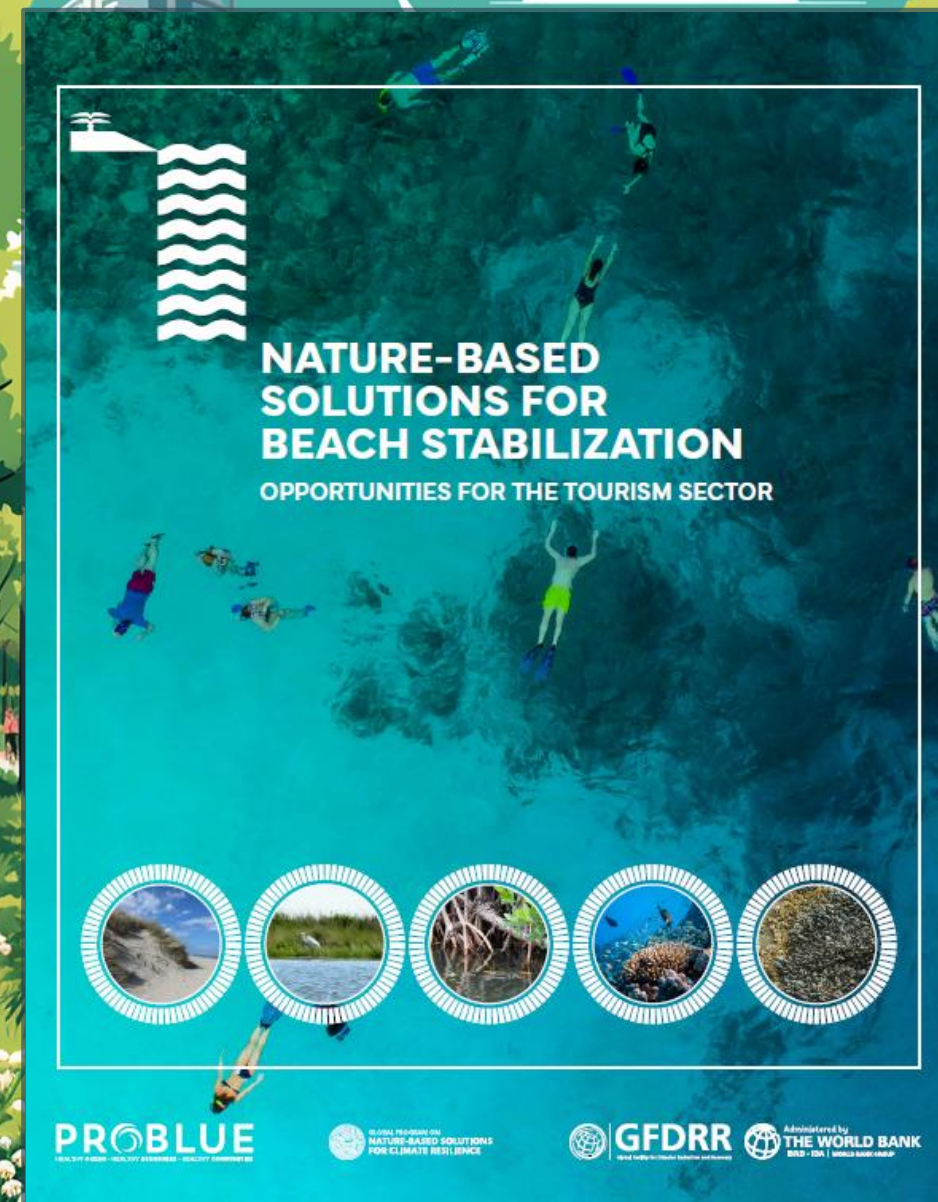


Nature-based Solutions for Beach Stabilization

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GPNBS aims to increase the uptake of NBS across the World Bank portfolio,
through 3 pillars of activities:

