6. Case Studies

The applicability of NbS for adaptation is underscored by the no one-size-fits-all approach. Examining real-world case studies is essential for learning their adaptation objectives, design context, implementation, and generation of co-benefits. The case study compilation looks at the effectiveness of various NbS approaches, offering valuable lessons and inspiration for research, decision-making, and implementation. The following sections have been sampled from global NbS initiatives that wrestle with complexities of development, population density, and climate vulnerability representative of developing nations, particularly along the tropics. They have been categorised broadly on the basis of implementation agencies for large-scale impact and specific targeted interventions. A summary of the case studies in this compendium is given in Table 4. Summary of case studies (n = 30), and the locations are highlighted in Figure 5. The timeline of implementation of the studied NbS projects is shown in Figure 6.

Figure 5. Distribution of case studies in India and Bangladesh

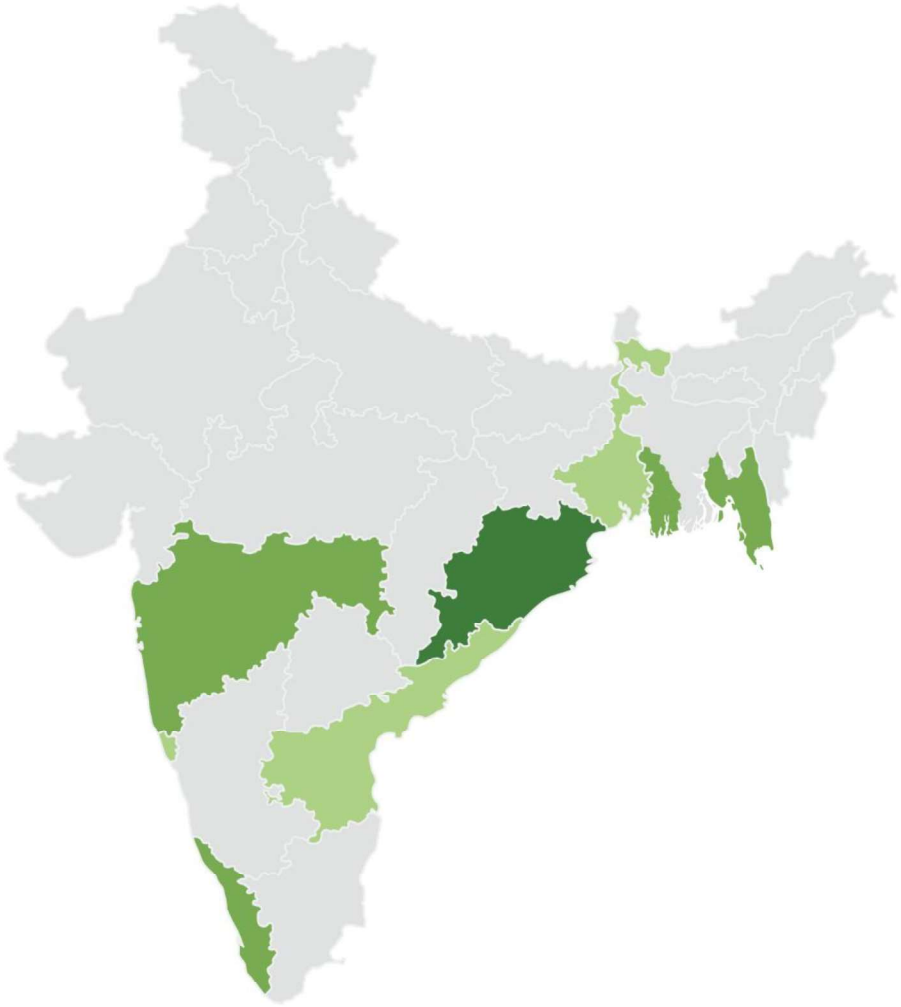

Figure 6. Timeline of implementation of NbS projects

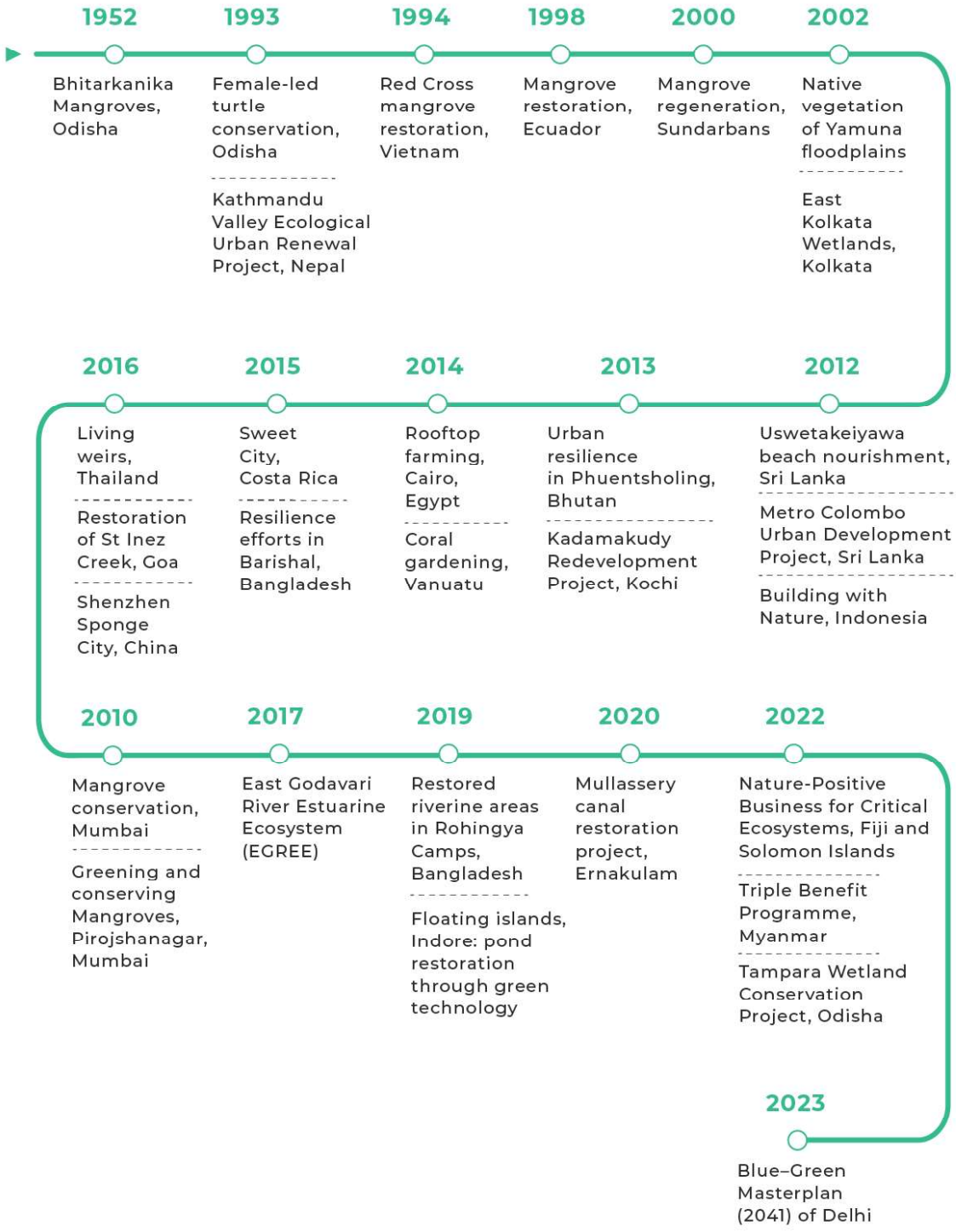

Table 4. Summary of case studies (n = 30)

