheng Haoyunjiao Tourism Resort Administrative Committee was established, effectively addressing institutional arrangements, fully meeting Criterion 2: Scale of Design.

Baseline surveys of marine ecological characteristics were conducted, with quantifiable and measurable indicators (e.g., salt marsh extent, terrestrial vegetation cover). Multi-stage monitoring and evaluation were implemented before, during, and after project execution. By reconnecting fragmented ecosystems and removing physical barriers, natural conditions were largely restored. The re-emergence of seagrass beds ecosystem and the increase in bird populations demonstrate strong compliance with Criterion 3: Biodiversity Net Gain.

The project feasibility study included investment and cost–benefit analyses, clarified funding sources and public-interest attributes, and secured both policy and financial support. Comparative analyses of multiple schemes were conducted, and optimal solutions were selected to address key issues. While government financial support was ensured, broader mobilization of social capital was not systematically considered. The project is therefore broadly aligned with Criterion 4: Economic Feasibility.

During implementation, diverse grievance and feedback mechanisms were established, including on-site coordination meetings, public announcements, and official notices.

Regular social satisfaction surveys (covering all genders and age groups) were conducted in the region. Information was communicated to local residents via signage and media outlets. Potentially affected stakeholders were identified, and mechanisms such as questionnaires and representative meetings were used to ensure their participation in evaluation processes. These measures demonstrate broad compliance with Criterion 5: Inclusive Governance.

The project explicitly addressed conflicts between the short-term and long-term interests of stakeholders in coastal tourism (which benefits from ecological restoration and improved natural landscapes) and traditional aquaculture. It analyzed potential cost changes (e.g., resulting from modifications or market fluctuations) and indirect economic benefits that could arise during implementation. Measures such as reclaiming aquaculture-use waters to restore open marine space were adopted to ensure effective safeguards, demonstrating broad alignment with Criterion 6: Balance of Trade-offs.

A detailed monitoring and evaluation framework was developed, with comprehensive outcome reports produced. These reports included quantitative comparative analyses of relevant data across the pre-, mid-, and post-restoration phases. Measures were taken to refine and reinforce restoration actions in response to monitoring results, fully consistent with Criterion 7: Adaptive Management.

From planning through implementation, the project was guided by NbS-based restoration concepts, marking a transition from unsustainable traditional approaches requiring continuous input to ecological approaches with inherent self-recovery capacity. Project practices have been systematically summarized and widely disseminated, with ecological restoration outcomes broadcast multiple times on television to raise public awareness of marine conservation. Related findings and summaries have also been published in journals such as Ocean and Coastal Management. These outcomes are highly consistent with Criterion 8: Sustainability and Mainstreaming.

Recommending Institution: Shandong Provincial Oceanic Administration

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Eco-DRR Case of Hua’ao Island, Ningbo City, Zhejiang Province, China

I Information

Hua’ao Island is located south of Gaotangdao Township, Xiangshan County, Ningbo City, Zhejiang Province, at the eastern entrance of Sanmen Bay, about 14 kilometers southwest of Shipu Town. The island derives its name from its abundant flowers (hua) and numerous coves (ao). It is endowed with unique landscapes and cultural heritage, including basalt columnar jointing stone forests formed by volcanic activity, the traditional sea-salt sun-drying technique recognized as a National Intangible Cultural Heritage, and the historic site of Zhang Cangshui’s military camp during the resistance against the Qing dynasty army.

Historically, the island has been highly prone to marine disasters, and under the influence of global climate change, the frequency of storm surges and wave disasters has increased in recent years. In addition, due to illegal sand mining, quarrying, and other unsustainable development activities, the island has suffered beach degradation, coastal collapses and subsidence in certain areas, latent geological hazards from abandoned mines, fragile ecosystems, and declining biodiversity. Moreover, weak infrastructure and a deteriorating living environment have diminished residents’ sense of well-being.

To promote ecological protection and restoration of the island, and to enhance disaster prevention and mitigation capacity, Xiangshan County has adhered to the development vision of “living in harmony with the sea and fostering coexistence between humans and nature.” Guided by the principle of sustainable development, the county adopted an integrated strategy of island-wide planning, phased implementation, and comprehensive governance. Since 2016, a holistic ecological island–reef restoration approach was carried out, including shoreline remediation and restoration, abandoned mine remediation, upgrading of the ring road, construction of ecological greenways, and conservation of rare species [1] (Figure 1). These measures effectively protected and restored the island’s ecosystems and strengthened disaster risk reduction capacity. Hua’ao Island has since been awarded several titles, including National Marine Park, one of the first batch of “Harmonious and Beautiful Islands” in China, a Provincial Geopark, and one of the Top Ten Island Parks in Zhejiang Province.

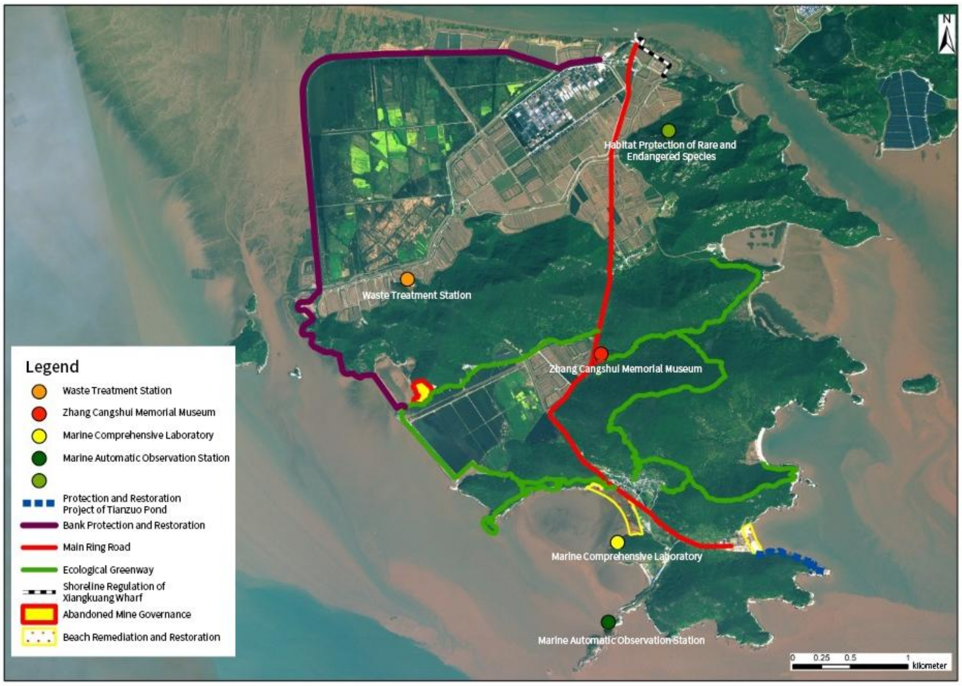

Figure 1. General layout of Hua'ao Island ecological island–reef construction

II Issues

Under the combined influence of natural and anthropogenic factors, Hua'ao Island has been increasingly affected by damaged natural shorelines, heightened risks of marine disasters, and a weakened environmental carrying capacity. On average, the island experiences approximately four storm surges and about 25 days of wave disasters annually [2]. In some coastal sections, wave action has caused collapses (Figure 2), localized damage and subsidence of seawall revetments, and a decline in structural stability. Beaches have retreated due to erosion (Figure 3), significantly reducing coastal protection capacity. Furthermore, marine disasters have exacerbated ecosystem fragility, threatening habitats of multiple nationally and provincially protected rare and endangered species, and leading to a decline in island biodiversity. Due to disorderly and unregulated mining activities, the Gaotuao mine has suffered damage to its original landform and structure, resulting in potential geological disaster risks. The island's transportation infrastructure remains underdeveloped, with poor overall connectivity. Inadequate facilities have led to waste accumulation; cultural and historical sites lack proper protection; and inefficient utilization of island resources has constrained the development of eco-tourism.

Figure 2. Collapsed coast on the south side of Tianzuotang
(Blue Bay Company, Hua'ao Island, 2016)

Figure 3. Ancient Guzhang beach eroded by waves
(Blue Bay Company, Hua'ao Island, 2016)

III Approaches

(1) Multiple Protective Measures: Building a Safety Barrier for Islands

Based on the geomorphological characteristics and ecosystem integrity of the island, and from the perspective of “strengthening disaster-prevention barriers, promoting the harmonious development of islands, and preserving cultural and ecological values,” the case study established an ecological disaster-mitigation framework of “beach buffering–revetment protection–slope stabilization.” On the southern side of Hua’ao Island, the Guchang Beach adopted a near-natural artificial beach nourishment approach for restoration (Figure 4). By clearing the beach surface, replenishing marine sand, and planting salt-tolerant vegetation, a composite structure of “sandy buffer zone + vegetative wave-dissipation layer” was formed, mitigating the impact of waves on the seawall. On the southeastern side, the Tianzuotang cobble beach was restored through the replenishment of natural cobbles, whose interstitial pore spaces helped disperse wave energy. On the northwestern side, the damaged revetment was stabilized through rubble clearance, base reinforcement, surface repair, and the construction of new retaining walls, thereby enhancing its capacity to withstand continuous wave impact. On the western side, the abandoned mine underwent stepwise slope cutting, with retaining walls constructed at the slope foot and vegetation bags laid on the slope surface. Through a combined approach of “engineering-based slope stabilization + vegetation-based soil fixation,” the stability of the landform was improved and geohazard risks were eliminated (Figure 5). This case successfully integrated ecological restoration with disaster mitigation, enhancing the resilience of the coastal zone. Furthermore, in alignment with the ecological island-reef construction practices of Hua’ao Island, the project contributed to the development of the national standard Guidelines for Ecological Island Construction, providing valuable experience for advancing ecological island and reef initiatives.

Figure 4. Full view of Guzhang Beach after restoration (Blue Bay Company of Hua'ao Island, 2023)

Figure 5. Full view of the restored abandoned mine
(Blue Bay Company of Hua'ao Island, 2025)

(2) Adapting to Local Conditions to Enhance the Ecological Function of Seawalls

By fully integrating the local hydrodynamic characteristics, an ecological renovation was carried out on 4.48 kilometers of artificial seawall revetments on the northwestern side of Hua'ao Island. Adopting the model of "wave dissipation in front of the seawall and protection behind the seawall," the project achieved a dual enhancement of both disaster-prevention capacity and ecological benefits. On the seaward slope, inclined tetrahedral hollow permeable concrete structures were installed to attenuate wave energy while simultaneously creating microhabitats for small marine organisms, thereby enhancing ecological stability in front of the seawall. Behind the seawall, a three-tier vegetative protection system was established, consisting of the slope surface, slope toe, and seawall toe zones: Slope surface behind the seawall: Applied three-dimensional mesh hydroseeding with herbaceous plants tolerant of saline–alkaline soils, rapidly forming dense vegetation cover to stabilize the seawall structure and prevent erosion. Slope toe: Planted salt- and alkali-tolerant ornamental shrubs such as *Nerium oleander* and *Photinia fraseri* (red tip photinia), which further reinforced the seawall while improving aesthetic value. Seawall toe: Planted coastal tree species such as *Casuarina equisetifolia* and eucalyptus, effectively blocking sea winds, reducing storm surge impacts on the seawall, and increasing both diversity and stability of the coastal ecosystem. Through these ecological modifications, "hard protection" and "ecological protection" were successfully integrated, delivering a dual enhancement of disaster risk reduction and ecosystem services (Figure 6).

Figure 6 Restored seawall (Blue Bay Company of Hua'ao Island, 2021)

(3) Revitalizing Resources to Build a Livable and Prosperous Island

Adhering to the principle that “blue seas and silver beaches are invaluable assets,” the project integrated ecological island–reef development with livelihood enhancement and cultural heritage conservation. A ring-island trunk road was upgraded, and multilayered ecological greenways were constructed between the mountains and the coastline (Figure 7). These greenways provided windbreak and sand-fixation functions for disaster mitigation, while also improving eco-friendliness. The Zhang Cangshui Memorial Hall and the Hua’ao Military Barracks site were restored, underscoring the cultural–ecological assets summarized as “century-old Cangshui, millennium-old camphor, thousand-mu salt fields, ten-thousand-year Buddha, and billion-year stone forest.” By actively exploring diversified models of industrial integration, the project introduced island garden complexes and boutique homestays, developed agritourism and tourism industries, and attracted visitors for sightseeing, leisure, and educational tours. This approach promoted diversified economic development on the island and facilitated the sustained release of ecological dividends, realizing a virtuous cycle in which “disaster risk reduction safeguards development, and development in turn supports ecological protection.”

Figure 7 Ecological greenway
(Blue Bay Company of Hua’ao Island, 2021)

IV Accomplishment

(1) Enhancing Island Stability and Improving Both Disaster Resilience and Livability

In the case area, 6.10 hectares of sandy beaches and 1.98 hectares of cobble beaches were restored; 249 meters of seawalls were reinforced; 6.76 km of revetments were rehabilitated; and 2.3 hectares of abandoned mines were remediated [3]. These measures effectively restored degraded shorelines (Figure 8), fully strengthened functions such as wave attenuation and coastal protection, and significantly reduced the adverse impacts of storm surges and strong waves, thereby comprehensively improving disaster prevention and mitigation capacity in the coastal zone. Since 2021, Hua'ao Island has withstood 14 storm surges triggered by typhoons such as Chanthu and Muifa, as well as cold-air events, without any casualties. Economic losses have shown a declining trend. At the same time, the construction and upgrading of public facilities—such as waste treatment stations, coastal defense cultural parks, and ecological greenways—have greatly improved residents' living conditions, expanded public access to the sea (Figure 9), and markedly enhanced the island's overall livability, injecting Hua'ao Island with renewed vitality.

Figure 8. Post-restoration condition of the collapsed coast on the southern side of Tianzuotang
(Blue Bay Company of Hua'ao Island, 2020)

Figure 9. After restoration, the beach has become a popular coastal recreation space
(Publicity Department of Xiangshan County, 2024)

(2) Multiple Measures Leading to Significant Biodiversity Enhancement

Alongside island ecological restoration, and in combination with the protection of rare, endangered, and endemic species, the populations of flora and fauna on the island have gradually increased, resulting in markedly enriched biodiversity. In 2020, the island supported 684 species of vascular plants, including 32 species under national or provincial protection or classified as rare; 24 species of mammals, amphibians, and reptiles, of which 6 were listed under national or provincial protection or categorized as endangered or near threatened; and approximately 20,000 individuals of 157 bird species, including as many as 104 species included in official protection catalogues [4]. The surrounding marine waters supported 134 species of plankton, 43 species of large benthic organisms, and 92 intertidal species [5]. In November 2022, Hua'ao Island's Marine Biodiversity Experience Site was designated as one of Ningbo's first municipal-level biodiversity experience sites.

(3) Value Transformation: Driving a New Blue Economy Engine

Building on the opportunity created by ecological island–reef construction, Hua'ao Island has leveraged its distinctive industrial resources to transform ecological advantages into economic assets by integrating ecotourism with environmental education, while developing branded eco-agriculture and eco-fisheries. The island has become a popular independent travel "hotspot" for family trips, study camps, and photography groups (Figure 10). This diversified set of industries has become an important component of Ningbo's marine economy. Between 2019 and 2023, the island received 634,000 visitors, generating tourism revenue of RMB 117 million, while the combined output value of agriculture and fisheries reached RMB 595 million. In 2024, the number of visitors rose to 226,000, a year-on-year increase of 43.1%, with tourism revenue reaching RMB 36.15 million, representing a 32.9% increase compared to the previous year.