1

PILLAR 1

KNOWLEDGE



2

PILLAR 2

OPERATIONS



3

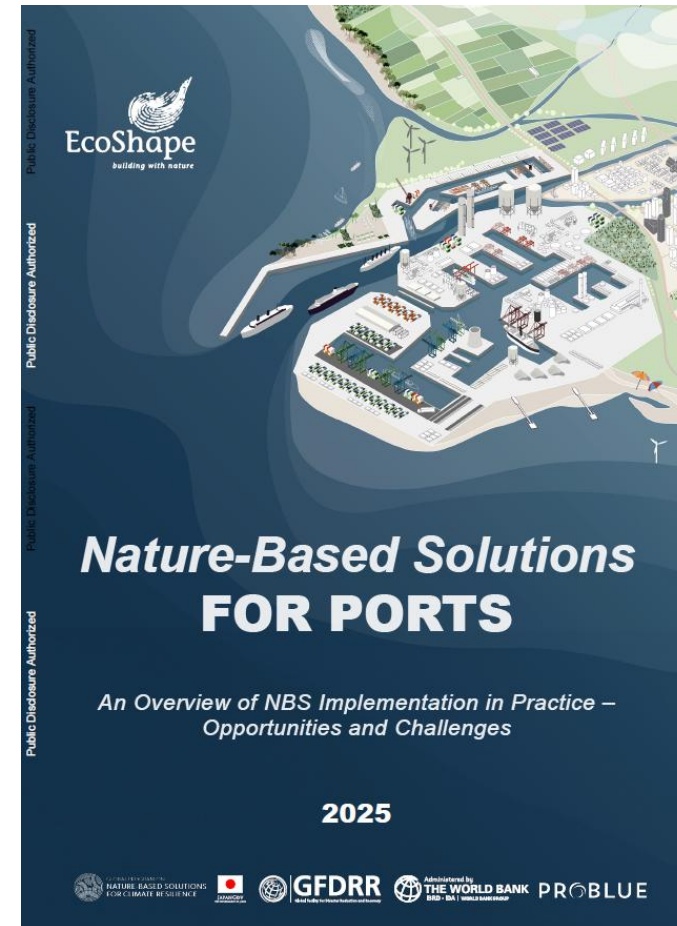
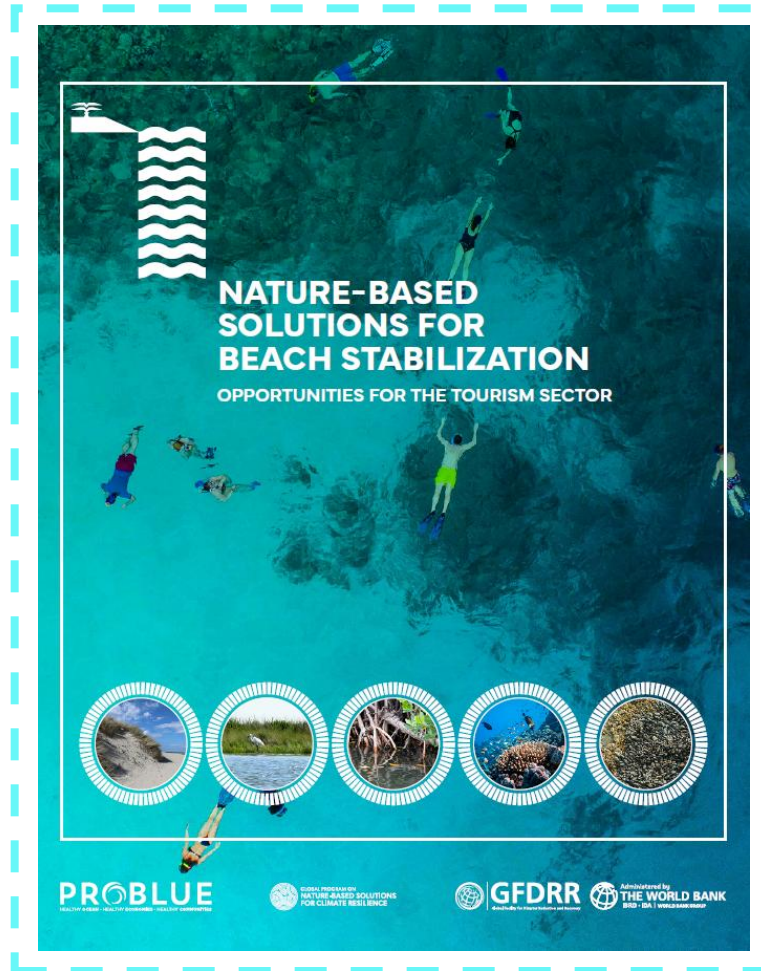
PILLAR 3

PARTNERSHIPS



KNOWLEDGE PRODUCTS

Selected knowledge products – also available at naturebasedsolutions.org



REPORT STRUCTURE

FIGURE 0.0 STRUCTURE OF THE REPORT AND KEY QUESTIONS ADDRESSED



Source: Authors' elaboration.

