ACCSCIENCE PUBLISHING

Asian Journal of Water, Environment and Pollution

ORIGINAL RESEARCH ARTICLE

A community-informed, multilayered vegetative bioshield for climate-related coastal erosion on Sonadia Island, Bangladesh

Mohammad Simul Bhuyan[1]*, Mohammad Tarikul Islam[1], Mehedi Hasan Peas[2], and Sayeed Mahmood Belal Haider[3]

[1]Bangladesh Oceanographic Research Institute, Cox's Bazar, Bangladesh

[2]Bangladesh Space Research and Remote Sensing Organization, Dhaka, Bangladesh

[3]Independent Researcher, Dhaka, Bangladesh

Abstract

Sonadia Island is an ecologically important barrier island on the southeastern coast of Bangladesh, where shoreline erosion, saline intrusion, cyclone exposure, and habitat degradation threaten both biodiversity and local livelihoods. This exploratory mixed-methods study assessed community perceptions of existing Jhaw plantations, documented selected dune and vegetation characteristics, and developed a site-specific conceptual bioshield for pilot testing. Fieldwork included measurements of lateral trunk deviation in 20 Jhaw trees, measurements of local dune height at 33 points in Mokchor and Poschim Para, and observations of Nishinda occurrence. Four focus-group discussions involving 32 residents and three key-informant interviews were analyzed thematically and triangulated with field observations and published ecological evidence. Mean lateral deviation of measured Jhaw trees was 1.53 ± 0.48 m (range, 0.73–2.71 m). Nishinda was recorded at 24 of 33 dune points, and the maximum observed local dune height occurred at a point where Nishinda was present; however, the purposive, cross-sectional design cannot determine whether Nishinda promoted sediment accumulation or preferentially occurred on pre-existing higher or more stable dunes. According to community participants, dense Jhaw stands are associated with the loss of native vegetation, reduced cultivable land, altered sand movement, perceived hotter and less ventilated microclimatic conditions, wildlife conflicts, and increased exposure to saline flooding. These accounts are treated as local ecological knowledge rather than verified biophysical effects. On the basis of complementary species functions, a six-layer seaward-to-landward bioshield is proposed: Sagarlata, Nishinda, Keya, Narikel, Boroi, and selectively retained inland Jhaw. The framework prioritizes native dune-building vegetation, ecological connectivity, and livelihood benefits. A pilot-scale restoration, formal baseline monitoring, taxonomic verification, and replicated comparison with Jhaw-dominated and open-dune sites are required before wider implementation.

Keywords: Coastal resilience; Dune restoration; Local ecological knowledge; Nature-based solutions; Sonadia Island

***Corresponding author:**
Mohammad Simul Bhuyan
(simulbhuyan@gmail.com)

Citation: Bhuyan MS, Islam MT, Peas MH, Haider SMB. A community-informed, multilayered vegetative bioshield for climate-related coastal erosion on Sonadia Island, Bangladesh. *Asian J Water Environ Pollut.*
doi: 10.36922/AJWEP026300201

Received: July 20, 2026

Revised: September 3, 2026

Accepted: September 10, 2026

Published online: September 28, 2026

Copyright: © 2026 Author(s). This is an Open-Access article distributed under the terms of the Creative Commons Attribution License, permitting distribution, and reproduction in any medium, provided the original work is properly cited.

Publisher's Note: AccScience Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. Introduction

Coastal barrier islands are dynamic landforms that provide habitat, fisheries, agricultural opportunities, and physical protection for adjacent communities.[1-3] Their stability depends on interactions among waves, currents, wind, sediment supply, dune topography, and vegetation. Climate change, sea-level rise, cyclones, storm surges, saline intrusion, and human disturbance can intensify shoreline retreat and reduce the recovery capacity of these systems.[4,5] Bangladesh is especially exposed to these threats because of its low-lying deltaic coast, dense coastal population, and recurrent tropical cyclones.

Nature-based solutions are increasingly promoted as complements to conventional coastal engineering.[6] Vegetative bioshields can trap wind-blown sediment, support dune formation, reduce wind speed, intercept salt spray, enhance habitat, and provide livelihood products.[7,8] Studies on mangroves, shelterbelts, and other coastal forests indicate that vegetation can contribute to cyclone-risk reduction by filtering wind, dissipating wave energy, and stabilizing sediment, but the degree of protection depends on belt width, porosity, species composition, topographic position, sediment supply, and event magnitude.[5-9] Vegetation should therefore be treated as one component of a broader coastal risk-reduction system rather than as a substitute for engineered protection, early warning, or evacuation infrastructure.

Jhaw (*Casuarina* spp.) has been widely planted in tropical coastal shelterbelts because of its rapid growth and tolerance of wind and salt spray. Such shelterbelts can reduce wind speed and control inland sand drift, but dense or poorly positioned stands may suppress native vegetation, alter habitat structure, and create unsuitable conditions on sensitive nesting beaches.[10-13] Their ecological value therefore depends on site, density, management, and landscape position rather than on the genus alone.