Figure 10. Hua’ao Island Becomes a Trending Social Media Attraction
(Blue Bay Company of Hua’ao Island, 2023)

(4) Social Engagement: Enhancing Public Ocean Literacy

The construction of the ecological island–reef has significantly raised the profile of the case area, attracting wide recognition and acclaim from various sectors of society. Major media outlets such as Geography China, Zhengda Variety Show, CCTV, CGTN, and Zhejiang Daily have reported on the initiative (Figure 11). Hua’ao Island has also been selected as one of the filming locations for the first domestically produced AAA video game. In 2023, a Biodiversity Legal Education Base was established on the island, together with a collaborative mechanism for ecological judicial protection, contributing to improved public ocean literacy and marine conservation awareness. These initiatives have transformed broad “ecological consensus” into proactive “ecological action.”

Figure 11. Media coverage of Hua’ao Island at various levels

V Alignment with IUCN Nature-based Solution Global Standard

In accordance with the IUCN Global Standard for Nature-based Solutions officially released in 2020, a self-assessment of this case was conducted, with the following results.

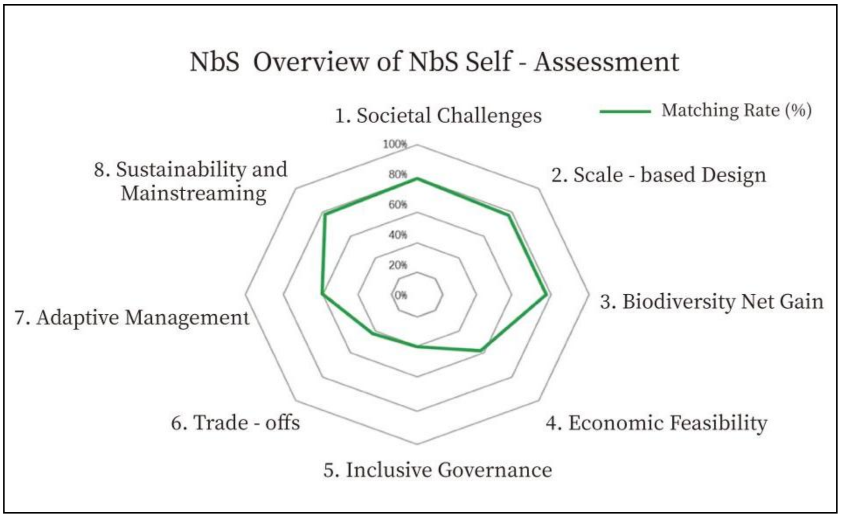

Figure 12. Radar chart of NbS self-assessment for this case

This case is closely aligned with the needs of human settlement environments and ecological security, effectively addressing social challenges related to climate change impacts on disaster risk reduction, economic and social development, living environment enhancement, and limited biodiversity. It comprehensively considers the needs of island residents, local government, and visitors. Through beach restoration, coastal revetment works, abandoned mine remediation, ecological greenway construction, and upgrading of the island's main road, the project has strengthened island stability and disaster risk reduction capacity, expanded public coastal spaces, and improved infrastructure—thereby creating a coastal environment characterized by harmony between people and nature. These outcomes are highly consistent with the criterion of addressing societal challenges (Criterion 1).

The project identifies the interactions among economic, social, and ecological systems. From the perspective of "strengthening disaster prevention, promoting harmonious island development, and safeguarding cultural–ecological heritage," it has advanced ecological island–reef construction, issued the Guidelines on Ecological Restoration of Natural Resources in Xiangshan County, and developed the national standard Guidelines for Island Ecological Construction. Potential risks and their drivers from unintended changes have been anticipated, demonstrating strong conformity with the criterion of design at scale (Criterion 2).

The case has been appropriately assessed across temporal and spatial scales. During implementation, specific measures such as surveys and awareness campaigns on rare and endangered endemic species were conducted. Monitoring stations for island surveillance were established, and baseline surveys of the island's ecological environment were completed. The Report on Rare, Endangered, and Endemic Species of Hua'ao Island was compiled, identifying and enhancing ecosystem connectivity, thereby showing high alignment with Criterion 3 (Biodiversity Net Gain).

Project direct costs have been clearly defined, with joint investment from central and local governments. Although direct economic returns are not generated, the project enhances Hua'ao Island's ecological advantages, investment attractiveness, and development competitiveness, while safeguarding the lives and property of coastal communities. These outcomes indirectly demonstrate cost-effectiveness and the long-term sustainability of investment. However, indirect costs and resource allocation were not fully specified, thus meeting only partial compliance with economic feasibility (Criterion 4).

The project was jointly implemented by sectoral authorities and professional teams, with clearly defined decision-making processes and responsibilities. While the decision-making process considered the rights and interests of some participating and affected stakeholders, it did not specify the extent of their participation or influence during implementation, nor did it establish feedback or grievance mechanisms. Hence, it only partially aligns with the criterion of inclusive governance (Criterion 5).

Although potential benefits were identified, detailed cost–benefit analyses were lacking. Safeguard measures helped maintain ecosystem stability through periodic inspections, but trade-offs among stakeholders regarding land and natural resource use were not explicitly addressed, nor was a post-project evaluation mechanism established. Future efforts should broaden and deepen governance, establish clear response mechanisms, and genuinely achieve multi-stakeholder inclusive governance. The project therefore only partially conforms to the criterion of balancing trade-offs (Criterion 6).

During implementation, regional ecological baseline surveys and monitoring programs were conducted, and a tracking and monitoring plan was developed. The Assessment Report on the Effectiveness of the Xiangshan Hua'ao Island Ecological Island–Reef Construction Project was compiled. Adjustments were made based on monitoring results—for example, canceling sand replenishment in the easily silted bay area of Guzhang Beach (approximately 3.7 hectares near the bay mouth). However, an iterative learning framework for continuously refining and adapting interventions was not established, resulting in only moderate alignment with adaptive management (Criterion 7).

The project received extensive coverage by Geography China, CCTV, Zhejiang Daily, and other media outlets, and facilitated inter-regional exchanges and mutual learning, providing a model for island ecological restoration. The establishment of the Marine Biodiversity Experience Site and the Biodiversity Legal Education Base further supports mainstreaming and long-term sustainability, demonstrating strong conformity with the criterion of sustainability and mainstreaming (Criterion 8).

Recommending Institution: Ningbo Municipal Bureau of Natural Resources and Planning

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Eco-DRR Case of Sandy Coast in Dongtou District, Wenzhou City, Zhejiang Province, China

I Information

Dongtou Island is located outside the Oujiang Estuary in Wenzhou, Zhejiang Province, on the southern side of the Dongtou Strait. The island's eastern and southern coastal areas are the Dongtou National Marine Park, which possesses remarkable ecological advantages and has earned the titles of the "Pearl of the East China Sea" and "Garden on the Sea." The region has a total population of approximately 69,000 and a coastline stretching about 50 kilometers, characterized by a meandering shoreline and numerous natural harbors, representing a typical open bay. A variety of habitats are distributed across the area, among which sandy coasts—an important coastal type—are mainly found along the island's southern shore in areas such as Dong'ao, Dongsha, and the western side of Banping.

since 1980s, long-term disturbances—including illegal sand excavation, sand mining, and other unsustainable development activities—have caused significant damage to the sandy shoreline. In addition, under the influence of global climate change, storm surges and destructive wave events have occurred frequently. Statistics show that between 1951 and 2020, a total of 143 typhoons affected the region, more than 60 of which caused severe economic losses. The storm surge hazard level is classified as Grade I [1]. The coastal zone has suffered serious damage from typhoon-induced storm surges, leading to erosion and degradation of gravelly beaches, reduction of beach surface area, and mounting pressure on disaster prevention and reduction.

Figure 1. Overall layout of the case study area
(Yellow areas represent sandy coast restoration sites)

In recent years, guided by the philosophy of Ecological Civilization and in line with President the strategy to "attach great importance to ecological and environmental protection, adhere to the path of sustainable development," and to "truly build Dongtou into a veritable garden on the sea," Dongtou has intensified efforts in marine ecological protection and restoration. Since 2016, two consecutive phases of the Blue Bay Remediation Initiative have been implemented, systematically advancing ecological restoration and disaster risk reduction of sandy coastlines (Figure 1). Measures such as submerged breakwaters for beach stabilization, beach replenishment, and drainage channel modifications, complemented by the construction of a coastal ecological corridor, have been adopted to alleviate beach erosion, restore natural beach morphology, and achieve a total restoration area of 15 hectares [2-3]. Following restoration, the regional ecological environment has continued to improve, shoreline disaster prevention and mitigation capacity has been effectively enhanced, and coastal ecosystem services have been steadily strengthened. Dongtou has subsequently received more than 20 national-level honors, including recognition as a National Marine Ecological Civilization Demonstration Zone and selection as one of the second batch of "Lucid Waters and Lush Mountains Are Invaluable Assets" Practice and Innovation Bases. In June 2023, Dongtou Island was successfully listed among China's first batch of "Harmonious and Beautiful Islands."

II Issues

Dongtou possesses abundant beach resources. However, in recent years, under the dual influence of natural disasters and human activities, beaches have generally experienced varying degrees of erosion and degradation, making it difficult for the coastal zone to sustainably fulfill its ecological disaster risk reduction functions. Specifically: 1) Dongtou Island directly faces the East China Sea without sheltering islands, has weak geological foundations, and is highly vulnerable to natural hazards such as storm surges and waves. Comparative monitoring data of coastlines over different periods show that the island's original gravelly coastlines have retreated landward to varying degrees. The beach berms are narrow, and at low tide, large areas of gravel are exposed on the beach surface (Figure 2), leaving no effective buffer zone for wave dissipation and current attenuation. 2) Long-term anthropogenic disturbances such as illegal sand excavation, sand mining, and other non-compliant development activities have resulted in uneven grain-size distribution, poor sediment gradation, and the mixing of gravel and sand on beaches. At the same time, influenced by the construction of breakwaters and other engineering works, the hydrodynamic conditions inside adjacent fishing ports have weakened, leading to increased siltation (Figure 3). As a result, the beaches have shown significant mudification (Figure 4), causing substantial degradation of recreational waterfront functions and a significant decline in ecological service value.

Figure 2. Mixed gravel and sand on Dong'ao Beach
(Dongping Subdistrict, Dongtou District, Wenzhou City, 2016).

Figure 3. Severe siltation at Dongsha Fishing Port before remediation (Wenzhou Dongtou Urban Development Co., Ltd., 2016).

Figure 4. Muddification phenomenon at Jiucai'ao Beach
(Dongping Subdistrict, Dongtou District, Wenzhou City, 2018)

III Approaches

(1) Targeted Interventions: "Beach Reshaping + Dredged Sediment Utilization" to Enhance Disaster Risk Reduction

To address problems such as beach gravelization, erosion, and ecological degradation, an ecological restoration model based on Nature-based Solutions (NbS) was adopted, drawing on the theory of dynamic equilibrium of beaches. Through environmental remediation and beach reshaping, underlying gravels were removed, and layered replenishment with basal sand, mid-layer sand, and surface sand was carried out (Figure 5). Meanwhile, ecological sand-stabilization facilities were installed to support the formation of stable beach morphology, resulting in the restoration of 15 hectares of sandy coast. To address beach muddification, dredging was conducted in Dongtou National Central Fishing Port and Dongsha National First-class Fishing Port, with a total dredged volume of 1.57 million m^3. The average water depth in the ports increased by 2.7 m, thereby improving regional hydrodynamic conditions (Figure 6). At the same time, the dredged sediment was utilized nearby as fill material for beach restoration, reflecting the principle of intensive resource utilization. Through beach remediation and restoration, the project not only reinstated the shoreline's original wave attenuation and coastal defense functions for disaster prevention and mitigation, but also achieved the goal to improve the ecological environment.

Figure 5. Jiucai'ao Beach after restoration
(Miao Weiduan, Wenzhou Municipal Bureau of Planning and Natural Resources, 2020).

Figure 6. Dongsha Fishing Port after restoration
(Wenzhou Dongtou Urban Development Co., Ltd., 2017).

(2) Long-term Management: "Blue Ocean Station + Intelligent Supervision" to Improve Governance Capacity

A three-dimensional long-term management and protection mechanism was established. In terms of marine waste management, a nearshore sea-cleaning campaign was launched, involving the deployment of specialized vessels such as sea surface cleaning ships and nearshore salvage boats, together with the installation of automated offshore debris interception belts (Figure 7), and the formation of dedicated maritime sanitation teams. "Blue Ocean Stations" were established as marine plastic waste collection points, exploring an operational model of "collection–landing–transfer–treatment–supervision." This system enabled the annual removal of more than 6,000 tons of beach waste, ensuring clean and tidy coastlines. In terms of supervision and intelligent prevention, tracking monitoring and effectiveness evaluation were carried out, leading to the pioneering development of the Blue Bay Ecological Restoration Assessment System (Blue Bay Index) and participation in the formulation of industry standards. In addition, the Zhehai Ankang Intelligent Marine Disaster Prevention application scenario was developed (Figure 8), establishing intelligent systems for perception, analysis, and control of marine disasters, and providing accurate early-warning and forecasting services. In terms of law enforcement coordination, an Integrated Maritime

Law Enforcement Brigade was formed to implement “a unified team for integrated enforcement” approach. Through collaboration with Taizhou and Yueqing, the Wenzhou–Taizhou Bay Cross-regional Judicial Cooperation Mechanism (“Five Districts, Ten Courts”) was established, enabling coordinated governance across regions.

Figure 7. Nearshore salvage vessel and floating debris interception belt
(Dongtou Branch, Wenzhou Municipal Bureau of Ecology and Environment, 2025).

Figure 8. Dongtou “Zhehai Ankang” intelligent marine disaster prevention application scenario.

(3) Innovative Mechanisms: “Social Capital + Multi-stakeholder Participation” to Boost Development Momentum

Following the principle of “those who restore, benefit,” Dongtou became the first county-level jurisdiction in China to issue the Provisional Measures for the Construction and Management of Marine Ecological Protection and Restoration Projects with Social Capital Participation in Dongtou District, Wenzhou City [4], which clarify stakeholder responsibilities and policy support. An innovative “government restoration + village–enterprise co-construction” model was adopted. By granting time-limited rights to use certain natural resource assets, more than 10 private enterprises were attracted to invest in marine ecological protection and restoration (Figure 9), with effective investments exceeding RMB 30 billion. For example: at Dongsha Fishing Port Beach, restoration was funded through social capital, integrating waterfront recreational functions with disaster prevention. At Dong'ao Beach, post-restoration management was undertaken by village collectives, with operating revenues covering management costs. At Jiucai'ao Beach, post-restoration management was leased to a cultural tourism company, reducing the government's financial burden for ongoing maintenance, while creating an "internet-famous tourism effect" that allowed enterprises to share in the ecological dividends generated by beach protection.

Figure 9. Social capital participation in Dongsha Fishing Port beach restoration (Dongtou Branch, Wenzhou Municipal Bureau of Planning and Natural Resources, 2024).

IV Accomplishment

(1)Strengthening the Sandy Coastline as an Eco-DRR Barrier

This case systematically implemented sandy coast restoration, cumulatively restoring 3.2 kilometers of sandy shoreline and replenishing 268,000 m^3 of beach sand. By reshaping the natural morphology of the beach and dredging fishing harbors to enhance the tidal prism, the resilience of the coastline against extreme events was significantly improved. For example, following restoration, the elevation of Dong'ao Beach (Figure

10) stabilized at approximately 3.1 meters. It has withstood repeated tests from strong typhoons (e.g., Typhoon Maria in 2018) and has remained in a state of dynamic equilibrium with high stability [5-6]. After several years of restoration and remediation, the marine ecological environment in the area has been substantially improved: over 90% of adjacent waters now meet Class I or Class II seawater quality standards; the frequency of algal blooms (red tides) has dropped markedly; and the ecosystem service functions of the marine environment have been comprehensively enhanced. Thus, the dual goals of disaster prevention and mitigation as well as ecological conservation have been successfully achieved [7].