Type	Case studies	Year	Location	Objective	Ecosystem type	Agency	Cost (in USD)
NbS	Uswetakeiyawa beach nourishment, Sri Lanka: Shoreline restoration and erosion control (Ongoing)	2012	Uswetakeiyawa, Western Province, Sri Lanka	Beach Nourishment; Tourism; Coastal Erosion	Coastal	Coast Conservation Department of Sri Lanka	300 million
NbS	East Godavari River Estuarine Ecosystem (EGREE): Policy-driven ecosystem management (Ongoing)	2017	East Godavari District, Andhra Pradesh, India	Biodiversity Conservation; Mangrove Restoration; Socio-economic Engagement	Estuarine; Mangroves	Government of India; Wildlife Institute of India; EGREE Foundation; Global Environment Facility, United Nations Development Programme	0.94 million
Hybrid	Urban resilience in Phuentsholing, Bhutan: Integrating NbS in urban planning for DRR (Ongoing)	2013	Phuentsholing, Chukha District, Bhutan	Urban Resilience; Disaster Mitigation; Community Development	Urban; Riverine	Royal Government of Bhutan, Department of Human Settlements, Phuentsholing Thromde (municipality), Global Environment Facility, and Asian Development Bank (ADB)	63 million
NbS	Living weirs, Thailand: Enhancing water quality and biodiversity in urban waterways (Ongoing)	2016	Khlong-La River, Songkhla Province; Khlong Wang Heep River, Nakhon Si Thammarat Province, Thailand	Water Management; Community Resilience; Biodiversity Enhancement	Urban; Riverine	Office of the National Water Resources - Kingdom of Thailand, and GIZ GmbH; United Nations Environment Programme-World Conservation Monitoring Centre	-
NbS	Native vegetation of Yamuna floodplains: Policy-supported ecological restoration (Completed in 2010)	2002	New Delhi, National Capital Territory of Delhi, India	Biodiversity Conservation; Ecosystem Restoration; Community Engagement	Urban; Wetlands	Government of National Capital Territory of Delhi; Government of Uttar Pradesh and its agencies; Delhi Development Authority; Centre for Environmental Management of Degraded Ecosystems of the University of Delhi	57 million
Hybrid	Restoration of St Inez Creek, Goa: Urban waterway revitalisation (Ongoing)	2016	Panaji, Goa, India	Urban Revitalization; Community Engagement; Ecological Restoration	Urban; Wetlands	Corporation of City of Panaji; Imagine Panaji Smart City Development Limited Taleigao Village Panchayat; Greater Panaji Planning and Development Authority; Asian Development Bank (ADB),	25 million
Grey	Mullassery Canal restoration project, Ernakulam: Local-led waterway revitalisation (Ongoing)	2020	Kochi, Kerala, India	Community Participation; Urban Resilience; Waterway Revitalisation	Urban; Coastal	Kochi Municipal Corporation, Cochin Smart Mission Limited and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) via Non-National Infrastructure Pipeline Real Estate Joint Venture	8.26 million

Type	Case studies	Year	Location	Objective	Ecosystem type	Agency	Cost (in USD)
Hybrid	Metro Colombo Urban Development Project, Sri Lanka: Urban flood resilience and water management (Ongoing)	2012	Sri Jayawardenapura Kotte, Colombo, Sri Lanka	Flood Resilience; Wetland Conservation; Urban Development	Urban, wetlands, coastal, riverine	Sri Lanka Land Development Corporation, Colombo Municipal Council. Funded by World Bank, International Bank for Reconstruction and Development	321 million
NbS	Sweet City, Costa Rica: Urban green space development for community well-being (Completed in 2020)	2015	Curridabat, San José, Costa Rica	Urban Green Space Biodiversity Restoration Citizen Participation	Urban, wetlands	Municipality of Curridabat, civil society organisations, private firms, not-for-profit organisations, and city residents/resident associations	45 million
Hybrid	Blue–Green Masterplan (2041) of Delhi: Integrating green and blue spaces into urban planning (Ongoing)	2023	New Delhi, National Capital Region, India	Integrated Urban Planning; Green-Blue Infrastructure; Environmental Rejuvenation	Urban, Floodplains	Delhi Development Authority	-
NbS	Female-led turtle conservation, Odisha: Community-driven marine conservation initiatives (Ongoing)	1993	Ganjam, Odisha, India	Community-Driven Marine Conservation, Female Empowerment, Turtle Habitat Protection	Coastal	Samudram Women's Federation, Odisha Marine Resource Conservation Consortium, Odisha Traditional Fish Workers' Union, United Artists Association, Greenpeace, World Wildlife Fund (India), Odisha University of Agriculture and Technology, Central Institute of Fisheries Education, Ford Foundation, International Council of Agricultural Research, Coastal Marine Fisheries Research Institute (Government of India), Berhampur University funded by Equator Initiative (United Nations Development Programme), Conservation International.	-
NbS	Mangrove regeneration, Sundarbans: Community efforts in mangrove conservation (Ongoing)	2000	Gosaba, West Bengal, India; Karamjal, Khulna, Bangladesh	Mangrove Conservation; Community Resilience; Ecotourism Sustainability	Mangroves	Caritas India, Gram Panchayats, community-based organisations; non-governmental organisations	-
Hybrid	Rooftop farming, Cairo, Egypt: Urban agriculture driven by community participation (Completed in 2017)	2014	Ezbet-al Nasr, Cairo, Egypt	Urban Agriculture, Community Empowerment, Climate Adaptation	Urban, Building Rooftops	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ); Shaduf	-
NbS	Coral gardening, Vanuatu: Community-	2014	Pele, Shefa Province, Vanuatu	Coral Reef Restoration; Community-Based	Coral reefs, Marine	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ); Vanuatu's	-