Sonadia Island in Cox's Bazar District, southeastern Bangladesh, supports dunes, salt marshes, mangrove remnants, migratory shorebirds, marine turtles, and fisheries-dependent communities. Previous floristic work recorded 138 plant species across island habitats, including the sandy-beach creeper Sagarlata (*Ipomoea pes-caprae* [L.] R. Br.), mangrove-associated Hargoza (*Acanthus ilicifolius* L.), Nunia gach (*Aegialitis rotundifolia* Roxb.) and Gewa (*Excoecaria agallocha* L.), as well as plantation-cultivated Jhaw (*Casuarina equisetifolia* L.).[14] Residents have raised concerns that extensive Jhaw planting has coincided with the decline of native coastal vegetation and changes in dune and livelihood conditions. However, these concerns have not yet been tested through a replicated biophysical study. The locally named species included in the proposed bioshield include Sagarlata, Jhaw, Nishinda (provisionally identified as *Vitex trifolia* L. f.), Keya (provisionally identified as *Pandanus tectorius* Parkinson), Narikel (*Cocos nucifera* L.), and Boroi (*Ziziphus mauritiana* Lamk.). Their complementary growth forms may support a more diverse and socially useful protective belt, but voucher-based taxonomic confirmation of Nishinda and Keya is required before propagation.

This study has three objectives:

(i) to document community perceptions of ecological and socioeconomic change associated with Jhaw plantations;
(ii) to describe the characteristics of Jhaw trees, dunes, and Nishinda occurrence; and
(iii) to develop a conceptual, multilayered bioshield for pilot-scale testing on Sonadia Island.

The study is explicitly exploratory. It generates a testable restoration framework but does not claim to demonstrate hydrodynamic protection or causal effects of Jhaw.

2. Materials and methods

2.1. Study area

Sonadia Island is a low-lying barrier island off the southeastern coast of Bangladesh near Moheshkhali and Cox's Bazar. It comprises beach–dune systems, tidal channels, salt-marsh and mangrove areas, aquaculture, agricultural land, and settlements, and it supports migratory shorebirds and marine turtle-nesting habitat. Field observations were focused on Mokchor and Poschim Para (Figure 1); the geomorphological context relevant to the bioshield is described in Section 2.2.

2.2. Geological and geomorphological setting

The island comprises sandy beaches, foreshore and backshore zones, dune ridges, tidal mudflats, tidal channels, mangrove areas, and saline intertidal environments. These landforms reflect interacting marine, tidal, fluvial, and wind-driven sedimentary processes along the northeastern Bay of Bengal coast.[14,15]

Surface sediments vary across Sonadia Island. Northern and relatively sheltered areas contain a greater proportion of fine materials and are regularly or periodically inundated by saline water, whereas southern and more exposed coastal areas are predominantly sandy; transitional areas contain sand and clay in varying proportions.[14,16] Sonadia has previously been described as having a general elevation range of approximately 0–4 m; however, this broad description should not be interpreted as the maximum elevation for individual dune ridges, particularly because local dune heights may be measured relative to nearby

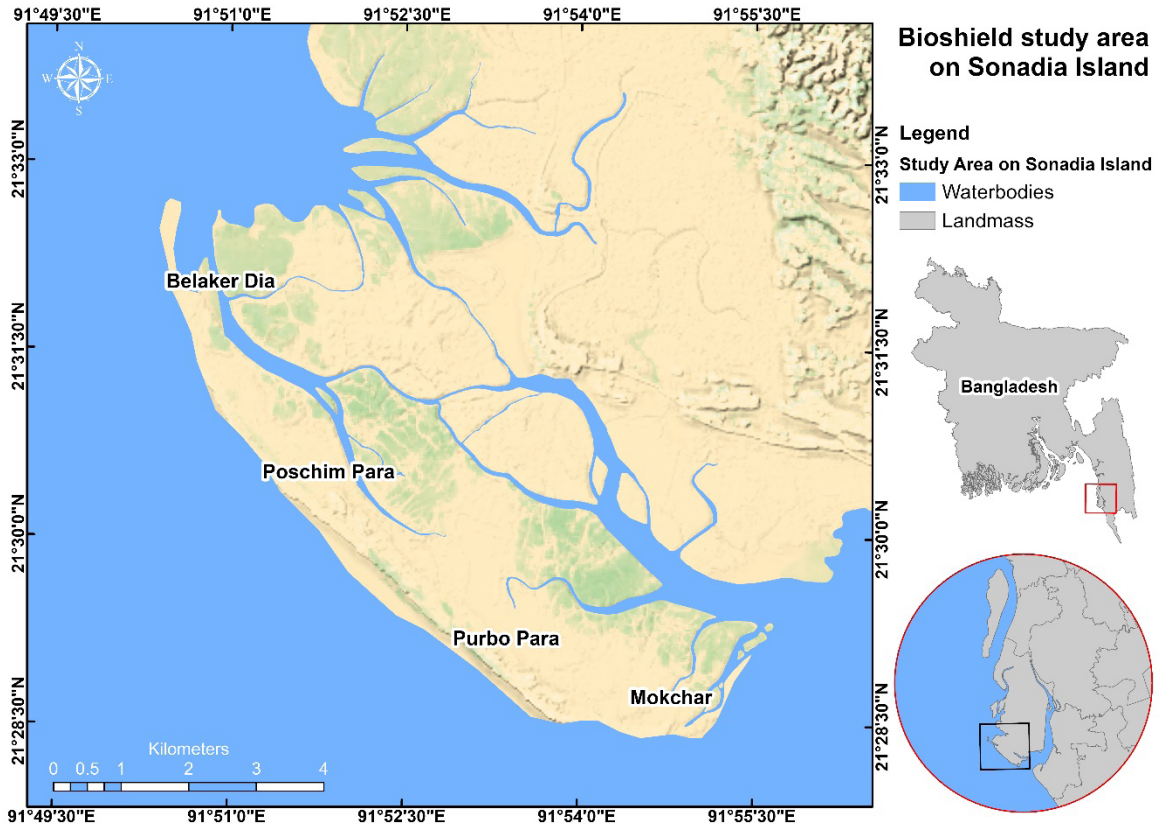


Figure 1. Location of the study area on Sonadia Island, Cox's Bazar District, southeastern Bangladesh

bases rather than a common geodetic datum.[14]