(2)Activating Green Momentum to Drive Island Economic Revitalization

Anchored in ecological restoration, the case area has successfully transformed ecological advantages into drivers of local development. Following the restoration of Dong'ao Beach, the number of local homestays surged from 16 to 105, with average annual household income reaching RMB 200,000. This created a development model whereby "every beach hosts a homestay cluster, and every cluster drives a community to prosperity." Aligned with the creation of an International Ecotourism Island and the upgrading of the area to a national 4A-level scenic destination, 70 "boutique garden villages" were developed, linked by 10 coastal scenic routes. This has fueled strong growth in coastal tourism: over the past five years, the area has received more than 30 million tourist visits (Figure 11), with an average annual growth rate of 20%. Fifteen homestay villages and 594 homestay businesses have created employment for 25,000 people, raising average annual household income by more than RMB 150,000. The hosting of branded events such as the International Rock Fishing Festival has further promoted the integrated development of "tourism + sports + culture" (Figure 12). The area has been recognized as "China's Most Beautiful Leisure Resort," realizing a win–win model of ecological protection and industrial upgrading through green development.

Figure 10. Post-restoration condition of Dong’ao Beach
(Dongping Subdistrict, Dongtou District, Wenzhou, 2018).

Figure 11. Beach-based leisure industry
(Dongtou Branch, Wenzhou Municipal Bureau of Natural Resources and Planning, 2022).

Figure 12. Triathlon competition
(Wenzhou Municipal Bureau of Natural Resources and Planning, 2019).

(3) Demonstrating Model Effects: Leading the Practice of Ecological Restoration

The model of "co-existence between people and the sea, and integrated land–sea governance" explored in this case has received broad recognition across society. It was selected by the Ministry of Natural Resources as a national demonstration exemplary case for marine ecological restoration, showcased at the Achievements Exhibition of the 70th Anniversary of the Founding of the People's Republic of China, and featured multiple times on CCTV programs such as News Broadcast and Focus Talk (Figure 13). In 2019, it was awarded the title of "Top Ten Outstanding Marine Engineering Projects (Second Edition)" by the China Association of Oceanic Engineering. In 2021, the experience was presented at the Eco Forum Global Guiyang, and the case was included in the Collection of Exemplary Cases of Ecological Restoration in China during the Ecological Civilization Forum of COP15 of the UN Convention on Biological Diversity. In 2022, it was selected as a "Best Practice Case" in Zhejiang's Common Prosperity Demonstration Zone, providing a practical reference for ecological restoration and sustainable development.

Figure 13. Related Media Reports

V Alignment with IUCN Nature-based Solution Global Standard

In accordance with the IUCN Global Standard for Nature-based Solutions officially released in 2020, a self-assessment of this case was conducted, with the following results.

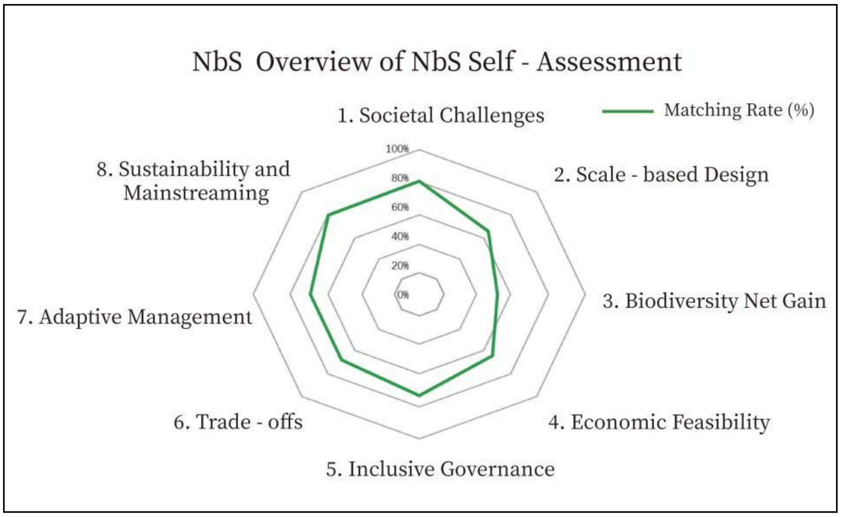

Figure 14. Radar chart of NbS self-assessment for this case

The case effectively identified and addressed several societal challenges, including disaster risk reduction, economic and social development, and environmental degradation accompanied by biodiversity loss. Guided by the principles of "protection first, planning first, distinctive development, and integrated development," step-by-step implementation was carried out through beach restoration, fishing port dredging, and related projects. By advancing from "use of the sea and protection of the sea" to "nurture and restoration of the sea," the project strongly aligned with the criterion of Addressing Societal Challenges (Criterion 1).

The interlinkages among economy, society, and ecosystems were clearly identified, shaping a vision of "clear waters, green shores, clean beaches, beautiful bays, abundant resources, and harmonious communities," thereby achieving integration of ecology, production, and livelihoods. The National Marine Park Plan for Dongtou District prioritized marine area, island, and coastal zone remediation, restoration, and protection, aligning well with the criterion of Design at Scale (Criterion 2).

Appropriate temporal and spatial assessments were conducted, with monitoring and evaluation systems established during implementation. Specific measurable indicators, such as sand retention rates in beach restoration, were set, and a land–sea integrated disaster prevention system was developed, aligning with the criterion of Net Gain to Biodiversity (Criterion 3).

Through diversified financing and the pioneering PPCC model (Public–Private Value Creation and Value Capture), the project leveraged Wenzhou's strong private sector to institutionalize social capital participation. Following the principle of "who restores, benefits," beach restoration for disaster risk reduction was linked to ecotourism, generating tourism revenue and aligning with the criterion of Economic Viability (Criterion 4).

The case was also among the first ten typical examples of ecological restoration with social capital participation selected by the Ministry of Natural Resources. Sectoral authorities and professional teams collaborated, stakeholders were identified, and post-restoration management of certain beaches was jointly undertaken by village collectives and private enterprises, strongly aligning with the criterion of Inclusive Governance (Criterion 5).

Although potential benefits were identified, detailed cost–benefit analyses were lacking. While long-term management measures ensured ecosystem and beach landscape stability, specific analyses of stakeholder rights and responsibilities over land and natural resources were absent, only partially meeting the criterion of Balancing Trade-offs (Criterion 6).

A four-tier, 23-indicator monitoring and early-warning system for the carrying capacity of marine resources and the environment was established. This included ecological assessments and predictive warnings for the Dongtou marine area, together with targeted Blue Bay remediation and restoration strategies, strongly aligning with the criterion of Adaptive Management (Criterion 7).

The project's outcomes were showcased in the Large-Scale Achievements Exhibition of the 70th Anniversary of the Founding of the People's Republic of China, twice endorsed at press briefings by the State Council Information Office, and featured prominently on CCTV News Broadcast, Focus Talk, and People's Daily, providing an exemplary reference and leadership role in marine ecological restoration. This strongly aligns with the criterion of Sustainability and Mainstreaming (Criterion 8).

Recommending Institution: Department of Natural Resources of Zhejiang Province

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Eco-DRR Case of Coastal Bays of Qinzhou City, Guangxi Zhuang Autonomous Region, China

I Information

Qinzhou Bay is located in the southern part of Qinzhou City and serves as a key node for the Beibu Gulf–Pinglu Canal Project, a major component of the New Western Land-Sea Corridor, enabling integrated river–sea transportation. Within the bay, the China–Malaysia Industrial Park was established in March 2012 with the approval of the State Council. It is the third international park jointly developed through intergovernmental cooperation between China and a foreign country, with a planned total area of 55 square kilometers and a planned population of 500,000. Peacock Bay and Yongfu Bay, situated in this region, are not only core natural distribution areas of mangroves in the Beibu Gulf, but also essential spawning and feeding grounds for economically important aquatic species such as oysters, prawns, mud crabs, and groupers. These areas constitute vital links in maintaining the stability of the regional ecosystem.

Anthropogenic disturbances, including the excessive expansion of development and construction around the park and the unchecked growth of the mariculture industry, have led to severe encroachment upon coastal wetland resources. Large areas of mangroves have been occupied, siltation within the bay has intensified significantly, and the biodiversity of the bay has been progressively weakened. Moreover, the region is severely affected by storm surges, with 3–4 typhoons making landfall annually. In 2014, Super Typhoon Rammasun impacted 1.097 million people in Qinzhou, causing direct economic losses of RMB 3.04 billion. Recurrent disasters have destroyed sandy coastlines and coastal vegetation, degrading the ecological barrier functions and creating a vicious cycle of “ecological degradation—reduced defense capacity—intensified disaster losses.”

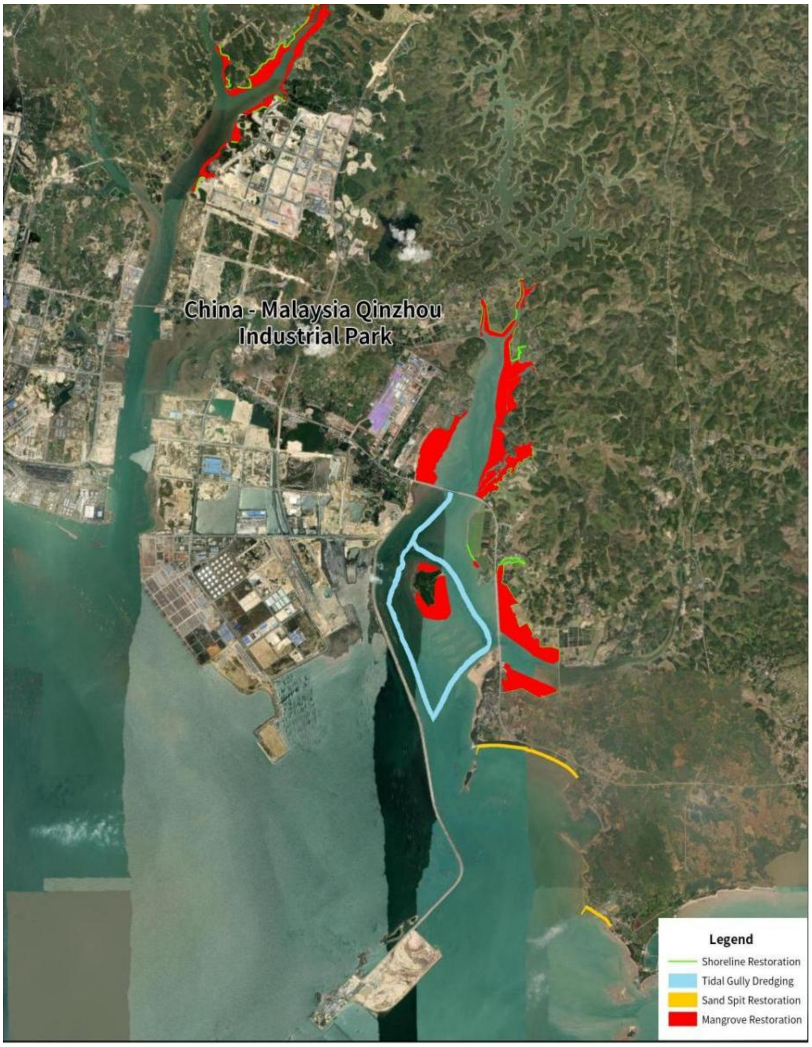

Figure 1. Schematic Diagram of the Overall Layout of the Case Area

In response, Qinzhou has earnestly implemented President Xi Jinping's instructions during his inspection of Guangxi that "Guangxi's ecological advantages are invaluable," and his important directive to "expand and strengthen the China–Malaysia 'Two Countries, Twin Parks' initiative, making it a key hub of the New International Land–Sea Trade Corridor to promote connectivity and development between the two countries and the wider region." Since 2020, continuous efforts have been made to advance ecosystem-based disaster risk reduction (Eco-DRR) and ecological restoration in Peacock Bay and Yongfu Bay, Qinzhou City. These initiatives have cumulatively resulted in the restoration of 512.99 hectares of mangroves, the rehabilitation of 33.94

kilometers of shoreline, the dredging of 2.9664 million cubic meters of tidal creek, the replenishment of 369,300 cubic meters of beach sand, and the restoration of 3.25 hectares of sand-based vegetation. Together, these measures have established an interwoven and interconnected spatial pattern of an integrated Eco-DRR system in the bay area [1] (Figure 1). Following restoration, shorelines and vegetation have been effectively rehabilitated, significantly enhancing regional disaster prevention and mitigation capacity. The bay's tidal prism and mangrove ecosystem stability have markedly improved, biodiversity has continued to increase, and eco-tourism along with ecological industries have been revitalized. This has achieved a synergistic relationship between ecological protection and economic development, thereby promoting the harmonious coexistence and mutual benefits of marine ecological conservation and socio-economic progress.

II Issues

Due to intensive surrounding development and historical aquaculture reclamation in Qinzhou Bay, the regional marine ecosystem has become overloaded, with a continuously declining capacity for disaster prevention and mitigation.

The first problem is that reclamation and aquaculture have triggered ecological crises. Densely distributed aquaculture ponds have occupied shorelines and mudflats, leading to the fragmentation of mangrove habitats (Figure 2). Between 1960 and 1995, Yongfu Bay alone lost 79 hectares of mangroves [2]. In addition, frequent outbreaks of mangrove pests and diseases in recent years—caused by species such as *Lasiognatha mormopa* and *Homona coffearia*—have inflicted large-scale damage in Qinzhou, leading to the gradual shrinkage of wetland ecosystems and a decline in biodiversity.

Figure 2. Enclosed pond aquaculture occupying tidal flats
(Left: Peacock Bay, Right: Yongfu Bay; Qinzhou Municipal Oceanic Bureau, 2019, 2021)

The second problem is that oyster stakes on tidal flats are obstructing water circulation. Dense oyster stakes and rafts have occupied sea channels (Figure 3), reducing seawater exchange and weakening the capacity for pollutant dispersion. In addition, upstream reservoirs in Yongfu Bay impound water, accelerating sedimentation from terrestrial inputs as well as suspended solids from offshore sources. The annual siltation rate in Yongfu Bay is 0.14–0.29 m [3]. As a result, the region's self-purification capacity and its ecological corridor functions between land and sea have been severely compromised.

Figure 3. Oyster stakes and rafts encroaching upon sea waterways in tidal flats
(Qinzhou Municipal Oceanic Bureau, 2021)

The third problem is that hardened seawalls are disrupting land–sea connectivity. Some seawalls have been constructed using cement hardening methods, resulting in a monotonous structure that blocks ecological linkages between land and sea.

The sandy shoreline is too short, with beach widths in certain sections measuring only 10–20 meters. These shorelines, eroded and sloping downward under wave action, are highly vulnerable to damage from storm surges (Fig. 4), posing a serious threat to the safety of production and daily life of coastal residents.

Figure 4. Seawall collapse and damage under storm surge and wave attack
(Qinzhou Municipal Oceanic Bureau, 2021)

The fourth problem is that beach erosion is destroying coastal waterfront space. Influenced by storm surges, reclamation, and other engineering activities that alter hydrodynamics and sediment transport in the bay [4], sandy beaches have undergone severe erosion (Figure 5). In some sections, beaches are now only 10 meters wide. Wave and rain scouring have carved gullies and undercut shorelines, damaging coastal vegetation and exposing the roots of shelterbelt forests. This has reduced disaster resistance capacity and degraded coastal tourism resources. The destruction of coastal resources has made it increasingly difficult to meet the public's demand for coastal access, while also negatively impacting both the economy and local livelihoods.