THE BUSINESS CASE FOR THE TOURISM INDUSTRY

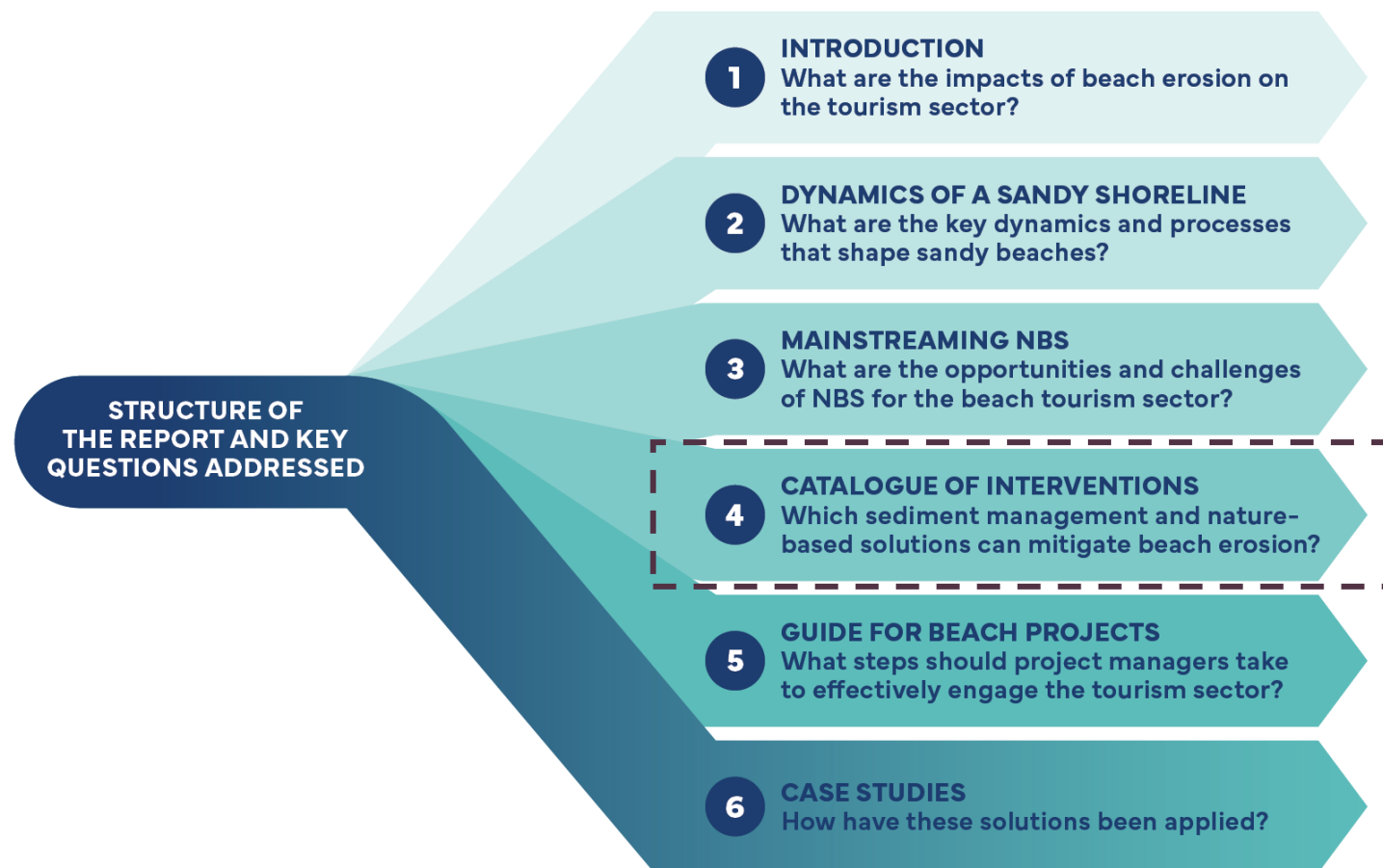
FIGURE 3.1 RECAP OF BENEFITS PROVIDED BY NBS FOR BEACH STABILIZATION AND POTENTIAL IMPACTS FOR TOURISM SECTOR BUSINESSES

BENEFITS OF NBS FOR BEACH STABILIZATION	TYPES OF BUSINESS IMPACTS				
		REDUCING COSTS		INCREASING REVENUE	 IMPROVED RISK MANAGEMENT
 Cost-effectiveness in the long term		✓			✓
 Costs distribution over time		✓			✓
 Enhancement of tourism experience				✓	
 Regulatory compliance					✓
 Brand reputation and credibility				✓	✓
 Financing opportunities		✓			

Source: Authors' elaboration.

REPORT STRUCTURE (2)

FIGURE 0.0 STRUCTURE OF THE REPORT AND KEY QUESTIONS ADDRESSED



Source: Authors' elaboration.