Sonadia Island is a geomorphologically dynamic island rather than a permanently stable landform. Historical maps, topographic records, satellite imagery, and field observations indicate that shoreline erosion and sediment accumulation occur simultaneously in different areas. A long-term morphological assessment identified regular and rapid shoreline modification and substantial spatial changes in beaches, dunes, tidal mudflats, mangroves, and other land-cover classes. The observed sediment accumulation was associated with the mixing and reworking of fluvial sediments, longshore currents, tidal activity, strong wave action, and seasonal coastal circulation.[15]

The geological and geomorphological characteristics of Sonadia Island are directly relevant to the design of the proposed vegetative bioshield. Plant establishment and sediment-retention capacity are likely to vary with substrate texture, dune stability, elevation, shoreline mobility, salinity, and frequency of tidal inundation. Low-growing pioneer vegetation is therefore more appropriate for mobile beach and incipient-dune sediments, whereas shrubs may be established on developing or semi-stable dunes. Taller trees and livelihood-supporting species should be positioned farther landward on comparatively stable, well-drained surfaces that are less exposed to direct wave attack and prolonged saline inundation. Consequently, the proposed bioshield should be adapted to local geomorphological conditions rather than applied as a uniform planting arrangement across the entire island.

2.3. Study design and evidence framework

A convergent exploratory design combining field measurements, local ecological knowledge, and published ecological evidence was adopted in this study. The quantitative observations were descriptive and were not treated as a causal experiment. Focus-group discussions and interview data were analyzed to identify perceived historical changes, livelihood impacts, and community preferences. Triangulation was used to distinguish direct measurements from perceptions and literature-based interpretations.

2.4. Field measurements

The field measurements were selected to characterize two exploratory questions rather than to estimate plant age or structural failure: (i) whether local dune height differs descriptively between points where Nishinda was observed and where it was absent, and (ii) how much lateral trunk displacement was present among the measured Jhaw trees. Local dune height was measured vertically from the local dune base to the crest using a tape, scale, and bamboo reference. Because no standard geodetic datum was used, these values are site-relative heights and not comparable as absolute elevations. The occurrence of Nishinda was recorded at each point. Measurement points were selected purposively based on accessibility and the presence of representative dune and vegetation features relevant to the exploratory objectives of the study. Dune points were chosen to include locations with and without Nishinda occurrence, while Jhaw trees were selected from available plantation areas where lateral trunk deviation could be measured safely. A total of 20 and 13 dune observations were made at Mokchor and Poschim Para, respectively. Lateral deviation in 20 Jhaw trees was measured as the horizontal displacement between the trunk and a vertically positioned bamboo reference. Because tree height, diameter at breast height, age, rooting exposure, and prevailing wind orientation were not recorded, lateral deviation is not interpreted as plant age, cyclone damage, erosion susceptibility, or plantation failure. Sampling was purposive, and the measurements are descriptive and not representative of island-wide conditions. An example of the field measurement is illustrated in Figure 2.

2.5. Focus-group discussions and key-informant interviews

Four focus-group discussions were conducted with eight participants in each group (n = 32). Participants were selected for their experience with fishing, agriculture, livestock, coastal vegetation, and environmental change. Three key informants with long-term knowledge of the island were interviewed separately. The qualitative component was used to document local ecological knowledge, understand perceived ecosystem services and livelihood consequences of vegetation change, and identify criteria for a community-acceptable bioshield; it was not designed to quantify ecosystem-service values or establish biophysical causation. The focus-group discussions covered native vegetation changes, dune development, erosion, saline flooding, plant cultivation, wildlife conflict, livelihoods, and preferred bioshield species. Participant responses were documented in field notes and expanded after each session. Figure 3 shows one focus-group discussion setting. Ethical approval of this study was obtained from the Bangladesh Oceanographic Research Institute Research Ethics Committee (BORI-REC; Approval No. BORI-REC-2022-001). All participants provided verbal informed consent before the study.



Figure 2. Example of field measurement on sandy terrain at Sonadia Island. Measurements were used for descriptive assessment rather than causal inference.



Figure 3. Focus-group discussion with residents concerning vegetation change, erosion, flooding, and livelihoods

2.6. Qualitative analysis

Field notes were reviewed repeatedly and coded inductively. Codes were grouped into six themes: vegetation change, dune and shoreline processes, saline flooding and storm exposure, agriculture and soil conditions, wildlife and security concerns, and livelihood preferences. Statements describing mechanisms or historical magnitudes were retained as participant perceptions unless independently supported by measurements or published evidence. Because the field notes were not linked to individual respondents, participant-level theme frequencies and the most and least common themes could not be ranked reliably; themes are therefore reported qualitatively rather than as counts or percentages. Detailed demographic profiles and formal thematic-saturation criteria were not available. Formal intercoder reliability could not be calculated because the available records did not document independent coding by multiple researchers.

2.7. Descriptive analysis

Jhaw tree lateral deviation and local dune height measurements were summarized using counts, means, standard deviations, medians, and ranges. Nishinda occurrence was expressed as a proportion of observed dune points. No inferential test was used because sampling was purposive, spatial independence was not established, and important covariates were unavailable; inferential *p*-values would therefore imply a level of population-based inference that the design does not support.