Figure 5. Sandy shoreline erosion and exposed windbreak tree root systems
(Qinzhou Municipal Oceanic Bureau, 2021)

III Approaches

(1) Constructing a "Beach - Ecological Revetment - Shelterbelt" Protective Barrier Outside the Bay

The outer bay protection system involves 369,300 m³ of sand nourishment on the seaward side and the construction of a 400-meter rubble revetment. On the landward side, the configuration of sand-tolerant vegetation has been optimized by planting 3.25 hectares of sand-adapted species, such as coconut trees (upper canopy) and *Ipomoea pes-caprae* (for surface sand stabilization). Vegetation belts are spatially integrated with recreational trails to form a "beach–ecological revetment–shelterbelt" protective barrier (Figure 6). This system improves hydrodynamic conditions in the beach area, effectively attenuates wave energy, mitigates beach erosion and shoreline collapse, and creates accessible coastal spaces for the public

Figure 6. “Beach–Ecological Revetment–Shelterbelt” comprehensive coastal protection system (Qinzhou Municipal Oceanic Bureau, 2024)

(2) Constructing a "Mangrove - Ecological Revetment" Protective Barrier Inside the Bay

The inner bay protection system involves dredging 10.6 kilometers of tidal creeks, with the collective removal of 34.55 hectares of oyster stakes and 183 oyster rafts, thereby restoring the natural morphology of waterways and widening key ecological migration corridors. In addition, 111 hectares of aquaculture ponds have been converted into mangrove forests, using local species such as *Aegiceras corniculatum* and *Kandelia obovata*, with on-site seedling cultivation prioritized. In total, 512.99 hectares of mangroves have been rehabilitated, reversing the over-dense layout of aquaculture ponds and restoring mangrove habitats. Ecological revetments have also been constructed, with 4.35 kilometers of artificial reef structures deployed. This forms an integrated coastal protection barrier and marine ecological corridor based on a “mangrove–ecological revetment” system (Figure 7), which enhances the tidal prism of the bay, improves water exchange, and provides favorable conditions for marine life and mangrove growth.

Figure 7. "Mangrove–Ecological Revetment" integrated coastal protection system
(Qinzhou Municipal Oceanic Bureau, 2023)

(3) Graded Utilization of Dredged Materials for Beach Formation and Afforestation, and Oyster Shell Recycling for Eco-Revetments

To address the significant reduction in tidal prism within the bay, the tidal creek dredging project enabled the graded utilization of 2.97 million cubic meters of dredged material. Fine -grained sediments were used to create 31 hectares of suitable land for mangrove afforestation, while coarse -grained sediments were applied to nourish and restore a 2.45-kilometer section of beach. This approach effectively reduced beach restoration and sand replenishment costs by approximately RMB 22 million, ensuring optimal resource allocation within the restoration project itself.

In addition, leveraging Qinzhou's resource advantage—known as the "Hometown of Oysters in China," with an annual production of 300,000 tons of oyster shells—6,000 tons of discarded oyster shells were repurposed as revetment materials for mangrove embankments. This initiative established an ecological protection belt (Figure 8), which not only mitigates wave erosion in restored zones and stabilizes tidal flats, but also reduces the costs associated with oyster shell disposal, thereby promoting circular resource utilization.

Figure 8. Recycled oyster shells used as eco-revetments for stabilizing tidal flats and promoting resource reuse (Qinzhou Municipal Oceanic Bureau, 2025)

(4) Monetizing the Ecological Value of Mangroves through Innovative Blue Carbon Trading

The project achieved Guangxi's first mangrove-based blue carbon trading initiative (Figure 9) by utilizing carbon sequestration generated from 11.72 hectares of newly planted mangroves in Peacock Bay. Of this, 500 tons of carbon credits were transacted to offset the carbon emissions of the First China–ASEAN Blue Economy Forum, thereby achieving a "zero-carbon conference" and advancing the concept of low-carbon, environmentally sustainable development. A closed-loop carbon sink trading system was established, integrating mangrove restoration, carbon sequestration assessment, market-based value transfer, and revenue reinvestment. This approach yielded dual benefits of ecological carbon sequestration and economic returns, pioneering a new pathway for realizing the value of ecological products by linking marine ecological governance with economic benefits.

Figure 9. Guangxi's first blue carbon trading: exploring new pathways for realizing the value of ecological products (Guangxi Zhuang Autonomous Region Oceanic Bureau, 2023)

(5) Technology Empowerment: Building an Intelligent Marine Early Warning and Disaster Reduction System

A comprehensive “Sky–Land–Sea” integrated marine early warning and monitoring system has been established, deploying more than 50 sets of equipment and facilities, including surveillance cameras, wave spectrum buoys, hydrological–ecological buoys, unmanned aerial vehicles (UAVs), unmanned surface vessels for marine ecological monitoring, and underwater online observation systems. In addition, three major marine observation networks and laboratories have been upgraded, enabling real-time collection of 12 categories of ecological parameters. An intelligent decision-making and management platform has been developed, integrating 900,000 datasets (hydrological, ecological, and disaster-related, both historical and real-time). This system enables real-time monitoring of mangrove growth, rapid detection of ecological anomalies, and early warning of marine disasters, significantly strengthening the intelligent and digital capacity of the integrated marine disaster prevention and mitigation framework, and promoting the shift from “passive disaster prevention” to “proactive disaster resistance.”

IV Accomplishment

(1) Establishing Triple Defenses and Significantly Enhancing Marine Disaster Prevention and Mitigation Capacity

Within the inner bay, 512.99 hectares of mangroves have been restored, forming a “mangrove–ecological revetment” coastal protective belt that serves as an effective barrier against typhoons and storm surges (Figure 10). Estimates indicate that wave height attenuation in the mangrove restoration area reached up to 32.4%. With the continued recovery of the ecosystem, the efficiency of disaster mitigation is expected to improve year by year. Following the implementation of the tidal channel dredging project in the central part of the bay, the average flow velocity in the inner bay increased by 11.3%, the tidal inflow by approximately 10.7%, and the tidal outflow by about 18.1%, thereby effectively enhancing the bay’s water exchange capacity [5]. On the outer bay side, the dry beach width increased to 15–30 meters. The combined system of beach nourishment and windbreak shelterbelts reduced the average wave height by up to 63.7%, effectively protecting roads, towns, and scenic areas located behind the coastline (Figure 11). In 2024, this system successfully withstood the direct landfall of Super Typhoon Yagi, providing empirical evidence of the comprehensive effectiveness of the bay-wide disaster prevention and mitigation system.

Figure 10. Building a green mangrove barrier for disaster prevention and mitigation (left: before restoration; right: after restoration; Qinzhou Municipal Oceanic Bureau, 2019, 2023)

Figure 11. Stabilizing coastal structures to enhance disaster reduction functions
(left: before beach restoration; right: after restoration; Qinzhou Municipal Oceanic Bureau, 2021–2024)

(2) Improving Natural Habitats and Enhancing Ecological Vitality of the Bay

Through ecological restoration, approximately 2,162 meters of artificial shoreline have regained ecological functions and been designated as restored ecological shorelines. The water quality at river estuaries entering the bay improved from Class V to Class III. The average canopy coverage of the mangrove communities increased by approximately 1.8% to 12%, with the communities overall undergoing positive successional development. Biodiversity also improved significantly: after restoration, 92 bird species were recorded, belonging to 12 Orders and 34 Families, including six species listed as Near Threatened or above in the national Red List of Protected Animals. Newly recorded migratory species included *Phoenicurus auroreus* (Daurian redstart), *Parus minor* (Japanese tit), *Anthus trivialis* (tree pipit), *Tringa nebularia* (common greenshank), and *Tringa totanus* (common redshank) (Figure 12). The number of intertidal and benthic species increased by 57% and 21%, respectively [6].

Figure 12. Habitat improvements in the area: a paradise for wildlife
(Qinzhou Municipal Oceanic Bureau, 2024)

(3) Leveraging Ecological Advantages to Promote Economic and Industrial Development

The significant enhancement of ecological functions has stimulated regional tourism (Figure 13). In 2024, the area received 3.213 million tourists, an increase of about 9.5% year-on-year. Capitalizing on restored beaches, a cluster of new coastal homestays attracted RMB 50 million in investment, creating niche services such as “starry sky sea view rooms.” Retired aquaculture farmers and local villagers benefited from increased incomes, with tourism-related consumption reaching RMB 2.722 billion, up 9.7% year-on-year. The ecological dividend has also promoted industrial agglomeration. In 2024, the China–Malaysia Industrial Park in the region achieved a GDP exceeding RMB 25.5 billion. In the 2024 national comprehensive evaluation of economic development zones, the China–Malaysia Industrial Park ranked 3rd in Western China and 34th nationwide, becoming the first economic development zone in Guangxi to enter the national top 40.

Figure 13. Environmental improvements in the area boosting local cultural tourism development (Xili Bay Scenic Area, 2023)

(4) Promoting Green Concepts with Broad Public attention and Recognition

Marine carbon sink trading has effectively explored new pathways for transforming "lucid waters and lush mountains" into "gold and silver mountains (invaluable assets)," providing a model for the valuation and trading of marine carbon sinks. The establishment of a mangrove marine science education base has integrated ecological restoration with science popularization and public education, continuously strengthening public awareness of marine conservation and allowing "green" concepts to take root and flourish. This initiative was designated as a Guangxi Marine Science and Awareness Education Base (Figures 14 and 15). The restoration experience has been widely covered by CCTV News, China Daily, CCTV-10, and Guangxi Daily (Figure 16). A thematic micro-video on ecological restoration, Declaration of Symbiosis, won First Prize at the 10th National Brand Story Competition Grand Final. Within the region, Peacock Bay Scenic Area was designated a National AAA Tourist Attraction, while the project won Guangxi's highest construction quality honor, the

Zhenwu Pavilion Award, and was recognized as a Model Case of Ecosystem Product Value Realization in Guangxi (Second Batch).

Figure 14. Student field trips based on the ecological restoration project (Qinzhou Municipal Oceanic Bureau, 2022)

Figure 15. Awards and media coverage (Qinzhou Municipal Oceanic Bureau, 2022–2024)

V Alignment with IUCN Nature-based Solution Global Standard

In accordance with the IUCN Global Standard for Nature-based Solutions officially released in 2020, a self-assessment of this case was conducted, with the following results.

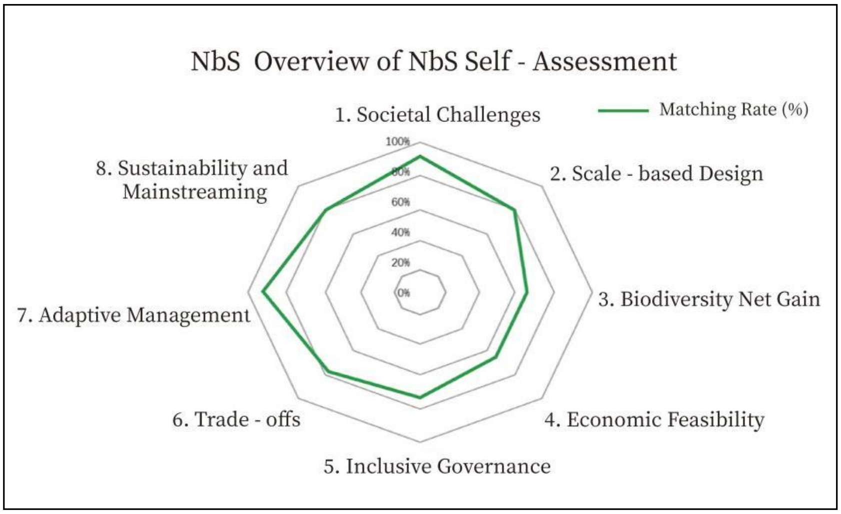

Figure 16. Radar chart of NbS self-assessment for this case

First, through field surveys and data collection, the project accurately identified societal challenges, including climate change mitigation and adaptation, disaster risk reduction, ecological degradation, and biodiversity loss. Extensive consultations were held with stakeholders such as aquaculture operators, and performance indicators—including improved living environments and enhanced disaster risk reduction capacity—were incorporated into the evaluation metrics. These measures demonstrate strong alignment with Criterion 1 (Addressing Societal Challenges).

Second, following the principles of "land–sea coordination, holistic conservation, systematic restoration, and integrated management," the project developed an integrated "outer bay–inner bay–land–sea" ecological disaster reduction system. The resulting benefits extend to surrounding areas, supporting high-quality regional development. Restoration measures were refined through multiple rounds of stakeholder consultation, and environmental impact assessments were carried out with relevant authorities, showing high alignment with Criterion 2 (Design at Appropriate Scales).

Third, two marine ecological baseline surveys were conducted prior to implementation, with annual monitoring (1–4 times) of key indicators such as mangroves, intertidal organisms, and birds, as well as overall evaluations of project effectiveness. Biodiversity in the bay improved significantly. However, detailed assessments of ecological corridors and migratory species remain insufficient. Overall, the project is broadly aligned with Criterion 3 (Biodiversity Net Gain).

Fourth, alternative restoration options—such as mangrove planting and tidal channel dredging—were compared, and private capital was successfully introduced. The project generally clarified both direct and indirect costs and benefits. However, quantitative evaluations of indirect costs and benefits remain limited. Thus, the project is broadly aligned with Criterion 4 (Economic Feasibility).

Fifth, active stakeholder coordination was undertaken, and a stakeholder feedback and grievance resolution mechanism was established. Local residents were engaged in project implementation, creating job opportunities. However, gaps remain in ensuring stakeholder participation throughout the full NbS intervention process, making the project broadly aligned with Criterion 5 (Inclusive Governance).

Sixth, feasibility studies and cost–benefit analyses were conducted. In addressing disputes over marine area ownership, stakeholders' rights were respected, and restoration schemes were optimized to resolve conflicts. A sound project management system and regular inspection mechanism were also established, making the project broadly aligned with Criterion 6 (Balanced Trade-offs).

Seventh, full-cycle monitoring and evaluation were carried out before, during, and after project implementation. Environmental issues identified during monitoring were analyzed, and restoration schemes were iteratively adjusted in response. This is highly consistent with Criterion 7 (Adaptive Management).

Eighth, a marine science education museum was established, integrating ecological restoration concepts into public education, and promoting both scientific innovation and environmental awareness. Restoration achievements and experiences were widely disseminated, providing valuable references for policymaking and bay management. This is broadly aligned with Criterion 8 (Sustainability and Mainstreaming).

Recommending Institution: Guangxi Zhuang Autonomous Region Oceanic Bureau

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Eco-DRR Case of Coastal Dune Restoration and Disaster Mitigation in Taeanhaean National Park, South Korea

I Information

Taeanhaean National Park, located in South Chungcheong Province, South Korea , spans approximately 326 km² and was designated as South Korea's 13th national park in 1978 (renamed in 1990)[1]. Its 1,352 km coastline includes 530 km under national park management, featuring 72 islands and 26 beaches with diverse landscapes such as rocky shores[2], tidal flats, and unique coastal dunes shaped by ria coastlines and erosion[3]. These dune ecosystems exhibited the typical characteristics of coastal protective belts even before restoration efforts, providing multiple disaster risk reduction functions.