CATALOGUE OF INTERVENTIONS

7

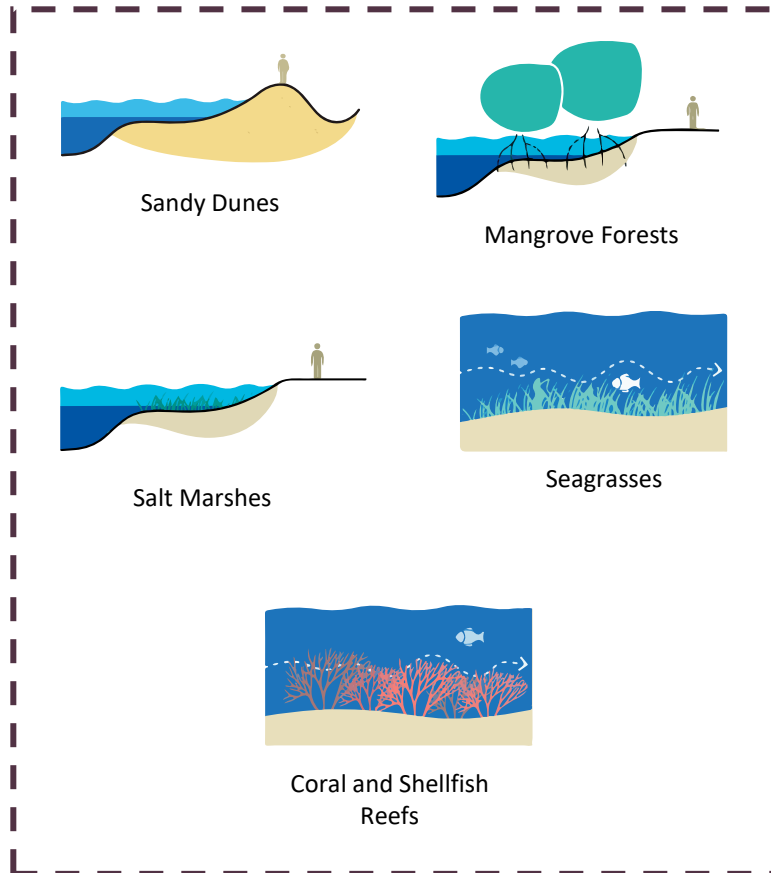
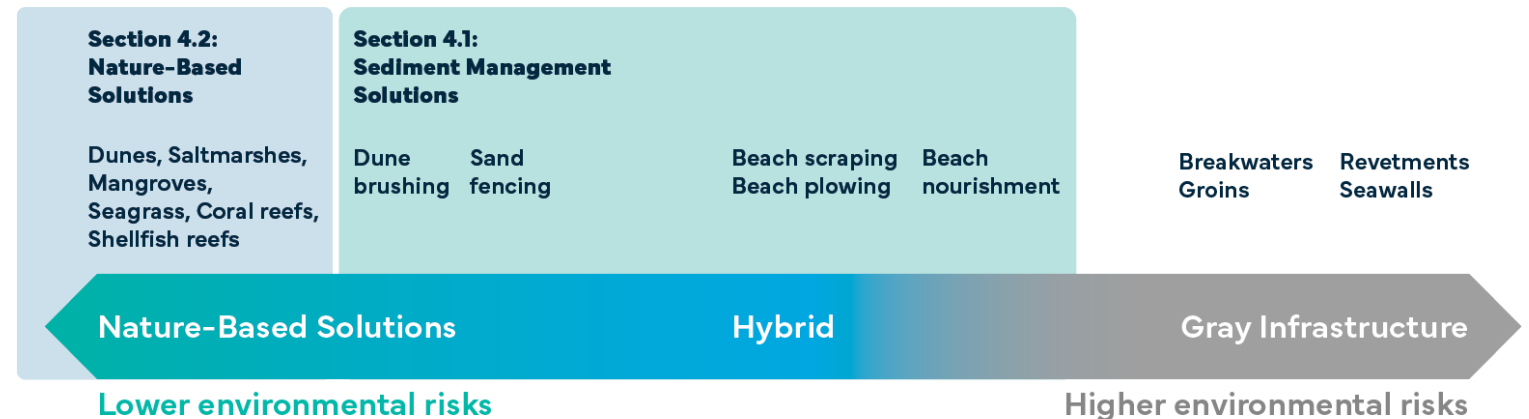


FIGURE 4.1 BEACH STABILIZATION METHODS INCLUDED IN THIS CHAPTER POSITIONED ON THE GREEN-HYBRID-GRAY SPECTRUM



Source: Authors' elaboration.

Note: This report focuses on structural and restoration methods when conservation or protection approaches are previously discarded, and active beach restoration strategies become most suitable options.

FLASHCARD EXAMPLE

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4. Beach Interventions to Mitigate Erosion 54

SAND FENCING

Sand fencing is the placement of fences along the upper beach or in the dunes to increase the capture of wind-blown sand. It is primarily used to promote the growth of dune volume, but can also be used to provide shelter to juvenile dune plants (that may have been planted as part of a rehabilitation effort) or to prevent sand from being blown farther inland. See case studies 1, 2, and 4.

SUITABLE FOR

most sites, provided it does not interfere with protected shorebird and turtle species or native vegetation and is not reached by daily high tides or minor storm waves. It can be used to build up existing dunes, create dunes at the base of banks, or form dunes in low-lying areas with blowing sand.

BENEFITS FOR THE TOURISM SECTOR

Sand fencing offers a low-cost, nonintrusive method for stabilizing sandy beaches, making it a good solution for both environmental preservation and tourism enhancement. Unlike hard structures, sand fencing helps maintain the natural aesthetic of dune environments, particularly when organic materials like wood are used.

Strategically placed sand fencing can direct pedestrian traffic to designated access points, minimizing the impact on dunes and other protected areas. This not only preserves the natural landscape but also enhances the visitor experience by providing clear paths and reducing habitat disturbance.

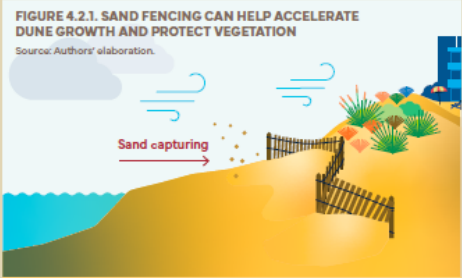
(See also: [Benefits of dunes](#))

CAPEX

Overall, the main costs in dune restoration are typically associated with dune renourishment (if required) and revegetation or planting, while fencing itself is generally relatively low-cost (RISC-KIT 2017a, 2017b). Costs will vary significantly depending on location, project scale, fencing material, and whether professional labor is required, but sand fencing projects typically have relatively low design and permitting costs and low construction costs (CZM n.d.).