3. Results and discussion

3.1. Field characteristics and ecological interpretation

The 20 measured Jhaw trees had a mean lateral deviation of 1.53 ± 0.48 m, a median of 1.57 m, and a range of 0.73–2.71 m (Table 1). These measurements demonstrate substantial variation among the observed trunks but represent lateral displacement only. Without tree height, age, diameter at breast height, rooting exposure, and prevailing wind-orientation data, lateral deviation cannot be interpreted as a direct measure of cyclone damage, erosion susceptibility, or plantation failure.

Nishinda was recorded at 24 of 33 observed dune points (72.7%). Local dune heights at points with Nishinda had a median of 2.29 m (range 0.43–13.87 m), whereas points without Nishinda had a median of 1.07 m (range 0.79–1.37 m). The largest recorded local dune height values occurred where Nishinda was present. Because heights were measured relative to local dune bases, they cannot be compared as absolute elevations among sampling points or used to infer long-term elevation change. The association is descriptive and does not establish direction of causality: Nishinda may contribute to sediment retention and dune development, may preferentially establish on pre-existing higher or more stable dunes, or both scenarios may occur under favorable sediment conditions.

Together, the measurements provide preliminary support for examining Jhaw stand condition and the

Table 1. Descriptive statistics from purposively selected field observations

Variable	*n*	Mean ± SD	Median	Range
Jhaw lateral deviation (m)	20	1.53 ± 0.48	1.57	0.73–2.71
Local dune height, Nishinda present (m)	24	3.02 ± 2.92	2.29	0.43–13.87
Local dune height, Nishinda absent (m)	9	1.05 ± 0.20	1.07	0.79–1.37

Abbreviation: SD: Standard deviation.

relationship between Nishinda and dune formation as testable ecological questions. Repeated sediment-elevation measurements, standardized measurements of tree-inclination angles, and replicated comparisons among vegetation types are required before either species can be assigned a quantified protective or destabilizing effect.

3.2. Community perceptions of Jhaw-dominated areas and their interpretation

Recurring themes across the focus groups and key-informant interviews included a perceived decline in native plants such as Sagarlata, Nishinda, and Keya following the expansion of dense Jhaw stands, as well as perceived hotter and less ventilated conditions within plantations and difficulty in cultivating vegetables and other crops beneath or adjacent to dense Jhaw stands. Because the field notes were thematic rather than respondent-indexed, exact participant-level frequencies cannot be reported; these statements are therefore presented as recurring qualitative themes rather than prevalence estimates. Concurrent measurements of vegetation diversity, canopy openness, air and soil temperature, soil nutrients, and crop performance were not available.

Recorded field notes also revealed perceptions that Jhaw-dominated areas altered sand movement, reduced dune formation, and allowed greater inland penetration of saline water during storms and spring tides, along with recollections of historical shoreline retreat or island lowering. These perceptions were not recorded as respondent-level frequency data. Without a common elevation datum, historical shoreline series, groundwater observations, or hydrodynamic measurements, the reported magnitudes and causal explanations cannot be verified. They are therefore interpreted as local ecological knowledge that defines hypotheses for future monitoring rather than as demonstrated biophysical effects of Jhaw.

A third cluster of concerns involved loss of cultivable land, reduced crop production, predation on livestock by foxes or jackals, reduced visibility, and the use of dense tree stands as cover for theft or unauthorized slaughter of livestock. These findings broaden the meaning of plantation performance: A coastal shelterbelt may provide wind protection and still be locally unacceptable when it restricts land access, creates security concerns, or displaces livelihood activities. Social acceptability, visibility, access, and equitable benefit distribution should consequently be evaluated alongside geomorphological protection.

The recurrence of these accounts across discussion sessions supports their value as hypothesis-generating local ecological knowledge, particularly because residents observe the landscape over periods longer than most field campaigns. Nevertheless, recurrence alone does not establish a mechanism. Claims concerning microclimatic change, soil subsidence, groundwater depletion, and the scale of shoreline loss require targeted measurement and therefore are not presented as confirmed impacts.

3.3. Community preferences and livelihood implications

Participants linked their vegetation preferences to two main considerations: perceived ecological functions and direct livelihood value. Nishinda was valued for its perceived role in retaining sand and for its fruits that can be collected, dried, and sold. Narikel and Boroi were favored for food and income, while Sagarlata and Keya were regarded as characteristic coastal plants that may contribute to dune formation and shelter.[17-19]

These preferences show that sustainable restoration is unlikely to depend on ecological performance alone. Productive species can create a direct incentive for residents to maintain vegetation, replace damaged plants, and prevent uncontrolled land clearing. Narikel can contribute to the upper canopy, provide soil erosion prevention properties, and supply multiple household products,[20-22] while Boroi can provide fruits and may contribute to near-ground structural cover through its dense branching habit, with potential value for vegetation establishment in relatively dry or marginal coastal environments.[23-27] Their placement

should remain landward of active erosion and frequent inundation spots, and their productive functions should complement rather than replace native dune vegetation.

3.4. Proposed bioshield: Functional design and ecological rationale

The proposed bioshield arranges vegetation according to exposure, growth form, and expected ecological function. The three seaward layers interact most directly with mobile sand and developing dunes, while the landward layers add value by providing vertical structure, wind-filtering properties, food, and income. Jhaw is retained only as a selective inland component rather than as the dominant shoreline species. The arrangement is a conceptual hypothesis for field testing and should not be interpreted as a hydrodynamically validated design. The conceptual sequence is shown in Figure 4, while the layer-specific functions and cautions are summarized in Table 2.