Figure 1. Ecological Restoration Sites of 14 Coastal Dunes in Taeanhaean National Park

Historically, Taean’s dunes formed an 80-meter-wide natural barrier (1978 data), supporting local fisheries and tourism. Post-1970s human activities reduced dune width to <30 meters by 2000, with coastline retreating at 1.2 meters annually. Typhoon-induced seawater intrusion threatened communities, prompting the Ministry of Environment and KNPS to launch a national restoration project in 2001 targeting core dune areas(Figure 1). This area had long served as a critical coastal protection belt with ecological functions including windbreak, sand stabilization, and storm surge defense, while also providing habitats for rare psammophytes (sand-adapted plant) and coastal bird species. Through systematic ecological restoration, the project successfully recovered both the disaster prevention functions and biodiversity of the dune system, establishing Taeanhaean National Park as a model case of coastal ecosystem restoration in South Korea.

II Issues

The degradation of Taean's coastal ecosystem stems from multiple human-induced disturbances. While the dense construction of artificial structures along the shore provides short-term protection, it alters natural hydrodynamic conditions, causing abnormal concentration of wave energy that actually worsens localized erosion(Figure 2). Upstream water conservancy projects and soil conservation measures have drastically reduced river sediment discharge. Combined with illegal sand mining activities, these factors have deprived the dune system of material replenishment, leading to continuously declining recovery capacity.

This systemic damage has triggered severe ecological chain reactions. Key sand-fixing plants like *Leymus mollis* have largely disappeared, while dune migration rates have surged from a historical average of 0.5 meters per year to 3.2 meters. Areas with vegetation coverage below 30% experience erosion five times greater than normal zones during typhoon seasons. The sharp decline in biodiversity has significantly weakened the ecosystem's resilience, creating a vicious cycle of progressive ecological degradation.

Figure 2 Schematic Diagram of Artificial Structures and Wave Erosion
(Top left: Seawall installed to prevent coastal erosion; Top right: Vehicle damage to coastal sand dunes; Bottom left: Tsunami erosion of the coastline; Bottom right: Coastal erosion damaging coastal forests)

III Approaches

(1) Implementing Sand Traps to Assist Dune Restoration

To address dune degradation and coastal erosion, sand trapping devices have been systematically installed since 2001 in 14 vulnerable areas, including Gijipo and Sambong(Figure 3). These structures primarily consist of 1.2-meter-tall bamboo fences arranged in zigzag formations, strategically aligned with the prevailing northwest winds. The mechanism relies on wind speed reduction and sand deposition. When sand-laden sea breezes encounter the barriers, wind velocity decreases on the windward side, creating localized eddies that allow sand particles to settle and accumulate. Over time, this process fosters the formation of new dune landforms, naturally reinforcing coastal defenses. Field measurements indicate that each sand trap captures an average of 3.2 cubic meters of sand per linear meter annually. The restored dunes have proven effective in withstanding typhoons [4]. During Typhoon Lionrock in 2016, the Gijipo pilot site effectively prevented seawater intrusion, with the dune structure remaining intact, thereby verifying its disaster mitigation effect[5].

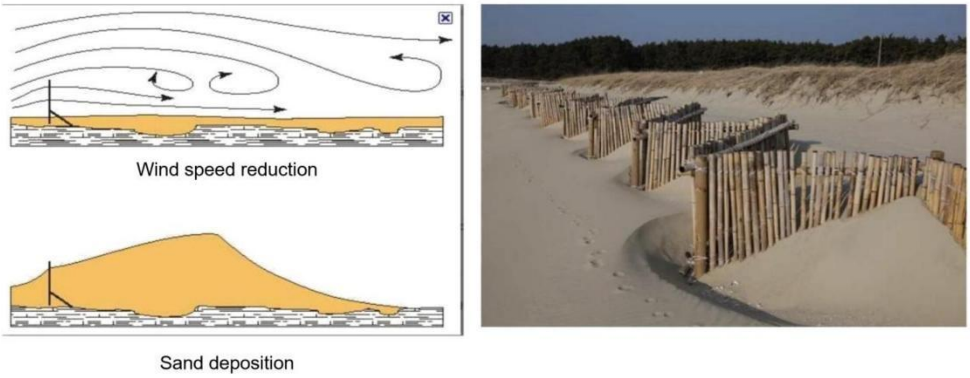

Figure 3. Schematic diagram and field photo of sand traps (Taeanhaean National Park)

(2) Establishing Volunteer Platforms to Drive Ecological Restoration and Foster Public Environmental Engagement

To address the shortage of manpower and public involvement in ecological restoration, Taeanhaean National Park has employed full-time staff and mobilized over 1,000 volunteers since 2001 to advance habitat rehabilitation efforts (Figure 4). Volunteers participate in tasks such as monitoring halophyte habitats, restoring coastal dunes, conducting beach surveys, and removing marine debris. The park provides on-site training, necessary tools, and certification to ensure participants acquire practical skills.

Figure 4. Volunteers participating in the construction of sand traps (Taeanhaean National Park)

To further engage the public, the "Happy Move" youth volunteer program is implemented, with around 100 university students organized each year to take part in coastal conservation activities (Figure 5). Volunteers take part in hands-on restoration work, including dune revegetation and invasive species removal, while receiving structured ecological training. This experiential learning model not only strengthens environmental awareness among younger generations but also cultivates sustainable conservation capacity within local communities. Additionally, the program leverages volunteers' social media outreach to amplify conservation messaging to a broader audience. [6]

Figure 5. Volunteer groups participating in coastal conservation activities (Hyundai Group)

(3) Expanding Restoration Scope for Sustainable Coastal Dune Recovery

The dune restoration project in Taeanhaean National Park has been incorporated into South Korea's long-term conservation strategy. Under the Taean Coastal Ecological Restoration Special Plan (2021-2025) approved by the Ministry of Environment, the park is systematically rehabilitating degraded dunes, with priority given to severely affected areas such as Gijipo, Meondong, and Gulhyeolpo—regions impacted by wind erosion and excessive tourist activity.As one of seven priority restoration projects outlined in the National Parks 2030 Mid-to-Long-Term Plan[7], the initiative aims to restore 0.9 hectares of dunes by 2025, with plans to extend proven methodologies nationwide. The project employs the validated sand trap system, which has demonstrated an average sand capture rate of 3.2 cubic meters per linear meter annually. Mid-term evaluations in 2023 confirmed the successful restoration of 0.4 hectares in Gijipo, achieving a 92% vegetation recovery rate.Implementation strictly adheres to the Coastal Dune Ecological Restoration Technical Guidelines (KNPS-2020-047), focusing on three key objectives: establishing an integrated coastal protection system, reviving rare psammophyte communities, and enhancing storm surge resilience. The ultimate goal is to reduce coastal erosion rates by 80% and foster a self-sustaining coastal ecosystem.

IV Accomplishment

(1) Cost-Effective Sand Barriers Demonstrate Remarkable Results

The project employs locally sourced bamboo sand barriers that deliver functional performance while significantly reducing costs(Figure 6, Figure 7). These simple structures cost just one-fifth of traditional concrete alternatives per linear meter, with substantially lower maintenance expenses. Through optimized spatial arrangements, Taean's coastal area has installed 10.7 kilometers of these sand barriers, accumulating approximately 78,900 cubic meters of captured sediment. This intervention has successfully formed a series of embryonic dune ridges averaging 2-3 meters in height and 20-30 meters in width, creating a robust foundation for subsequent ecological rehabilitation.

Installation of sand traps in 2016 | Sediment collection in February 2017 | Expansion of dune vegetation in May 2019

Figure 6. Restoration Process of the Mageompo Coastal Dunes from 2016 to 2019 (Taeanhaean National Park)

Installation of sand traps – October 2012 | Sediment accumulation observed – November 2014 | Establishment of dune vegetation – June 2016

Figure 7. Restoration Process of the Sambong Coastal Dunes from 2012 to 2016 (Taeanhaean National Park)

(2) Comprehensive Restoration of Dune Vegetation Ecological Functions

The rehabilitated dune areas have witnessed the natural regeneration of native sandbinding plant species including Asian sand sedge (*Carex kobomugi*) and sea wheatgrass (*Leymus mollis*), establishing a stable dune ecosystem. The restored vegetation forms a scientifically designed three-tiered protection system, with each plant species demonstrating distinct ecological functions. In the coastal frontline zone, Asian sand sedge effectively reduces dune mobility through its extensive root network. The transitional zone features sea wheatgrass, which exhibits remarkable salt tolerance through organic acid secretion and selective ion absorption, continuously improving topsoil conditions. Concurrently, beach morning glory (*Calystegia soldanella*) forms natural sand barriers via its sprawling rhizome network, demonstrating exceptional adaptability to harsh coastal environments.

The inland zone is reinforced with rugose rose (*Rosa rugosa*) shrubs, whose deep root systems and dense foliage create a dual windbreak mechanism. This synergistic plant community has increased overall vegetation coverage from below 30% to 60%. Notably, the decaying plant matter continuously enriches the sandy soil, improving its physicochemical properties and providing sustained nutrient cycling. This gradient configuration has not only enhanced system stability but also significantly improved disturbance resistance, serving as a successful model for coastal ecological restoration.

(3) Synergistic Benefits of Disaster Risk Reduction and Carbon Sequestration

The restored dune system has demonstrated significant disaster prevention functions. By reducing wind speed and blocking drifting sand, dunes serve as effective windbreaks and sand stabilizers. At the same time, their accumulated sand volume can absorb and dissipate the energy of storm surges and waves, thereby mitigating damage from typhoons and tsunamis. In combination with dune vegetation, the system can withstand wind waves generated by typhoons and reduce flooding impacts caused by rising tidal levels (Figure 8). Monitoring data indicate that 3-meter dunes can effectively reduce wave run-up by 40%, while vegetation coverage of 60% can efficiently block sediment carried by storm surges[8].

Dune restoration, together with the planting of native wind-resistant vegetation, has also enhanced carbon sequestration capacity, contributing positively to climate change mitigation. Studies have shown that healthy and stable dune vegetation systems possess much higher carbon storage potential compared with bare or degraded dune areas, thereby providing dual benefits of coastal protection and carbon sequestration.

Figure 8. Representative coastal natural resources after restoration (Taeanhaean National Park)

V Alignment with IUCN Nature-based Solution Global Standard

A self-assessment was conducted in accordance with the IUCN Global Standard for Nature-based Solutions, officially released in 2020. The results are as follows:

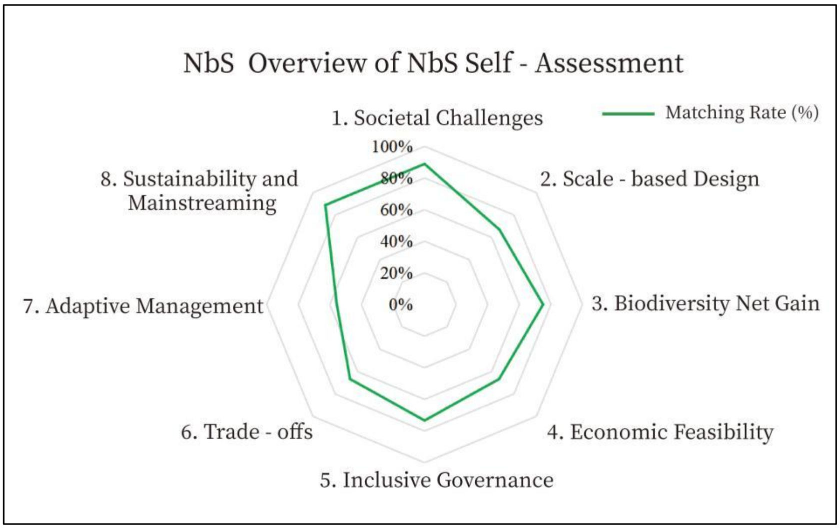

Figure 9. Alignment with NbS standard self-assessment

The Taean Coastal Dune Ecological Restoration Project, assessed against the IUCN NbS Global Standard, demonstrates significant achievements across multiple criteria, while also revealing areas that require further improvement.

In terms of addressing societal challenges (Criterion 1), the project strongly aligns with the core principles of NbS. By accurately identifying coastal erosion and ecological degradation as primary issues, the project prioritized dune restoration and adopted engineering-based interventions such as sand-trapping fences. As a result, 6.575

hectares of dune ecosystems were successfully restored. The establishment of a multi-stakeholder collaboration mechanism significantly enhanced implementation efficiency, and the restored dunes now provide reinforced coastal protection. As South Korea's first coastal dune restoration demonstration project, its technical approaches have been integrated into the national park management system and expanded to the private sector through corporate partnerships. Furthermore, sites such as Gijipo have become important environmental education hubs, where deep community engagement has not only advanced ecological restoration goals but also helped promote broader environmental awareness. These achievements align closely with Criterion 1 and Criterion 8.

Regarding biodiversity net gain (Criterion 3), more than ten species of dune plants have naturally regenerated in the project area. Notably, the successful reestablishment of keystone species such as sedges indicates the formation of a stable vegetation community, meeting a high degree of alignment with the standard. However, the absence of pre-project baseline biodiversity data and the lack of a well-developed quantitative monitoring system currently limit the scientific assessment of ecological outcomes. Future efforts should focus on supplementing baseline biodiversity surveys and establishing a systematic long-term monitoring framework to enable more comprehensive and objective evaluation of the project's impact on biodiversity.

For design of NbS is informed by scale and inclusive, transparent and empowering governance processes (Criteria 2 and 5), the project is considered to be largely aligned. It spans 14 dune sites with wide geographical distribution, addressing ecosystem protection, carbon sink enhancement (through the restoration of ten native dune plant species), and ecotourism potential—demonstrating integration across ecological, economic, and social dimensions. A multi-actor governance model involving government leadership, corporate funding, and volunteer participation has been adopted. However, the project has not yet systematically identified potential risks outside the intervention sites, and the mechanism for balancing community interests lacks institutional design—highlighting areas for optimization.

In terms of economic sustainability (Criterion 4), the project meets the basic alignment criteria. The public-private partnership ensures funding input, and indirect benefits from ecotourism enhance long-term viability. However, as required by Criterion 4, there is a need for clear cost accounting and mechanisms to secure long-term funding, which remain to be clarified.

Trade-off management (Criterion 6) is partially addressed through visitor control measures that support a preliminary balance between ecological and economic interests and reflect public participation rights. However, mechanisms for livelihood compensation for key stakeholders such as fishers and tourism operators are lacking, and no quantitative assessment has been conducted—thus only meeting basic alignment with Criterion 6.

Regarding adaptive management (Criterion 7), although the project applies scientific principles (e.g., sand trap technology) to support dune restoration and plans to continue efforts through 2025, it has yet to establish routine monitoring systems for key indicators such as dune stability. Additionally, no clear framework for strategy iteration is in place, resulting in only partial alignment.

Recommended by: IUCN China Office

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Eco-DRR Case of Coastal Mangrove Restoration in Demak District, Indonesia

I Information

Demak district is located adjacent to the Java Sea, approximately 26 km from Semarang, the capital city of Central Java. Its coastal areas cover 13 villages including Bedono and Timbulsloko in Sayung Subdistrict, with a lowland topography of 0-3 m elevation. Over 30% of the area is used for agriculture, and the rest for settlements, yards, aquaculture and infrastructure. The region faces major risks from coastal erosion, driven by mangrove loss (extensive conversion to aquaculture ponds in the 1980s), sediment reduction due to development in Semarang, and land subsidence from groundwater extraction (exceeding 8 cm per year in some areas).

Coastal ecological restoration in Demak has undergone a significant shift from traditional single measures to systematic governance. Early mangrove planting efforts (pre-2015) struggled in high-wave conditions (average wave height 1.5–2.5 m) and increased water depth (reaching 80–120 cm in parts), resulting in seedling survival rates below 30%. Since 2015, Wetlands International and Ecoshape, in collaboration with the Indonesian government, implemented the Building with Nature approach. (Figure 1) Starting from Timbulsloko village, the project aimed to promote natural mangrove regeneration along a 20-kilometre coastline and boost sustainable aquaculture. This involved techniques such as installing temporary permeable structures and introducing eco-friendly aquaculture practices. Beyond engineering interventions, the case engaged local communities, government agencies and knowledge institutes to address the root causes of coastal breakdown and deliver multiple benefits. It also supported upscaling the approach elsewhere through training and knowledge exchange. The ecological, social and economic success of the efforts leads to the belief that this approach can be mainstreamed on many other coastlines with similar problems.