Type	Case studies	Year	Location	Objective	Ecosystem type	Agency	Cost (in USD)
	based coral reef restoration (Completed in 2017)			Adaptation; Marine Biodiversity		Nguna-Pele Marine and Land Protected Area Network	
NbS	Building with Nature, Indonesia: Community-centric coastal protection (Ongoing)	2012	Demak, Central Java Province, Indonesia	Coastal Resilience; Mangrove Rehabilitation; Community-Centric Protection	Mangrove; Coastal	Government of Indonesia, Wetlands International, Ecoshape, World Bank, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany)	400 million
NbS	Restored riverine areas in Rohingya Camps, Bangladesh: Rehabilitation of water systems and natural areas within refugee settlements (Ongoing)	2019	Ukhiya, Chittagong, Bangladesh	Refugee Camp Rehabilitation, Riparian Ecosystem Restoration, Water System Improvement	Coastal, Highland Riparian	Center for Natural Resource Studies and United Nations High Commissioner for Refugees	0.44 million
NbS	Mangrove restoration, Ecuador: Ecosystem recovery project aimed at restoring vital mangrove habitats for biodiversity and coastal protection (Ongoing)	1998	Esmeraldas, Manabí, Guayas, El Oro, Ecuador	Mangrove Conservation; Coastal Protection; Sustainable Use Agreements	Mangroves	Conservation International Ecuador, Coastal Fisheries Initiative in Latin America	25 million
NbS	Nature-Positive Business for Climate Critical Ecosystems, Fiji and Solomon Islands: Business-led initiatives promoting conservation and restoration in biodiversity-rich areas (Ongoing)	2022	Macuata and Ba Province; Western Province, Fiji, Solomon Islands	Business-Led Conservation; Habitat Restoration; Community Resilience	Mangroves, Coral reefs	World Wildlife Fund Pacific, Matanataki Pte Ltd, Strongim Bisnis; Locally Managed Marine Area Network, Western Province Fisheries	0.67 million
Hybrid	East Kolkata Wetlands, Kolkata: Ecosystem services and livelihoods through wetland conservation (Ongoing)	2002	Kolkata, West Bengal, India	Wetland Conservation; Natural Sewage Treatment; Sustainable Livelihoods	Urban, Wetlands	East Kolkata Wetlands Management Authority, East Kolkata Wetlands Development Society, National Wetlands Authority, Kolkata Municipal Corporation	0.24 million
NbS	Bhitarkanika Mangroves, Odisha: Mangrove ecosystem conservation for biodiversity and coastal protection (Completed in 2002)	1952	Bhitarkanika Conservation Area, Odisha, India	Mangrove Conservation; Biodiversity Protection; Coastal Resilience	Mangroves	Rajnagar Wildlife Division - State Forest Department, State Pollution Control Board, Department of Water Resources of Odisha, United Nations Development Programme, Food and Agriculture Organization	-