The seaward-to-landward sequence follows a general coastal restoration principle: low-growing, flexible pioneer species occupy the most exposed zone; dense shrubs reinforce developing dunes; intermediate vegetation filters near-ground wind and salt spray; and taller, productive trees occupy more stable landward terrain. Sagarlata spreads laterally and can trap wind-transported sand on tropical foredunes.[28-30] Nishinda occurs in coastal dune vegetation and exhibits physiological mechanisms associated with salt tolerance, although this tolerance is not unlimited.[31,32] Keya provides dense structure with prop roots and has been evaluated as a component of storm-surge risk reduction in Bangladesh.[17,18]

Jhaw may remain useful for wind-filtering and sand-drift control on stable inland sites. Studies of *Casuarina* shelterbelts in Bangladesh and other tropical regions report both social and protective benefits, while dense monocultures may reduce understory diversity or create

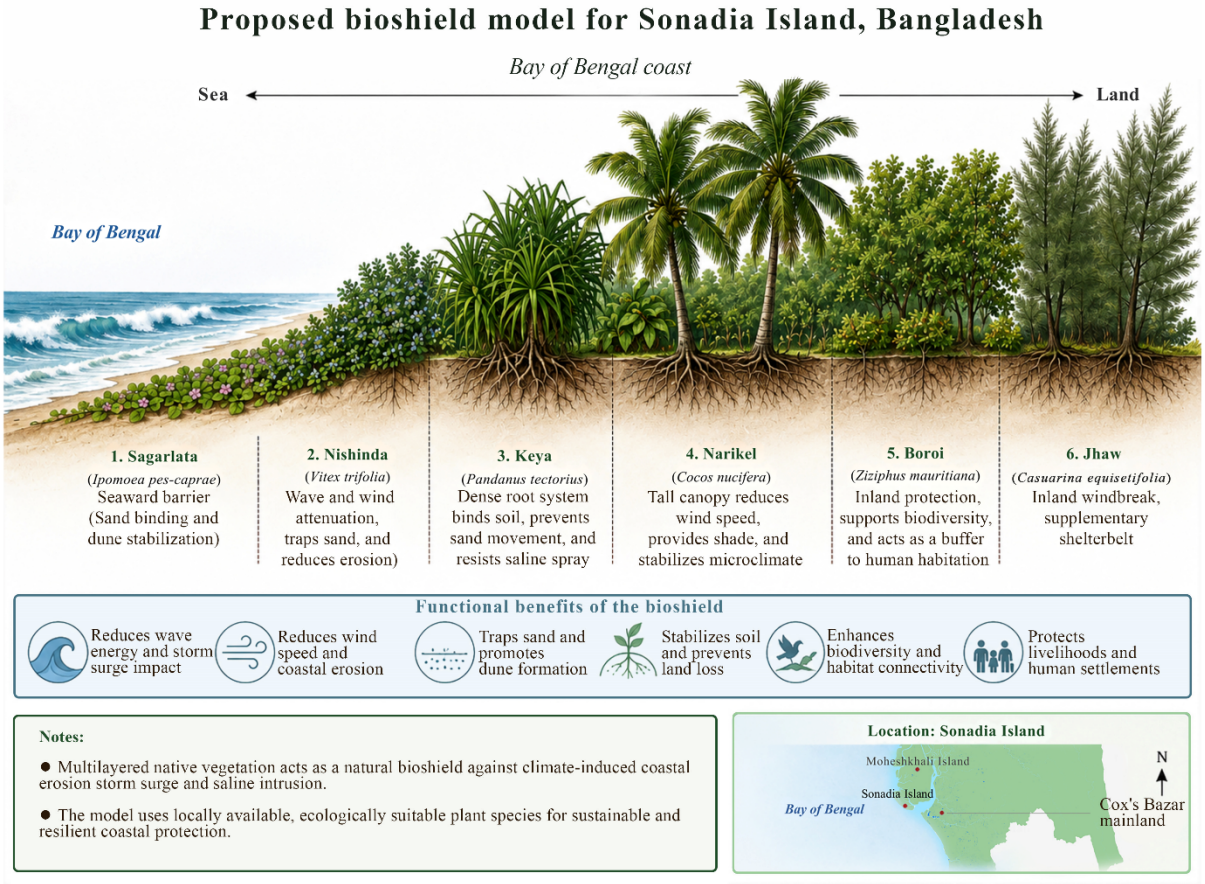


Figure 4. Conceptual six-layer bioshield proposed for pilot testing. The arrangement is a hypothesis derived from field observations, local ecological knowledge, and published species functions; it has not yet been validated hydrodynamically. Figure created by the authors using ChatGPT for visual elements, ArcGIS for the inset map, CANVA pro, and Adobe Illustrator and Adobe Photoshop for assembly and final editing.