FIGURE 4.2.1. SAND FENCING CAN HELP ACCELERATE DUNE GROWTH AND PROTECT VEGETATION

Source: Authors' elaboration.



BEACH STABILIZATION FUNCTION

Sand fencing promotes beach stabilization and reduces erosion risks by trapping and accumulating sand. This technique involves installing wooden (or synthetic fences) perpendicular to the prevailing wind direction, which reduces wind velocity and encourages sand deposition on the leeward side of the fence (Itzkin et al. 2020). As the wind-blown sand particles hit the fence, they lose momentum and settle, gradually building up the dune system. This accumulation of sand forms a physical barrier that protects inland areas from storm surges and high waves, thereby enhancing beach resilience. Sand fencing is particularly effective in promoting the growth of dune vegetation, which further stabilizes the accumulated sand through root systems, reducing the likelihood of erosion during severe weather events. This method has been widely studied and validated in coastal management literature as an efficient, cost-effective strategy for maintaining beach stability (Nordstrom 2021).

OPEX

Maintenance costs are expected to be low but may include repair or replacement after storm or human-induced damage. The lifespan of fences is proportional to its height relative to the speed of sand capture. Fences will gradually lose their trapping function once sand accumulates to about 80 percent of their height (Morris et al. 2021). Generally, new fences may need to be placed after three to five years (CZM n.d.).

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4. Beach Interventions to Mitigate Erosion 55

IMPLEMENTATION CONSIDERATIONS AND CHALLENGES

Understanding prevailing wind speeds and directions is essential for optimizing design and minimizing costs. Sand fences should be placed well above the high-water mark to avoid damage and to capture dry sand (Tasmanian Government 2001). Materials such as chestnut palings, brushwood, or synthetic fabrics can be used, with a solid ratio of 30–50 percent (Morris et al. 2021) and an optimal height around 0.5 meters (Lima et al. 2017). Material choice depends on lifespan, maintenance commitment, and vandalism potential (RISK-KIT 2017). However, certain designs and materials, such as sturdy drift fencing and plastic fencing, can have additional impacts that need consideration. Another concern is ensuring the fencing is not placed too close to sensitive habitats, such as nesting areas for protected shorebird or turtle species.