Type	Case studies	Year	Location	Objective	Ecosystem type	Agency	Cost (in USD)
Hybrid	Kadamakudy Redevelopment Project, Kochi: Habitat restoration and sustainable development (Ongoing)	2013	Kadamakudy, Kerala, India	Habitat Restoration; Sustainable Urban Development; Mangrove Conservation	Urban, Wetlands, Mangroves	Cochin University of Science and Technology, Department of Town and Country Planning, International Council for Local Environmental Initiatives [South Asia], Deutsche Gesellschaft für Internationale Zusammenarbeit, Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, Germany	-
NbS	Mangrove conservation, Mumbai: Initiative focussed on preserving mangrove ecosystems to enhance urban biodiversity and flood resilience (Ongoing)	2010	Vasai Creek, Thane Creek, Manori and Malad, Mahim-Bandra, Versova, Sewree, and Mumbra-Diva, Maharashtra, India	Urban Biodiversity; Flood Resilience; Mangrove Protection	Mangroves	Soonabai Pirojsha Godrej Foundation; Various government bodies, local non-governmental organisations (NGOs)	-
NbS	Greening and conserving Mangroves, Pirojshanagar, Mumbai (Ongoing)	2010	Vikhroli-Mumbai, Maharashtra, India	Mangrove Conservation, Climate Resilience, Community Engagement	Mangroves, Urban, Coastal	Godrej and Boyce Manufacturing Company Limited	62 million
Hybrid	Floating islands, Indore: pond restoration through green technology (Ongoing)	2019	Indore, Madhya Pradesh, India	Pond Restoration, Green Technology, Water Quality Improvement	Urban, Ponds	Clean-Water (Sustainable Water Technologies Private Limited), Police Training College	-
Hybrid	Red Cross mangrove restoration, Vietnam: Mangrove reforestation for storm protection (Completed in 2010)	1994	Thai Binh, Thai Binh Province, Vietnam	Mangrove Reforestation, Coastal Protection, Community Benefits	Mangroves, Coastal	Vietnam Red Cross, Danish Red Cross, Japanese Red Cross Societies	8 million
NbS	Triple Benefit Programme, Myanmar: Multi-faceted approach targeting DRR, climate change adaptation, and sustainable livelihoods (Ongoing)	2022	Kachin and Shan States, Mandalay, Magway, Ayeyarwady Divisions, Myanmar	Community Forestry; Benefit-sharing Mechanisms; Sustainable Livelihoods	Tropical Rainforests	Danish International Development Agency (Strategic Partnership), World Wildlife Fund (Kenya, Uganda, Madagascar and Myanmar)	10 million
Hybrid	Kathmandu Valley Ecological Urban Renewal Project, Nepal: Urban renewal integrating green spaces for enhanced resilience against	1993	Kathmandu, Central Hill Zone, Nepal	Risk-sensitive Land Use; Blue-Green Infrastructure; Urban Renewal	Urban, Mountain, Riverine	The Kathmandu Urban Development Project, High-Powered Committee for Integrated Development of the Bagmati Civilization; funded by ADB, World Bank and Deutsche Gesellschaft für Internationale Zusammenarbeit	12 million

Type	Case studies	Year	Location	Objective	Ecosystem type	Agency	Cost (in USD)
	natural disasters (Ongoing)						
Hybrid	Resilience efforts in Barishal, Bangladesh: Community and ecosystem resilience to flooding (Ongoing)	2015	Kutubdia, Barishal, Bangladesh	Climate Migration; Natural Drainage Restoration; Salinity Intrusion	Urban, Riverine, Coastal	Barishal District Administration, Barishal City Corporation, 'Barisal-Problem and Prospects' Facebook civic engagement group and funding from Kreditanstalt für Wiederaufbau (KfW) Development Bank	40 million
NbS	Tampara Wetland Conservation Project, Odisha: Protection and restoration of a Ramsar site to maintain its ecological integrity and water quality (Ongoing)	2022	Chatrapur, Odisha, India	Wetland Conservation; Salinisation Risks; Peri-urban Wetlands	Peri-urban; Freshwater Wetlands	Pallishree Limited, Chilika Development, Panchayats in Chatrapur Block, Ganjam District funded by Government of India	4 million
Hybrid	Shenzhen Sponge City, China: National programme for urban water retention and flood control (Ongoing)	2016	Shenzhen, China	Urban Water Retention; Stormwater Management; Urban Liveability	Urban, Riverine	Public–private partnership with Shenzhen Government	206 million

Women line up to plant mangrove saplings along the banks of the Matla River, Sundarbans, India, as a critical defence against coastal storm surges and tiger habitat incursions.