Figure 1. Overview of the implemented measures in Demak (Wetland International)

II Issues

Demak District is facing a severe compound ecological crisis, driven by the combined effects of human activities and natural processes. Since the 1980s, large areas of mangroves have been converted into aquaculture ponds. This, together with sediment loss caused by the expansion of Semarang city and excessive groundwater extraction (leading to land subsidence of up to 8 cm per year in some areas), has resulted in coastal retreat of 25-50 m annually. Between 2003 and 2012, more than 500 hectares of aquaculture ponds were engulfed (Figure 2), and several villages became accessible only via raised causeways. A Deltares modelling report warns that, under a ten-year scenario without intervention, high rates of subsidence could bring economic losses of up to €1.8 billion, with 70,000 people and 6,000 hectares of aquaculture ponds at serious risk[2].

Conventional restoration measures implemented before 2015 suffered from systemic shortcomings and failed to deliver the expected outcomes. Monitoring data show that the single-species mangrove planting programs carried out between 2010 and 2014 achieved seedling survival rates of less than 30%, far below the expected 70% standard[4]. The failure was mainly due to three factors: (i) strong wave conditions with an average annual wave height of 1.5-2.5 m, far exceeding the tolerance of mangrove seedlings; (ii) subsidence-induced water depths of 80-120 cm across 60% of the planting sites, surpassing the optimal 20-50 cm growth range for mangroves; and (iii) the mono-species planting strategy lacked ecological diversity, preventing the formation of a stable protective system.

With sea-level rise exacerbating ongoing subsidence, ecosystems continue to degrade. Salinization is threatening agricultural productivity, while infrastructure is at growing risk. Conventional sea dykes are not only prohibitively expensive but also worsen erosion by blocking sediment deposition, making them ineffective against relative sea-level rise. This vicious cycle underscores the urgency of developing innovative ecological restoration strategies.

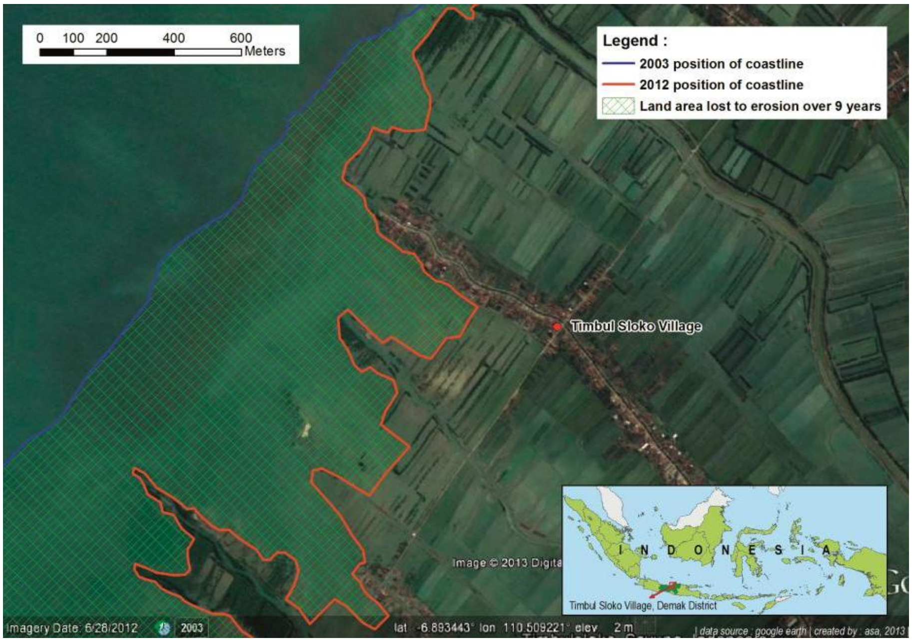

Figure 2. Estimated land loss of 200-900 meters between 2003 (blue line, Google Earth image) and 2012 (orange line, Google Earth image) due to erosion in Demak District, Central Java, Indonesia[3].
(Apri Susanto)

Figure 3. Flooding over sea wall. (Stephan Verschure)

III Approaches

(1) Rebuilding Mangrove Ecosystems

Mangroves are highly resilient and adaptive; their seeds naturally exist in coastal waters and can regenerate if suitable habitat conditions are provided. In Demak, two key measures were adopted:

(a) The construction of permeable structures mimicking mangrove roots

The Building with Nature project constructed 3.425 km of semi-permeable structures along the coastline. The Indonesian government subsequently replicated this approach nationwide, achieving a total construction length of 23 km. These semi-permeable structures were initially made of locally sourced bamboo and brushwood (Figure 4; later replaced by PVC pipes filled with concrete to resist shipworm damage). By mimicking mangrove root systems, these structures dispersed wave energy and created an environment favorable for mangrove seedling growth. Field measurements showed that wave heights were reduced by 10%-60%, supporting the long-term objective of replacing artificial structures with naturally regenerated mangroves.

By 2017, severe land subsidence submerged monitoring poles and newly established vegetation. Nevertheless, the structures continued to capture sediment and mitigate erosion, proving their important value as transitional protective measures. However, achieving long-term sustainability will require addressing broader systemic issues such as hydrological processes and land-use practices.

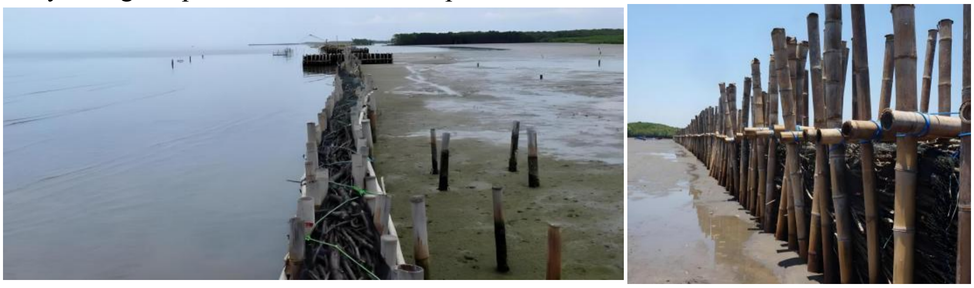

Figure 4. Permeable structures constructed by Wetlands International in Demak (top) and by Ministry of Marine Affairs and Fisheries of Indonesia in East Lombok (bottom).
(Yus Rusila Noor/Wetlands International Indonesia (top) and the Ministry of Marine Affairs and Fisheries of Indonesia (bottom))

(b) Converting ponds to grow mangrove greenbelts

In areas with moderate erosion, abandoned aquaculture ponds along the Demak coast were transformed into "tidal sedimentation basins" by restoring tidal connectivity (Figure 5). Through adjustable sluice gates, the basins were selectively connected to the sea, allowing seawater and mangrove seedlings to enter while preventing strong waves from damaging seedlings. This system promoted both sediment deposition (averaging about 10 cm per year) and mangrove regeneration, while also functioning as temporary flood retention zones to reduce inundation risks for nearby villages. Unlike conventional planting approaches, engineers designed an adaptive system that enabled mangroves to "grow back by themselves". Former pond bunds were removed, sluice gates installed to regulate water inflows, and permeable structures applied to slow water velocity and trap sediments without blocking tidal movement.

These measures created an ideal environment for mangrove establishment: soft sediment foundations gradually accumulated, salinity levels remained within the optimal range for seed germination, and seeds carried by the tides could naturally settle and root. Monitoring data show that within just two years, more than one-third of the naturally dispersed seeds had successfully developed into seedlings.

Figure 5. Mangrove seedlings. (Kuswantoro/Wetlands International Indonesia)

(2) Boosting community prosperity

The coastal communities of Demak once relied heavily on aquaculture, transforming mangroves into ponds for substantial income. But by 2015, yields dropped by 60–80% due to environmental degradation. Mangrove restoration can actually support sustainable aquaculture by serving as natural wave buffers and improving water quality. By repositioning mangroves as a complementary component of aquaculture landscapes, rather than a competing land use, a more resilient coastal economy becomes possible.

(a) Coastal Field Schools

Coastal field schools were established to build the capacity of small-scale aquaculture farmers in sustainable practices that support both livelihoods and coastal ecosystems (Figure 6). Facilitated by local experts from the Indonesian NGO Blue Forests and the Faculty of Fisheries and Marine Science at Diponegoro University, these schools offered training on coastal and pond ecology, mangrove functions, and improved management techniques, focusing on the Low External Input Sustainable Aquaculture (LEISA) system. It encouraged the use of local natural inputs to boost pond fertility and promote diverse co-culture of species and enhance resilience.

Figure 6. Participants of a post-field school planning workshop for greenbelt recovery. (Boskalis)

Figure 7. Farmers working together to realign the dyke of the associated mangrove aquaculture system. (Wetlands International)

(b) Associated Mangrove Aquaculture

Another innovation promoted during the case was Associated Mangrove Aquaculture (AMA) (Figure 8). AMA establishes mangrove buffers outside the pond boundaries, constructing a double bund line parallel to riverbanks, with sluice gates that control water flow and encourage sedimentation between the bunds. This newly formed habitat allows for natural mangrove colonisation, and once the forest matures, the river-facing bund can be removed to restore a more natural shoreline. In the double-bund system, the outer bund served as a barrier against daily wave action, while the inner bund functioned as an emergency flood defense, with sluice gates enabling rapid water release during extreme events. The mangrove buffer that developed between the bunds significantly reduced disaster risks for aquaculture ponds, lowering the frequency of flood damage from 3-4 times per year to less than once annually. Although AMA requires farmers to forgo a portion of their pond area, this trade-off is typically offset by improved yields and pond resilience. Its ecological impact is amplified when implemented across entire river or canal systems, thus gained rapid popularity in farmers.

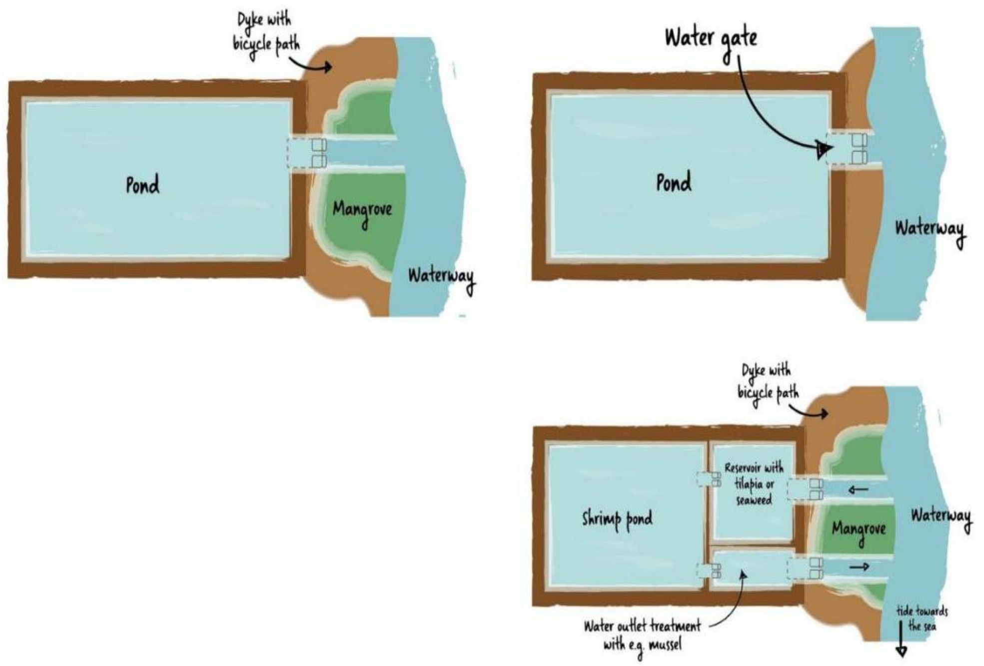

Figure 8 Above: Overview of a common pond without mangrove (right) and a standard associated mangrove aquaculture pond for a single farm (left) Below: A complex associated mangrove aquaculture system for better water management. (Roel Bosma)

(c) Bio-rights and Alternative Livelihoods

The Bio-rights mechanism linked conservation with community livelihoods by offering loans to those who adopted sustainable aquaculture and mangrove restoration. Repayment was waived if environmental and livelihood goals were met, encouraging accountability and long-term conservation. Funding supported activities like building permeable structures and converting degraded ponds. Over time, community perceptions shifted regarding pond management, coastal protection, and biodiversity conservation, leading to the formation of the "BINTORO" group(Figure 9) to advance the Building with Nature project. This mechanism not only enhanced community livelihoods but also strengthened social cohesion and environmental governance.

Figure 9. Meeting Community Ocean Forum BINTORO.
(Kuswantoro/Wetlands International Indonesia)

(3) Adaptive management

The Building with Nature approach is grounded in a system of adaptive management. In Demak, this approach was operationalised through a combination of biophysical and socio-economic monitoring, covering indicators such as sediment accumulation rates, mangrove regeneration success, aquaculture yields, and household income levels(Figure 10). Both project staff and community members engaged in detailed and routine data collection and interpretation to guide real-time decision-making. An annual planning and adaptation cycle (Figure 11) was developed to align ecological rhythms with institutional processes. During the November to February, comprehensive data was gathered and analyzed to inform revisions of ecosystem engineering and socio-economic strategies. Preliminary designs were drafted and adjusted in April based on monitoring outcomes and stakeholder consultations, with final designs completed by May to match government planning and budgeting cycles. June and July were dedicated to further monitoring, allowing refinements in coastal safety interventions. Field implementation of these measures was scheduled for September and October. In contrast, socio-economic interventions followed the aquaculture production calendar, which varied across localities and therefore required more flexible timing.

Figure 10. Community group of Berkah Alam from Surodadi Village conducting monitoring of mangrove growth and water quality in their associated mangrove aquaculture pond. (Netherlands Enterprise Agency on behalf of the Dutch Ministry of Foreign Affairs)

Figure 11. Annual cycle Building with Nature measures. (Wetlands International)

IV Accomplishment

(1) Remarkable Achievements in Coastal Ecological Restoration

The case has achieved remarkable results. Through the installation of 23 kilometers of permeable structures that mimicked mangrove root systems (including 3.425 km contributed by the Building with Nature project), the annual coastline erosion rate was reduced from 25-50 meters to less than 5 meters[1]. Numerical simulations confirmed that these structures reduce wave transmission energy by 20%-30%[5]. Sedimentation rates increased from an average of 0.195 cm per year during 2011-2013 to 0.4 cm per year in 2016, representing a 104% increase, with some areas accumulating more than 25 cm of sediment within three years[6].

The disaster risk reduction benefits of mangrove restoration were particularly evident: the rehabilitation of 119 hectares of mangrove ecosystems reduced wave heights and significantly mitigated the impacts of storm surges. Community surveys indicated property damage reduced by 40% after mangrove regrowth near dwellings[2]. In addition, Demak successfully placed 60 hectares under strengthened protection, expanding the total mangrove area from 409 hectares to 455.79 hectares, thereby forming a more complete ecological protection belt.