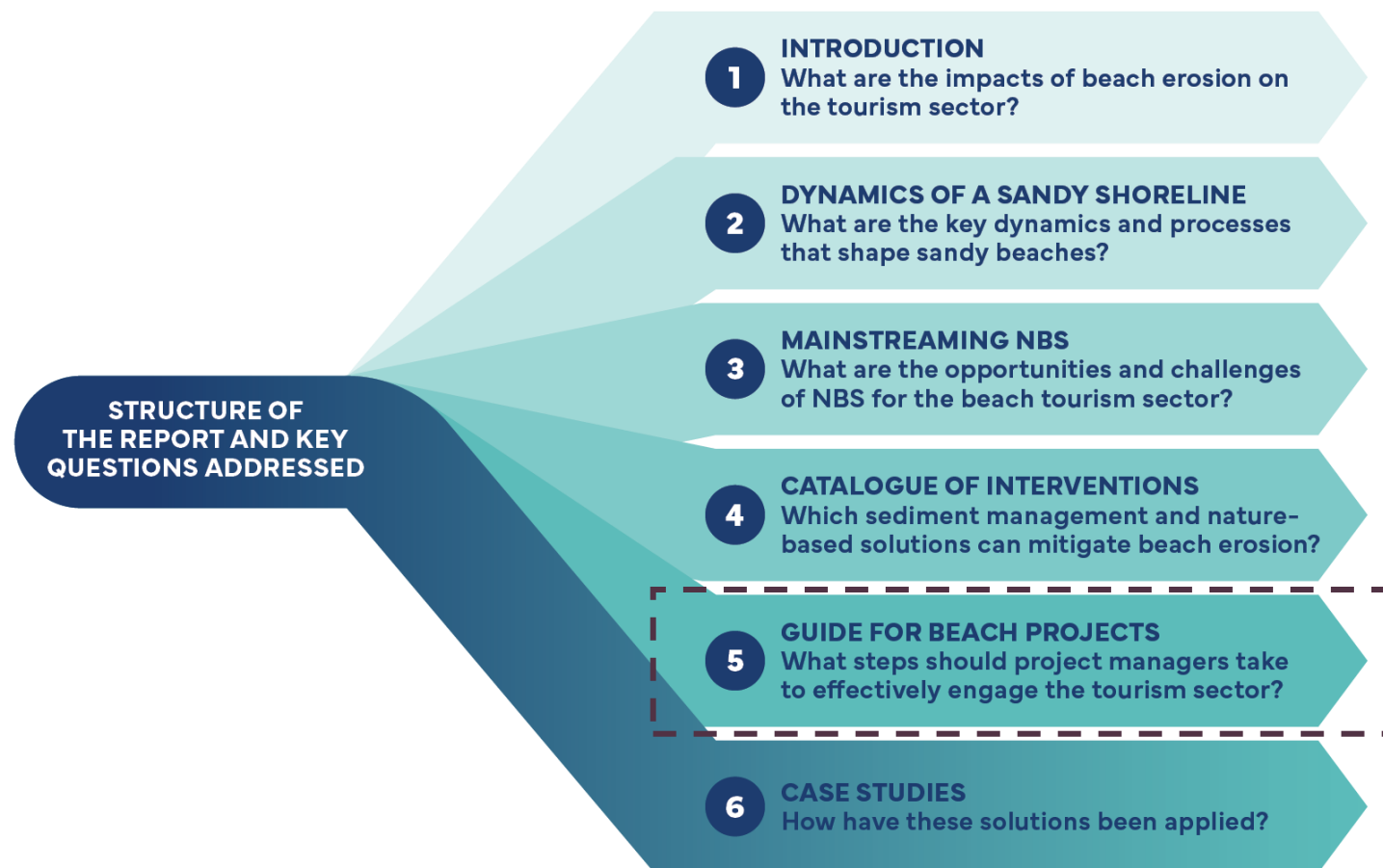


PHOTO 4.2.1. SAND FENCING WITH GEOTEXTILE GRID AIMS TO CAPTURE WIND-BLOWN SAND TO PROMOTE DUNE GROWTH

Source: Authors' elaboration (AI-generated image).

REPORT STRUCTURE (3)

FIGURE 0.0 STRUCTURE OF THE REPORT AND KEY QUESTIONS ADDRESSED



Source: Authors' elaboration.

GUIDE TO BEACH MAINTENANCE WITH TOURISM SECTOR ENGAGEMENT

FIGURE 5.1 SIX STEPS FOR IMPLEMENTING BEACH MAINTENANCE PROJECTS WITH TOURISM SECTOR ENGAGEMENT



Source: Authors' elaboration.

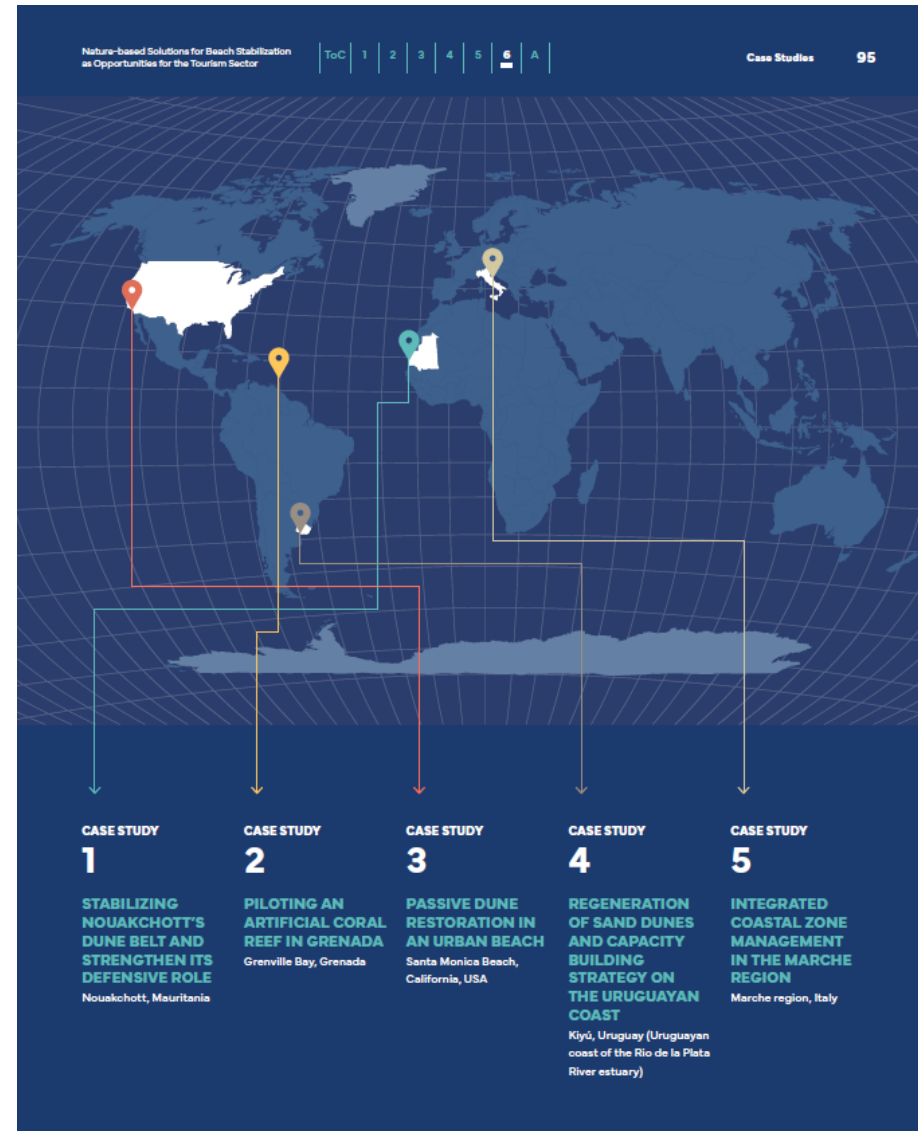
REPORT STRUCTURE (4)

FIGURE 0.0 STRUCTURE OF THE REPORT AND KEY QUESTIONS ADDRESSED



Source: Authors' elaboration.