Table 2. Functional logic of the proposed bioshield

Layer	Indicative species	Proposed position	Primary hypothesized functions	Key caution	Field photograph of the indicative species
1	Sagarlata (*Ipomoea pes-caprae*)	Active beach/incipient foredune	Ground cover, mobile-sand capture, and surface stabilization	Protect natural colonies; avoid disturbing turtle nesting	
2	Nishinda (*Vitex trifolia*)	Developing dune	Sediment retention, shrub reinforcement, and fruit for household use and income	Verify taxonomy, spacing, and seasonal salinity tolerance	
3	Keya (*Pandanus tectorius*)	Dune crest/landward slope	Prop-root reinforcement, porous wind and salt-spray filtering	Avoid dense planting on active nesting corridors	
4	Narikel (*Cocos nucifera*)	Stable, well-drained landward dune	Upper-canopy wind reduction, food, and income	Not suitable for persistent waterlogging or direct wave attack	
5	Boroi (*Ziziphus mauritiana*)	Landward productive buffer	Near-ground shelter, soil reinforcement, fruit, and habitat	Use locally sourced planting material and monitor spread beyond planted areas	
6	Jhaw (*Casuarina equisetifolia*)	Modified inland sites only	Supplementary windbreak, poles and fuelwood	Avoid shoreline monoculture; retain or thin adaptively	

conflict with sensitive nesting habitat.[10,11,13] The proposed model therefore favors adaptive retention and gradual thinning over either universal planting or abrupt island-wide removal.

3.5. Biodiversity safeguards

The beaches and dunes on Sonadia Island are not vacant land awaiting plantation. They provide habitat for shorebirds, crabs, invertebrates, and nesting turtles, while some naturally mobile dune sectors provide ecologically essential functions. Restoration planning should therefore map active turtle-nesting beaches, shorebird roosts, tidal channels, and open-dune habitat before tree planting. Dense vegetation should be excluded from important access corridors, while artificial lighting, fencing, harvesting, and other human disturbance should be managed along with the vegetation plan. Biodiversity indicators should be treated as core performance outcomes rather than as secondary benefits.

3.6. Pilot implementation and monitoring

A staged and replicated pilot is recommended before wider implementation of the proposed bioshield. Experimental blocks should compare among: (i) existing dense Jhaw

stands; (ii) selectively thinned Jhaw stands with native understory restoration; (iii) the proposed mixed bioshield; and (iv) open or naturally vegetated reference dunes. Baseline and repeated measurements should include shoreline position, cross-shore elevation profiles, sediment accretion or erosion pins, vegetation survival and cover, wind speed at multiple heights, air and soil temperature, soil moisture and salinity, groundwater level, inundation depth and duration, biodiversity, and household livelihood outcomes. Remote-sensing analysis should reconstruct historical shoreline change and help identify sectors where vegetation restoration is physically appropriate. The minimum monitoring indicators and suggested monitoring intervals are summarized in Table 3.

4. Management recommendations

To ensure a successful implementation of the proposed bioshield, the following management strategies should be adopted:

(i) Protect existing native ground cover and avoid clearing Sagarlata, Nishinda, and Keya during plantation establishment.
(ii) Begin with small replicated pilot plots rather than island-wide planting.
(iii) Retain healthy Jhaw only on stable inland or modified sites; gradually thin dense stands where they suppress native vegetation or create conflicts with habitat.
(iv) Establish community co-management rules for planting, harvesting, controlling grazing, preventing fire, and sharing benefits.
(v) Map turtle-nesting beaches, shorebird areas, and tidal channels before selecting restoration sites.
(vi) Use locally sourced planting material and determine the scientific identity of Keya and Nishinda through voucher-based botanical verification before propagation or large-scale restoration.
(vii) Integrate vegetation with evacuation planning, early warning, raised infrastructure, and other disaster risk reduction measures; do not present vegetation as a substitute for cyclone shelters or engineered protection where these are required.

Table 3. Minimum monitoring framework for a pilot bioshield trial

Outcome domain	Core indicator	Suggested monitoring frequency
Geomorphology	Shoreline position, dune crest elevation, cross-shore profile, and sediment pins	Quarterly and after major storms
Vegetation	Survival, cover, height, belt continuity, and natural recruitment	Monthly in year one; quarterly thereafter
Microclimate	Wind speed, air/soil temperature, and soil moisture	Seasonal and during strong onshore winds
Hydrology	Soil salinity, groundwater level, and inundation depth and duration	Monthly in wet and dry seasons; event-based
Biodiversity	Turtle nesting, shorebird use, crab/invertebrate activity, and plant richness	Seasonal with specialist protocols
Livelihoods	Harvest, income, land access, maintenance labor, and perceived benefits/conflicts	Household assessment every six months

5. Conclusion

This exploratory case study indicates that coastal protection on Sonadia Island should be evaluated as an ecological and social system rather than as a single-species plantation program. Community participants consistently questioned the compatibility of dense Jhaw stands with native vegetation, cultivation, and local safety, while field observations showed frequent Nishinda occurrence on measured dunes. These findings are suggestive but not causal.

The proposed bioshield, consisting of Sagarlata, Nishinda, Keya, Narikel, Boroi, and selectively retained inland Jhaw, offers a testable framework that combines dune formation, wind filtering, habitat connectivity, and livelihood benefits. Its value lies not in claiming proven protection, but in converting local knowledge and species ecology into a structured pilot hypothesis.

Wider adoption should depend on replicated monitoring of geomorphology, salinity, vegetation performance, biodiversity, and household outcomes.

Acknowledgments

The authors are grateful to the Bangladesh Oceanographic Research Institute for providing research facilities.

Funding

This research received no funding.

Conflict of interest

The authors declare no conflicts of interest.