(2) Comprehensive Enhancement of Ecosystem Services

Beyond disaster risk reduction, mangrove restoration in Demak has significantly improved multiple ecosystem services. Studies showed that the restored mangroves increased annual carbon storage by about 8.3 Mg C/ha, with a total carbon sequestration of approximately 987.7 Mg C per year, equivalent to absorbing 3,621 tons of CO_2[2]. This value is largely consistent with the regional average for Southeast Asian mangroves (10.1±1.7 Mg C/ha/yr).

Biodiversity monitoring revealed that fish species richness in the restored areas increased from 1.2 to 2.4, while benthic biomass grew 3.8-fold, and the key indicator species Scylla serrata reappeared. The reconstruction of 60 hectares of tidal channels successfully re-established the “mangrove-mudflat-shallow sea” ecological chain, providing habitat for 47 fish species and 29 benthic organisms. Quarterly assessments across 23 monitoring sites ensured that engineering measures did not negatively affect sensitive species[6].

(3) Sustainable Community Development and Improved Well-being

Demak has achieved a win-win outcome for ecological conservation and community development through innovative governance. More than 80% of participating farmers adopted LEISA across 464 hectares (Figure 12), using natural fertilizers and polyculture techniques. Shrimp yields increased up to sixfold, while profit margins grew threefold. Through a bio-rights mechanism, 78 hectares of abandoned ponds were converted into mangrove habitat, contributing to a 32% increase in household income.
Community-based management has also proved highly effective. In 2018, ownership of the permeable structures was formally transferred to local communities, marking a transition from externally driven management to community stewardship. The BINTORO community organization has played a central role in maintaining coastal

defense structures and conducting ecological monitoring, establishing a sustainable management model. This positive cycle of “ecology-disaster risk reduction-economy” provides valuable lessons for other coastal regions.

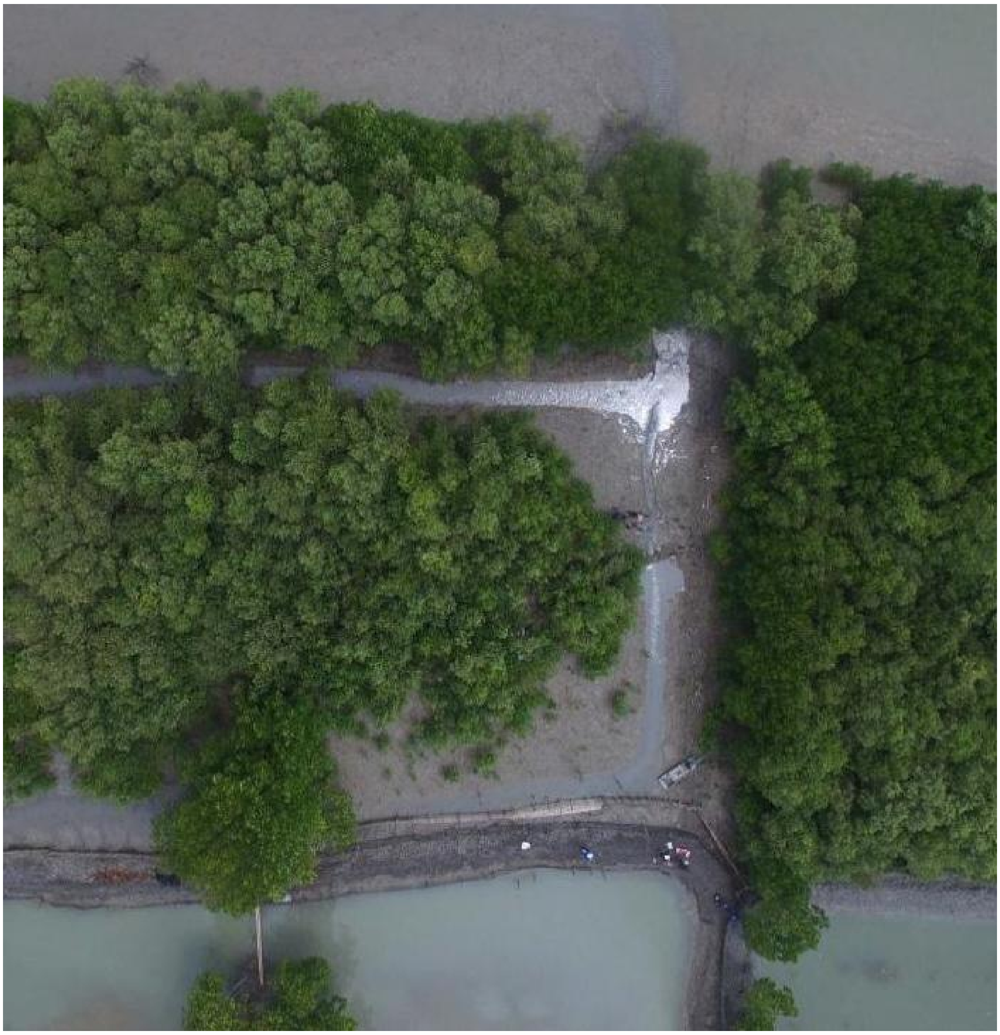

Figure 12. Associated mangrove aquaculture pond in Timbulsloko showing natural mangrove restoration. (Wetlands International)

V Alignment with IUCN Nature-based Solution Global Standard

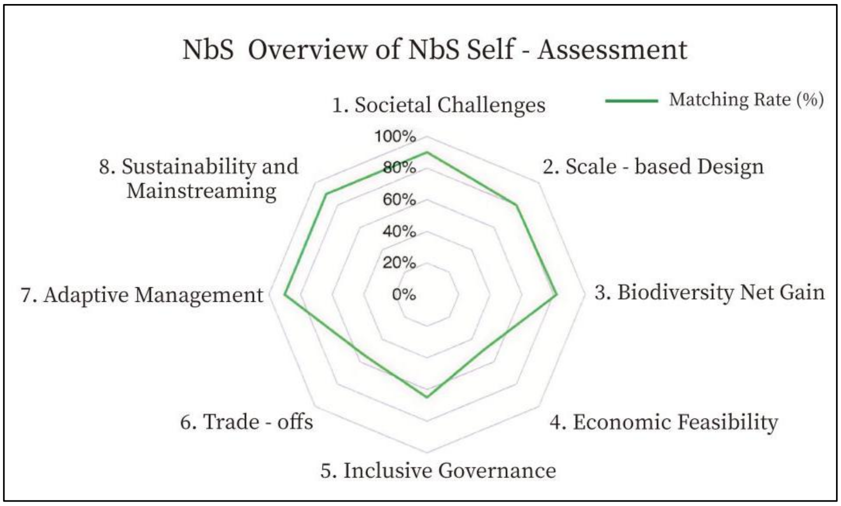

Figure 13. Alignment with NbS standard self-assessment

The project conducted a self-assessment based on the IUCN Global Standard for Nature-based Solutions (NbS) issued in 2020, with the following results (Figure 13):

For societal challenges (Criterion 1), the case targeted coastal erosion, community livelihood decline, and ecological degradation. By restoring mangroves, constructing permeable structures, and promoting sustainable aquaculture, it achieved disaster reduction, economic development, and biodiversity protection, showing strong adherence with Criterion 1. In terms of design at scale (Criterion 2), the case implemented coastal ecological restoration at local scales while enhancing community livelihoods. At regional scales, it identified land subsidence and cross-regional hydrological connections, facilitating provincial policy coordination, integrating efforts across communities, governments, and NGOs to couple ecological-social systems, therefore is highly compliant (Criterion 2). Regarding net gain to biodiversity (Criterion 3), the case used permeable structures to facilitate sedimentation and restored tidal connectivity to degraded ponds. These efforts provided habitats for mangroves and fish, leading to a significant increase in fish populations and enhanced ecosystem integrity. This matched well with Criterion 3.

The case established a monitoring system covering sediment thickness, mangrove survival rates, and household income. It implemented an annual cycle of "data collection-design adjustment-project implementation" aligned with the monsoon season. This flexible approach informed national policies and created a responsive management loop, satisfying the criterion of adaptive management (Criterion 7). Regarding sustainability and mainstreaming, the case was incorporated into local and national planning. The Indonesian government set up a Presidential Task Force to promote the Building with Nature approach nationally, making the project a global model for climate adaptation and biodiversity protection.This achievement closely aligns with the mainstream criteria for mainstreaming NbS (Criterion 8).

Balanced trade-off (Criterion 6) is a common challenge in project implementation. The case compared natural solutions with traditional sea walls. Through relevant mechanisms, it balanced protection and livelihoods with regular monitoring to maintain ecological and economic equilibrium. However, it lacked quantitative cost-benefit analysis, resulting in only partial alignment with Criterion 6. In terms of economic feasibility (Criterion 4) and inclusive governance (Criterion 5), the case leveraged community participation and public-private partnerships. Yet, the available materials didn't present a full cost-benefit analysis or clear definition of stakeholders' rights and responsibilities, leading to only partial fulfillment of these criteria.

Overall, this case study demonstrates the integrated ecological, social, and economic benefits achievable through NbS. It effectively reduced losses from natural disasters and provides a replicable model for enhancing resilience in coastal regions.

Recommended by: IUCN China Office

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Eco-DRR Case of Beach-Dune-Lagoon Restoration and Disaster Mitigation in La Pletera, Spain

I Information

The La Pletera case study area is situated in Torroella de Montgrí on the northern coast of Catalonia, Spain, covering a total area of 63 hectares. It borders farmland to the west, residential areas to the north, the Mediterranean Sea to the east, and the Ter River to the south. As a key component of the Montgrí Natural Park, the Illes Medes archipelago, and the Baix Ter Natural Park, the area is included in the European Natura 2000 protected area network. The region experiences a typical Mediterranean climate characterized by dry summers and rainy autumns, resulting in irregular hydrological patterns. It is susceptible to marine storms and heavy rainfall, leading to frequent flooding or increased salinity during droughts. This dynamic environment supports diverse ecosystems such as coastal lagoons, Mediterranean salt meadows, and dunes (Figure 1), with approximately 58.7% of the area designated as Habitats of Community Interest[1].

Figure 1. Schematic Diagram of the Overall Layout of the Case Study Area (LIFE Pletera)

In the late 1980s, local urbanization projects severely damaged the La Pletera coastal salt marsh ecosystem. Large amounts of construction waste were dumped into the salt marsh area to raise ground levels, and when the projects were abandoned, unfinished roads and derelict buildings were left behind.

From the 1990s onwards, three major measures were undertaken to address the habitat loss caused by urbanization: the removal of land reclamation structures, the creation of artificial lagoons, and the restoration of coastal dunes. These interventions restored hydrological connectivity in the area, significantly improving drainage capacity and resilience to both droughts and floods. The reconstructed dune–salt marsh complex ecosystem enhanced coastal protection functions and restored key ecological services, while biodiversity increased markedly. In addition, adaptive management was carried out through dynamic monitoring and the adjustment of management strategies, supported by a collaborative governance mechanism involving government, researchers, and local communities. These efforts not only strengthened long-term ecological restoration and conservation, but also promoted tourism development, thereby achieving a synergistic outcome of ecosystem recovery, sustainable management, public education, and local economic benefits.

II Issues

In the late 1980s, as part of urbanization projects involving land reclamation, large quantities of construction waste were dumped into the salt marsh area to raise ground levels, leading to significant habitat fragmentation and changes in geomorphological structure (Figure 2). These infill materials not only interfered with the natural hydrological cycle and soil ecological environment of the salt marsh but also obstructed normal seawater flow, causing hydrological system disruption and reduced drainage capacity in the salt marsh. The direct consequences included increased flood risk, disruption of salinity balance, and severe threats to the survival of endemic species like the Spanish Toothcarp *(Aphanius iberus)*. Such anthropogenic terrain modification has hindered the formation of dune morphology (Figure 3), further weakening the region's resilience to natural disasters and resulting in frequent flooding events that caused ongoing negative impacts on residents' lives and regional economic development.

Figure 2. Damage to the Coastal Salt Marsh Caused by Tourism Development Plans (Institut Cartogràfic i Geològic de Catalunya, 1986)[2]

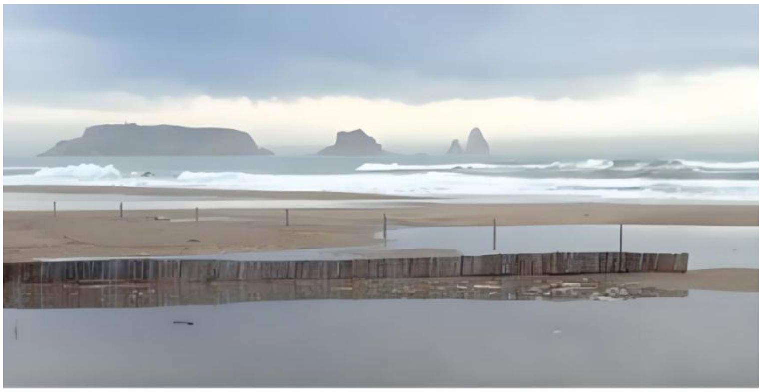

Figure 3. State of the Beach Dunes in 2012 (Dune morphology was difficult to form due to the coast's inability to dissipate storm energy) (Roig-Munar et al., 2022)[3]

The sharp increase in tourist numbers ,particularly during the 1990s and early 2000s driven by the boom in Mediterranean package holidays and the growing popularity of Costa Brava as a mass tourism destination,also impacted the salt marsh ecosystem, damaging its already fragile vegetation communities and biological habitats, while placing persistent pressure on ecological restoration efforts. Simultaneously, due to the lack of a robust community participation mechanism in the past, the salt marsh's ecological functions (such as carbon sink regulation, coastal protection) and their ecosystem service value were not promoted within the context of local development. This meant that urban development was often prioritised over ecological protection, further exacerbating the conflict between human activities and ecological conservation and undermining the provision of important ecosystem services.

III Approaches

(1) Synergistic Structural Ecosystem Restoration and Ecological Disaster Risk Reduction

To address habitat fragmentation and hydrological barriers caused by urbanization, La Pletera demolished the unfinished infrastructure from the 1980s (Figure 4) and removed approximately 200,000 m^3 of infill material. This restored the elevated terrain to its original altitude, eliminating the blocking effect of artificial structures on salt marsh hydrology. Some structures were preserved as landscape markers. For example, an abandoned transformer building was converted into a bird observatory, achieving both ecological restoration and preserving the site's historical memory.

Figure 4. Demolition of Abandoned Facilities (LIFE Pletera)

During the de-urbanization process, 21 new permanent artificial lagoons were created in the area (Figure 5). These lagoons are distributed in parallel bands along the coastline and feature gradient depth design to rebuild tidal connectivity and water retention functions during the dry season. The deepest zone is below sea level, maintaining a permanently flooded state. Shallow areas connect to the sea at high tide and form independent habitats at low tide. Additionally, by lowering the banks of natural lagoons to 1.1 meters, the exchange of materials with surrounding water bodies was restored, thereby improving water quality and organic matter cycling capacity[4].

Figure 5. Artificial Lagoons (Torroella de Montgrí Town Council, 2018)

To address dune morphological damage and reduced disaster prevention capacity caused by storm erosion, a dune restoration project was implemented along a 1-kilometer stretch of coastline in La Pletera to rebuild the dune-salt marsh complex ecosystem. By installing sand fences to promote aeolian sand deposition (Figure 6) and planting salt-tolerant vegetation to stabilize dune morphology (Figure 7), the total dune volume increased by 71.5% compared to pre-restoration, with an average height increase of 1 meter. Furthermore, a gradient transition zone was created between the dunes and lagoons using a mixed substrate of clay and sand to create diverse microhabitats, supporting the natural succession of halophytic plant communities[6].