CASE STUDIES



PASSIVE DUNE RESTORATION IN AN URBAN BEACH

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CASE STUDY 3

PASSIVE DUNE RESTORATION IN AN URBAN BEACH



LOCATION

Santa Monica Beach, California, USA

DATES AND STATUS

Intervention in 2016 and monitoring ongoing

MAIN IMPLEMENTING ORGANIZATION

The Bay Foundation, City of Santa Monica, California Department of Parks and Recreation, and the University of California, Santa Barbara

FUNDING SOURCE

The U.S. Environmental Protection Agency and the Metabolic Studio funded the initial implementation of the pilot restoration project. Research funding came from the University of Southern California, California Sea Grant Program, University of California Office of the President Climate Action Seed Fund, California Ocean Protection Council, and the National Science Foundation.

PROBLEM:

Santa Monica Beach, a globally recognized urban tourist destination, faces challenges from long-term erosion and sediment loss, worsened by sea-level rise and intensive human activities. The beach has a long history of beach nourishment. It had also been mechanically groomed for decades to enhance its appeal for recreation, leading to the removal of natural dune formations and weakening its natural defense against storm surges. To address these issues, a dune restoration pilot project was initiated to restore the beach's resilience while enhancing its value for tourism and wildlife.

INTERVENTION:

The project restored 1.2 ha of degraded beach by promoting natural dune formation through passive interventions (the sediment addition or use of heavy equipment). Key actions included the installation of sand fencing to trap sediment, halting mechanical grooming, and planting native dune vegetation. These actions helped restore the natural sand accumulation, while also making the beach more attractive to visitors.

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The project was informed by scientific assessments of wave and sediment dynamics and engaged

local tourism businesses and the community in awareness campaigns.



PHOTO 6.3. OBLIQUE AERIAL PHOTOGRAPH OF THE RESTORATION PROJECT SITE FROM THE NOVEMBER 20, 2022 UAS FLIGHT

Source: Johnston et al. 2023.
Note: Key elements have been labeled, including the project boundary, perimeter fence, various habitat types, adjacent groomed beach (control site), and the incipient foredune ridge. Alongshore distance of the site was ~150 m, with a dune cross-shore length of ~80 m.

OUTCOMES AND SUCCESSSES:

- The restoration used 1-meter wood slat sand fences, a central path through the restoration area, seeding of California native perennial dune plant species, two interpretive signs installed along pathways, and an unenclosed perimeter on the seaward edge.
- No irrigation was used, and maintenance consisted of occasional removal of a nonnative plant.
- Sand accumulation and incipient foredune crest height: The project resulted in the accumulation of 1,777 m³ of sand, forming a 0.9-meter-high foredune, stabilizing the beach, and mitigating erosion (see Figure 6.1).
- Vegetation cover: Native plant cover reached 7 percent, with species like *Abronia maritima* and *Ambrosia chamissonis* contributing to sand stabilization.

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→ **Biodiversity benefits:** The restoration supported the return of shorebird nesting in the studied site.

→ **Following an extreme wave surge event in December 2023,** the performance of the pilot dune restoration section was compared to an adjacent mechanically groomed control site. Using total water level (wave setup, tide, wave runup) as a proxy

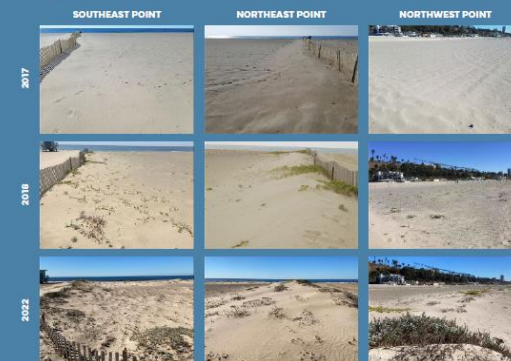
for flooding potential, the average wave runup incursion distance was found to extend 13.6 meters farther inland on the groomed control site compared to the restored dune, demonstrating the dune's effectiveness in reducing flood risk (see Figure 6.2).

→ **Increased tourism appeal:** Restored dune features and native vegetation provided a more natural beach aesthetic,

enhancing the experience for visitors.

→ **Community engagement:** Local businesses, especially those in tourism, supported the project, recognizing the long-term benefits of preserving beach assets for both visitors and residents. Awareness-raising campaigns helped promote the project as an eco-friendly initiative.