Author contributions

Conceptualization: Mohammad Simul Bhuyan
Formal analysis: Mohammad Simul Bhuyan, Mohammad Tarikul Islam, Sayeed Mahmood Belal Haider
Investigation: Mohammad Simul Bhuyan, Mohammad Tarikul Islam, Sayeed Mahmood Belal Haider
Methodology: Mohammad Simul Bhuyan
Visualization: Mohammad Simul Bhuyan, Mehedi Hasan Peas
Writing–original draft: Mohammad Simul Bhuyan
Writing–review & editing: All authors

Ethics approval and consent to participate

Ethical approval was obtained from the Bangladesh Oceanographic Research Institute Research Ethics Committee (BORI-REC; Approval No. BORI-REC-2022-001). All participants provided verbal informed consent before participation.

Consent for publication

All participants provided verbal consent for publication before participation.

Availability of data

Data will be made available from the corresponding author upon reasonable request.

References

1. Wright LD, Syvitski JPM, Nichols CR, Zinnert J. Coastal morphodynamics and ecosystem dynamics. In: Wright L, Nichols C, eds. *Tomorrow's Coasts: Complex and Impermanent*. Coastal Research Library, vol 27. Cham, Switzerland: Springer; 2018:69-84.

   doi: 10.1007/978-3-319-75453-6_5

2. Hein CJ, Fenster MS, Gedan KB, Tabar JR, Hein EA, DeMunda T. Leveraging the interdependencies between barrier islands and backbarrier saltmarshes to enhance resilience to sea-level rise. *Front Mar Sci*. 2021;8:721904.

   doi: 10.3389/fmars.2021.721904

3. Houser S, Cho HJ, San Antonio KM, Parida SS. Impacts of Changing Beach and Dune Configurations on Communities: A Case Study of the Atlantic Coast of East Central Florida. *Sustainability*. 2026;18(13):6891.

   doi: 10.3390/su18136891

4. Calvin K, Dasgupta D, Krinner G, *et al*. *IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland: IPCC; 2023.

   doi: 10.59327/ipcc/ar6-9789291691647

5. Rahman MA, Rahman S. Natural and traditional defense mechanisms to reduce climate risks in coastal zones of Bangladesh. *Weather Clim Extrem*. 2015;7:84-95.

   doi: 10.1016/j.wace.2014.12.004

6. Inácio M, Karnauskaitė D, Mikša K, Gomes E, Kalinauskas M, Pereira P. Nature-based solutions to mitigate coastal floods and associated socioecological impacts. In: Ferreira CSS, Kalantari Z, Hartmann T, Pereira P, eds. *Nature-Based Solutions for Flood Mitigation: Environmental and Socio-Economic Aspects*. The Handbook of Environmental Chemistry, vol 107. Cham, Switzerland: Springer; 2020:35-58.

   doi: 10.1007/698_2020_675

7. Kozhikkodan Veettil B. Towards Sustainable Coastal Futures. In: *The Potential of Bioshields for Coastal Protection*. Advances in Natural and Technological Hazards Research, vol 55. Cham, Switzerland: Springer; 2026:415-453.

   doi: 10.1007/978-3-032-22888-8_16

8. Kozhikkodan Veettil B. Successful Coastal Bioshield Projects Around the World. In: *The Potential of Bioshields for Coastal Protection*. Advances in Natural and Technological Hazards Research, vol 55. Cham, Switzerland: Springer; 2026:311-332.

   doi: 10.1007/978-3-032-22888-8_12

9. Athikalam PT, Karur Vaideeswaran A. Vegetation bioshield for coastal protection in South Asia: Status and way forward. *J Coast Conserv*. 2022;26(1):3.

   doi: 10.1007/s11852-022-00850-x

10. Awale D, Phillott AD. A review of the adverse effects of *Casuarina* spp. on coastal ecosystems and sea turtle nesting beaches. *Indian Ocean Turtle Newsl*. 2014;19:15-19. Accessed July 29, 2026. https://www.iotn.org/wp-content/uploads/2015/09/IOTN-19.pdf#page=17

11. Miah MD, Siddik MA, Shin MY. Socio-economic and environmental impacts of casuarina shelterbelt in

the Chittagong coast of Bangladesh. *For Sci Technol*. 2013;9(3):156-163.

doi: 10.1080/21580103.2013.814592

12. Xu Z, Zuo L, Zhang Y, Huang R, Li L. Is allelochemical synthesis in *Casuarina equisetifolia* plantation related to litter microorganisms? *Front Plant Sci*. 2022;13:1022984.

doi: 10.3389/fpls.2022.1022984

13. Zaldívar-Cruz B, Pérez-Ceballos R, Zaldívar-Jiménez A, *et al*. Structural and diversity changes in coastal dunes from the Mexican Caribbean: the case of the invasive Australian pine (Casuarina equisetifolia). *Manag Biol Invasions*. 2022;13(1):131-146.

doi: 10.3391/mbi.2022.13.1.08

14. Arefin MS, Hossain MK, Hossain MA. Plant diversity of Sonadia Island—An ecologically critical area of South-East Bangladesh. *Bangladesh J Plant Taxon*. 2017;24(1):107-116.

doi: 10.3329/bjpt.v24i1.33037

15. Hossain MS, Yasir M, Shahriar MS, Jahan M, Liu S, Niang AJ. Morphological change assessment of a coastal island in SE Bangladesh reveal high accumulation rates. *Reg Stud Mar Sci*. 2023;62:102969.

doi: 10.1016/j.rsma.2023.102969

16. Hossain MS, Rahman MS, Taki G, Jahan M. Geochemical characterization and reserve estimation of the economic heavy minerals of Sonadia Island, Bangladesh. *Discov Geosci*. 2024;2(1):65.