Figure 6. Composite Sand Fence Engineering (LIFEPletera)

Figure 7. Artificial Dunes Completely Recolonised by Dune Vegetation between 2002 and 2016 (Garcia-Lozano et al., 2022)[7]

(2) Adaptive Management and Dynamic Regulation

A hydrological-ecological monitoring network was established to continuously collect key indicator data such as salt marsh water levels, soil salinity, vegetation succession, and biological communities(Figure 8). Simultaneously, dune migration rates and lagoon water quality parameters were monitored, with management plans dynamically adjusted annually based on the data. In 2017, tidal gate operation strategies were optimized based on monitoring results, cumulatively improving carbon sequestration efficiency by 12%, fully demonstrating the feasibility and effectiveness of dynamic adaptive management[11].

To address threats from invasive species and degradation of native species habitats, regular species surveys were conducted, and targeted conservation measures implemented. Starting in 2016, deep-water refuges were constructed and maintained for the Spanish Toothcarp for five consecutive years, while the population density of the invasive Eastern Mosquitofish (*Gambusia holbrooki*) was monitored and controlled quarterly. Following habitat optimization, the breeding success rate of the Kentish Plover (*Charadrius alexandrinus*) cumulatively increased by 30%, and its population maintained stable growth. These measures not only effectively protected key species but also enhanced the overall stability of the salt marsh ecosystem through cascading effects in the food chain .

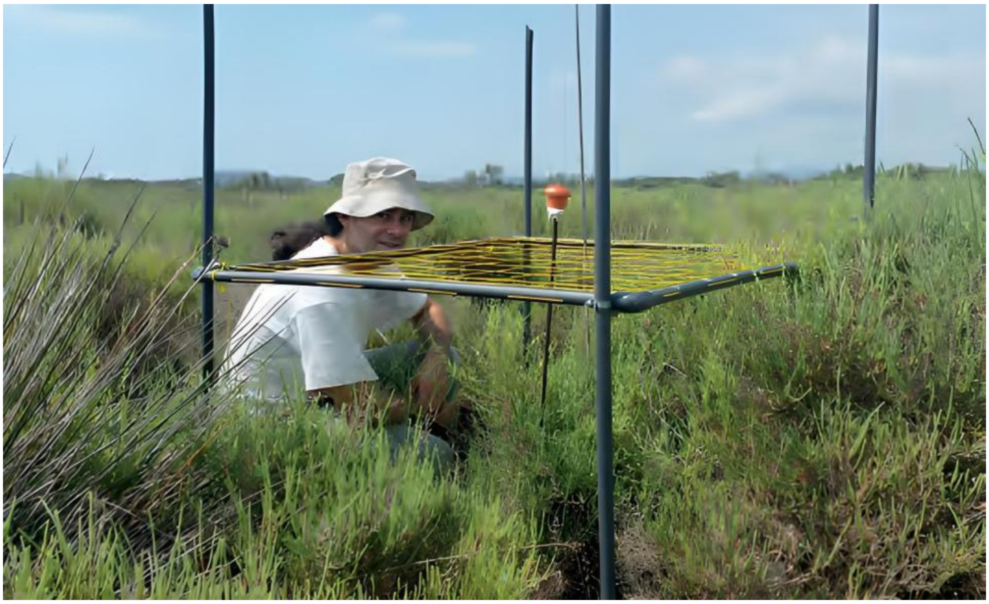

Figure 8. Local Residents Monitoring Vegetation (LIFE Pletera)

Through a deep integration model of policy-research-practice, efforts were actively made to seamlessly link the restoration project with regional policies, integrating it into the European Natura 2000 network and securing long-term support through the European Green Deal. Concurrently, La Pletera salt marsh collaborated with the University of Girona on research projects such as salt marsh carbon stock assessment and climate change impact simulations on hydrology. The research results directly served management decisions, forming a "Monitoring-Research-Adjustment" loop[1].

(3) Social Value and Cultural Empowerment

To harmonize ecological protection and public education, a spatial zoning management model was adopted: 30% of the core area was designated as a strict protection zone, while elevated wooden boardwalks and multilingual interpretation systems were installed in the buffer zone. This minimized disturbance from human activities while raising public environmental awareness, reducing tourist damage to surface vegetation, and ensuring sustainable coexistence between visitor activities and ecological conservation.

A tripartite collaborative governance framework of “Government-Research-Community” was constructed to promote multi-stakeholder participation and sharing. This mechanism was led by the Torroella de Montgrí Town Council for implementation.

The University of Girona provided technical support for ecological monitoring. Local residents participated in image documentation and public awareness through photography associations, collaborated with the local museum to design educational routes, and combined field observation and specimen-making activities to build a comprehensive ecological education system. Furthermore, installation art and video works themed around salt marsh restoration were created, establishing a visual archive to further enhance community emotional connection and participation awareness in ecological restoration[6].

IV Accomplishment

(1) Synergistic Effects of Ecosystem Restoration, Disaster Reduction, and Carbon Sink Enhancement

The ecological restoration project increased local species richness by 183%[7], forming a complete food web centered around the Spanish Toothcarp, the Gull-billed Tern (*Gelochelidon nilotica*), and the Kentish Plover. The coastal lagoon area expanded to 24 hectares, becoming a vital habitat for endangered species in the Mediterranean region. The breeding pair count of Kentish Plovers doubled compared to pre-restoration (Figure 9), verifying the improvement in habitat quality for this key species.

Figure 9. Kentish Plover Habitat Restored (LIFE Pletera)

The reconstructed dune-salt marsh complex ecosystem demonstrated significant protective efficacy during the Gloria storm event in 2018. The dune complex effectively dissipated storm energy, reducing the flood inundation area in surrounding regions by 40% compared to historical periods (Figure 10). The drainage capacity of the salt marsh increased by 50%, prolonging surface runoff retention time by approximately 2 to 3 hours during heavy rainfall, significantly alleviating urban waterlogging pressure. During drought periods, the salt marsh maintained the inundation of key habitats, enhancing ecosystem stability[5].

The carbon sink system formed by salt marsh vegetation and soil achieved an annual carbon sequestration rate of 28.86 kg/ha, providing crucial support for regional carbon neutrality goals. By optimizing lagoon water circulation processes (e.g., adjusting tidal gate operation strategies), carbon sequestration efficiency was cumulatively increased by 12%, further highlighting the key role of ecological restoration in enhancing blue carbon sink capacity[4]. Simultaneously, the amplitude of water salinity fluctuations decreased by 30%, dissolved oxygen content increased by 15%, and the ecosystem health index significantly improved[1].

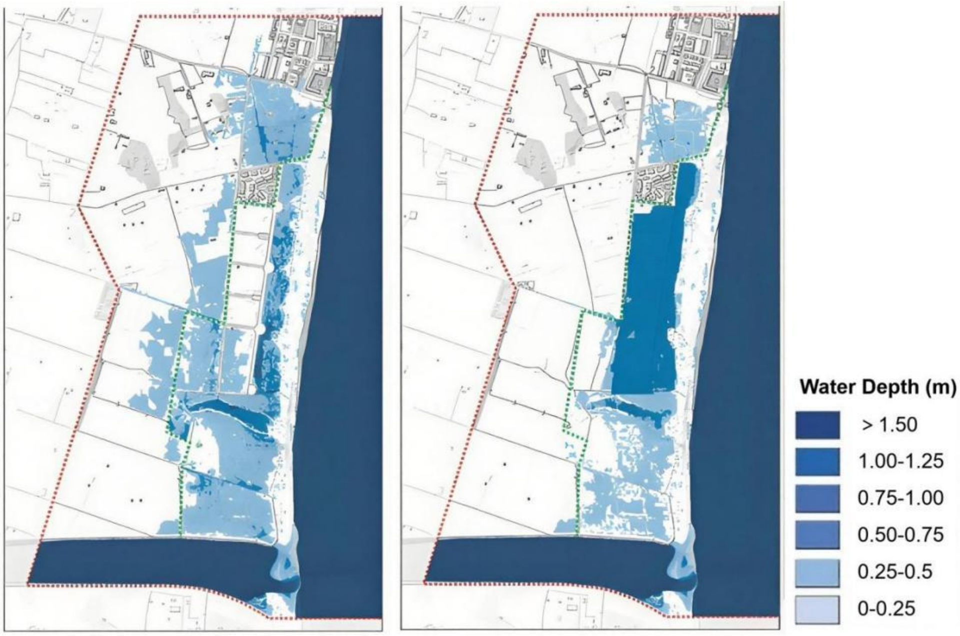

Figure 10. Hydrological Simulation Comparison of Coastal Storm Inundation Areas Before (Left, 2014) and After (Right, 2018) Case Implementation (Quintana et al., 2018)[5]

(2) Mutual Promotion of Socio-Economic Development and Conservation

The restored area has developed into a core ecotourism destination for the region, receiving 126,000 visitors in 2022, a 65% increase compared to pre-restoration, with a visitor satisfaction score of 8/10[6]. The development of high-end tourism products like bird-watching tours and nature photography effectively stimulated a 12% annual income growth in surrounding guesthouses and restaurants, achieving a virtuous cycle of mutual promotion between ecological conservation and economic development[6].

Multiple long-term management and maintenance positions were created, attracting local residents to actively participate in ecological monitoring and visitor guidance, forming a mechanism where ecological protection and employment reinforce each other. Through focus group discussions and public consultation meetings, La Pletera coastal zone successfully secured support from 85% of local residents for incorporating salt marsh protection into local development plans, significantly enhancing community awareness and recognition of ecological conservation.

Simultaneously, market-based sustainable operational mechanisms were actively explored. In collaboration with the Barcelona Stock Exchange, a pilot for trading “Blue Carbon” products was successfully developed and launched. The first batch of carbon sink quotas for 100 hectares of salt marsh has been pre-sold, providing a stable source of funding for subsequent conservation and management work.

(3) Successful Construction of a Long-Term Sustainability Safeguard System

To ensure the long-term sustainability of restoration benefits, the project established a long-term safeguard mechanism. Regarding the scientific monitoring system, an assessment system covering core indicators such as biodiversity and carbon stocks was established, jointly implemented by the University of Girona and natural park institutions. Regular public reports are issued to ensure ecological functions are quantifiable and traceable. Regarding market-based operational mechanisms, through blue carbon product trading and the development of agricultural products with "eco-labels", the premium effect of the salt marsh brand is utilized to form a circular economic model where ecological protection promotes economic income. Regarding policy mainstreaming, the case was included in the “Best Practices for Nature-based Solutions in the Mediterranean”, prompting the Spanish government to build a 120-kilometer-long ecological restoration belt along the Catalan coast. It also connects with the European Green Deal and the Natura 2000 network, achieving a systematic upgrade from local restoration to a regional ecological resilience network.

V Alignment with IUCN Nature-based Solution Global Standard

A self-assessment of the project was conducted according to the IUCN Global Standard for Nature-based Solutions (NbS) officially issued by IUCN in 2020. The assessment results are as follows:

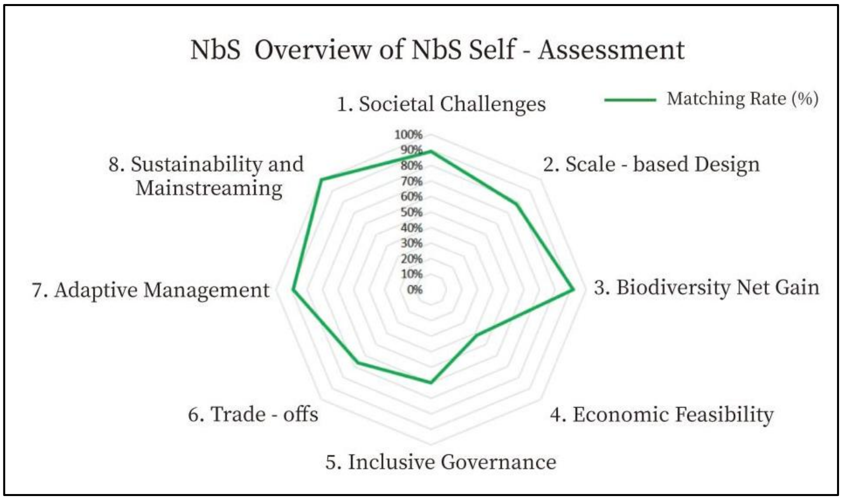

Figure 11. Alignment with NbS standard self-assessment

Criterion 1 (Social challenges): La Pletera coastal zone simultaneously addressed multiple challenges (disaster risk reduction, biodiversity loss, socio-economic development) through measures like removing abandoned infrastructure and restoring hydrological systems, forming a comprehensive solution integrating ecological conservation and economic development. A tripartite collaboration mechanism with local government, university, and community was established early on, involving multiple rounds of consultation with full records. The restored salt marsh system not only enhanced disaster prevention capabilities but also drove ecotourism development (65% visitor growth in 2022), achieving an ecological-economic win-win. Highly matches the core requirements of Criterion 1.

Criterion 2 (Scale-based design): La Pletera coastal zone formed a network at the regional scale with the 120 km coastal restoration belt. At the site scale, multi-scale hydrological control was achieved through 21 gradient-depth lagoons. The dune restoration increased volume by 71.5%, forming a complex ecosystem with lagoons. The effectiveness of the design was validated during the 2018 Gloria storm (40% reduction in surrounding inundation area). Cross-sectoral research confirmed economic-social-ecological interactions, but long-term cross-jurisdictional cooperation mechanisms still need strengthening. Basically matches Criterion 2.

Criterion 3 (Net gain on biodiversity): Ecosystem restoration results were significant: native species richness increased by 183%, forming a complete food web centered on Spanish Toothcarp and Kentish Plover. Deep-water refuges increased breeding success for endangered species by 30%. The dune-lagoon transition zone design enhanced landscape connectivity by 35%. Highly matches Criterion 3. Shortcomings: the invertebrate monitoring system is incomplete; long-term ecological observation points are needed.

Criterion 4 (Economic feasibility): Initial investment was secured by combining EU funds with local matching funds. Partial economic self-sufficiency was achieved using "ecosystem service fees". However, the implementation process lacked cost-effectiveness assessment. Long-term maintenance of restoration measures still relies on external funding. Market mechanisms like salt marsh carbon trading and eco-labeled products are not yet mature. Partially matches the relevant requirements of this criterion.

Criterion 5 (Inclusive governance): The case innovatively adopted an integrated "Engineering-Policy-Community" model, enhancing community participation through art programs and ecological education. Decision-making processes maintained complete archives, but records of consulting indigenous peoples were insufficient. Buffer zone boardwalk design balanced protection and education needs, but public opinion adoption rates lack quantitative indicators, and feedback mechanism response efficiency needs improvement. Basically matches this criterion.

Criterion 6 (Balanced trade-off): Balance between protection and use was achieved through spatial zoning: strict protection in the core area and visitor flow limits in the buffer zone. Monitoring showed an 80% decrease in vegetation damage by visitors post-restoration, but no quantitative trade-off model was established. Land tenure was fully confirmed through municipal planning, but scientific research on ecosystem service thresholds needs deepening. Basically matches this criterion.

Criterion 7 (Adaptive management): A dynamic "Monitoring-Assessment -Adjustment" management mechanism was established. In 2017, tidal gate operation was optimized based on data, increasing carbon sink efficiency by 12%. An annual hydrological-ecological monitoring network continuously tracks 21 parameters. Highly matches this criterion. Recommendation: Systematically transform research results into management tools; improve knowledge management systems.

Criterion 8 (Mainstreaming for sustainability): The practices were listed as "Best Practice for NbS in the Mediterranean Region," prompting Catalonia to issue the Coastal Zone Ecological Restoration Guidelines. It provides an implementation pathway ("Ecological Engineering - Policy Integration - Community Participation") and capacity-building training for NbS in similar areas. Criterion 8 is therefore strongly adhered to.

Recommended by: IUCN China Office

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