FIGURE 6.1. COMBINATION PANEL OF GEOREFERENCED PHOTOGRAPHS OF THE RESTORATION SITE OVER TIME



Source: Johnston et al. 2023.

Note: Top photographs were taken in January 2017, middle in May 2018, and bottom in November 2022. Left series is the southeastern portion of the restoration area and fence line, middle is the northeastern point and fence line, and right is the northwest point facing south across the incipient foredune ridge.

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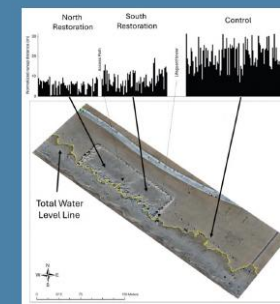


FIGURE 6.2. AN ORTHOMOSAIC OF THE PILOT PROJECT DUNE RESTORATION SITE

Source: Emery et al., 2024.
Note: Orthomosaic with an inset of normalized wave runup incursion distances showing the greater inland distance of the total water level line on the beach in the control site outside of the dune restoration site. Enclosed regions (process path and if-guard tower) are indicated with dashed lines.

LIMITING FACTORS AND CHALLENGES:

- **Limited scale:** The restoration site covered only a small portion of the larger Santa Monica Beach, meaning further expansion is necessary to ensure broader ecological recovery, protection of tourism infrastructure, and fully assess the potential to enhance coastal resilience.
- **Human disturbances:** Continued grooming and beach driving outside the restoration area may limit the full recovery of the ecosystem and reduce the long-term benefits for coastal protection.

★ KEY LESSONS LEARNED:

- The project demonstrates the potential use of dune restoration with minimal human intervention, cost, and maintenance as an adaptation approach that not only restores coastal habitat and function but also improves resilience to sea level rise and coastal erosion without heavy engineering or disrupting the beach's recreational use.
- The applicability of dune restoration in urban areas requires careful consideration of opportunities and constraints, such as balancing with other beach uses.
- The results of this restoration project over six years suggests that replication of a dune nature-based adaptation strategy could be a successful approach to improving coastal resilience in appropriate geomorphic conditions around the globe; for example, wide beaches with sufficient aeolian sand transport and fetch distance.



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CLOSING INSIGHTS

Context matters



Combine approaches



Know the limits



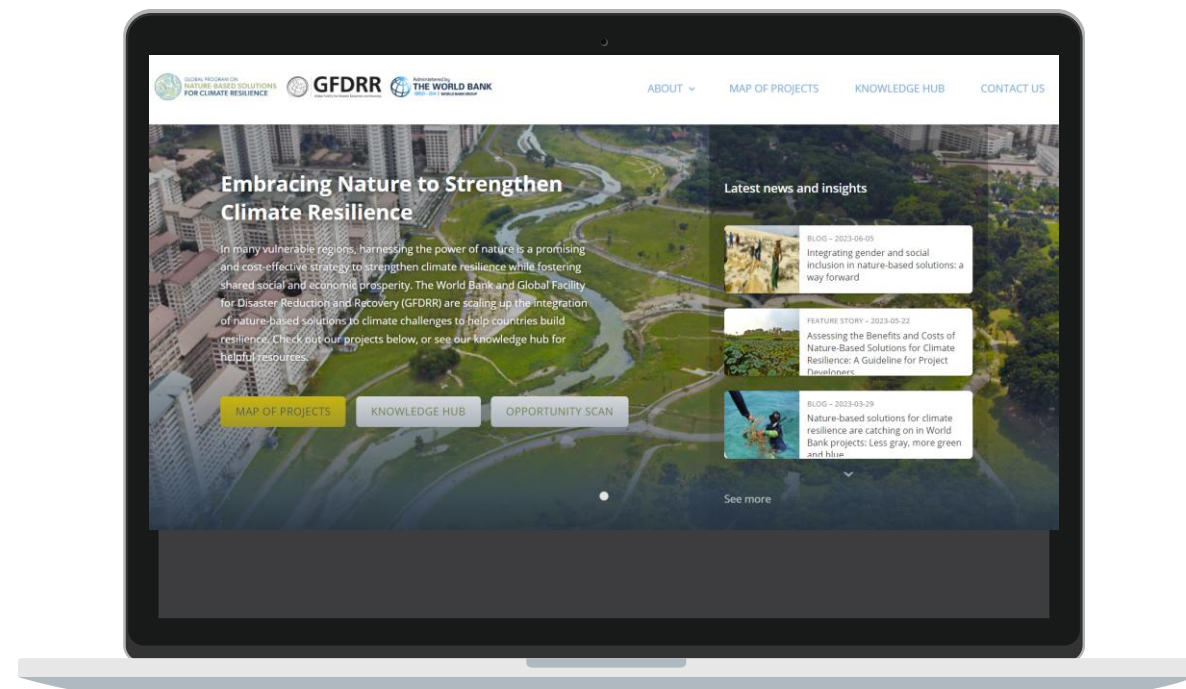
Maintenance is essential



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