doi: 10.1007/s44288-024-00073-7

17. Thomson LAJ, Englberger L, Guarino L, Thaman RR, Elevitch CR. *Pandanus tectorius* (pandanus), version 1.1. In: Elevitch CR, ed. *Species Profiles for Pacific Island Agroforestry*. Holualoa, HI: Permanent Agriculture Resources; 2006. Accessed February 10, 2026. https://ukuleles.com/wp-content/uploads/P.tectorius-pandanus.pdf

18. Kayum S, Shimatani Y, Minagawa T. Evaluation of *Pandanus* trees as a means of Eco-DRR against storm surge wave on Saint Martin's Island, Bangladesh. *Water*. 2022;14(11):1781.

doi: 10.3390/w14111781

19. Nizam, Benazir, Ibrahim MSI, Setyandito O, Purnomo. Field study of deposition and erosion patterns around *Pandanus* clusters on sandy coasts: A preliminary investigation. *J Civ Eng Forum*. 2024;11(1):11-22.

doi: 10.22146/jcef.13286

20. Takle ES, Chen TC, Wu X. Protective functions of coastal forests and trees against wind and salt spray. In: Braatz S, Fortuna S, Broadhead J, Leslie R, eds. *Coastal Protection in the Aftermath of the Indian Ocean Tsunami: What Role for Forests and Trees? Proceedings of the Regional Technical Workshop*. Khao Lak, Thailand, August 28–31, 2006. Rome, Italy: Food and Agriculture Organization of the United Nations; 2007. Accessed January 1, 2026. https://www.fao.org/4/ag127e/ag127e08.htm

21. Rajendra IGNA, Sumariati DAR. The role of coconut plants in relation to disaster management in the tropical coastal regions. In: Haigh R, Comfort L, Hakam A, Ismail FA, eds. *MATEC Web of Conferences*. *International Conference on Disaster Management (ICDM 2018), Andalas University, Indonesia, May 2–4, 2018*. Vol 229. Les Ulis, France: EDP Sciences; 2018:01012.

doi: 10.1051/matecconf/201822901012

22. Shinde VV, Sumitha S, Maheswarappa HP. Soil fertility properties, leaf nutrient status and yield of coconut and intercrops as influenced by coconut-based cropping system in the coastal plain of western India. *Bangladesh J Bot*. 2021;50(4):1067-1075.

doi: 10.3329/bjb.v50i4.57074

23. Arndt SK, Wanek W, Clifford SC, Popp M. Contrasting adaptations to drought stress in field-grown Ziziphus mauritiana and Prunus persica trees: Water relations, osmotic adjustment and carbon isotope composition. *Aust J Plant Physiol*. 2000;27(11):985-996.

doi: 10.1071/PP00022

24. Chan E, Elevitch CR. Cocos nucifera (coconut), version 2.1. In: Elevitch CR, ed. *Species Profiles for Pacific Island Agroforestry*. Holualoa, HI: Permanent Agriculture Resources; 2006. Accessed February 15, 2026. https://raskisimani.com/wp-content/uploads/2013/01/cocos-nucifera-coconut.pdf

25. Orwa C, Mutua A, Kindt R, Jamnadass R, Anthony S. Ziziphus mauritiana. In: *Agroforestree Database: A Tree Reference and Selection Guide Version 4.0*. Nairobi, Kenya: World Agroforestry Centre; 2009. Accessed March 10, 2026. https://apps.worldagroforestry.org/treedb/AFTPDFS/Ziziphus_mauritiana.PDF

26. Maruza IM, Musemwa L, Mapurazi S, Matsika P, Munyati VT, Ndhleve S. Future prospects of *Ziziphus mauritiana* in alleviating household food insecurity and illnesses in arid and semi-arid areas: A review. *World Dev Perspect*. 2017;5:1-6.

doi: 10.1016/j.wdp.2017.01.001

27. Heuzé V, Tran G, Boval M, Lebas F. Indian jujube (*Ziziphus mauritiana*). Feedipedia. Accessed July 31, 2019. https://www.feedipedia.org/node/80

28. Devall MS. The biological flora of coastal dunes and wetlands. 2. *Ipomoea pes-caprae* (L.) Roth. *J Coast Res*. 1992;8(2):442-456. Accessed March 17, 2026. https://www.jstor.org/stable/4297988

29. Gomes Neto A, Cunha SR, Voigt EL. Vegetative propagation of the dune-building plant Ipomoea pes-caprae for use in dune rehabilitation projects. *J Coast Res*. 2006;Special Issue 39:1251-1254. Accessed June 24, 2026. https://www.jstor.

org/stable/25741787

30. Lee JT, Yen LZ, Chu MY, *et al*. Growth characteristics and anti-wind erosion ability of three tropical foredune pioneer species for sand-dune stabilization. *Sustainability*. 2020;12(8):3353.

doi: 10.3390/su12083353

31. Arun AB, Beena KR, Raviraja NS, Sridhar KR. Coastal sand dunes—A neglected ecosystem. *Curr Sci*. 1999;77(1):19-21. Accessed August 5, 2026. https://www.jstor.org/stable/24102908

32. Yin D, Bu F, Xu Y, *et al*. Mechanism of salt tolerance in *Vitex trifolia* Linn. var. simplicifolia Cham: Ion homeostasis, osmotic balance, antioxidant capacity and photosynthesis. *Acta Sci Pol Hortorum Cultus*. 2021;20(4):3-16.

doi: 10.24326/asphc.2021.4.1