Credit: Avijit Ghosh, 2022 / Climate Visuals

6.1. National government initiatives

These projects encompass nature-based initiatives that have received substantial backing and collaboration from national governments, aiming for broad-scale impact and holistic integration within country-level frameworks for sustainable development. They represent the top-down thrust for large-scale NbS either in response to existing climate risks or undertaken proactively to tackle anticipated environmental challenges. The involvement of national governments in these cases has been able to draw substantial funding and facilitate administrative support at an ecosystem scale.

6.1.1. Uswetakeiyawa beach nourishment, Sri Lanka: Shoreline restoration and erosion control

Beach nourishment is a soft engineering solution for shoreline stabilisation in areas that are affected by a reduction of sand owing to either natural or man-made reasons (Ratnayake et al., 2018). Beach nourishment initiative in Sri Lanka began in the mid-1980s with the aim to preserve its picturesque beaches, crucial for both natural heritage and a thriving tourism industry (Food and Agricultural Organisation, 2006). Initiated by the Government of Sri Lanka, the Uswetakeiyawa project is one of the earliest interventions of artificial beach nourishment. as part of a long-term coastal management strategy (Box 1). Along with other sites on the west coast, it seeks to address the underlying causes of erosion, as part of the Coastal Zone Management Plan (Coast Conservation and Coastal Resources Management Department, 2023) to ensure the sustainability of local fisheries and maintain ecological balance.

Box 1. Case study of Uswetakeiyawa, Sri Lanka

Location	Uswetakeiyawa, Western Province, Sri Lanka
Enforcement Agency	Coast Conservation Department of Sri Lanka (Ratnayake et al., 2018)
Timeline	2012 onwards
Objective	Artificial nourishment of the beach to combat coastal erosion (areas affected because of sediment supply issues, including Uswetakeiyawa beach, Negombo Lagoon, and Kelani River), potential tourist hub development, and conducting pilot projects for future beach nourishment programmes
Ecosystem type	Coastal
Climate change impacts addressed	Mitigation of coastal erosion and preservation of the beach ecosystem in the face of changing environmental conditions
Socio-economic outcomes	Potential economic benefits from tourism and addressing coastal erosion issues to maintain recreational and economic activities along the coast
Project cost	USD 300 million

Monitoring and evaluation	• Continuous monitoring of beach profiles and sand grain size data over a 1-year period • Satellite image analysis covering the period from 2010 to 2015 • Assessment of the performance of breakwaters and beach nourishment strategies
Trade-offs/Limitations	Potential impacts on longshore sediment transport, variations in beach profiles, and potential downstream effects on neighbouring coastal areas due to the presence of breakwaters

6.1.2. East Godavari River Estuarine Ecosystem (EGREE): Policy-driven ecosystem management

EGREE is the second-largest mangrove area in India (Shankar, 2022) and cited as an Important Bird Area and settling site for the olive ridley sea turtle (Box 2). The landscape is characterised by mangroves, tidal flats, and sand dunes under the constant threat from activities including aquaculture expansion and habitat loss due to submersion, urban development, and Casuarina plantations (Bagaria et al., 2021). Since 2011, the Government of India has initiated biodiversity conservation projects in the region (Wildlife Institute of India, 2017) along with other resilience-focussed initiatives including effective knowledge management to disseminate vital information about biodiversity, ecological changes, and anthropogenic impacts in the region.

Box 2. Case study of East Godavari River Estuarine Ecosystem, Andhra Pradesh, India

Location	East Godavari District, Andhra Pradesh, India
Enforcement agencies	Government of India, Wildlife Institute of India, EGREE Foundation funded by Global Environment Facility, United Nations Development Programme
Timeline	2017 onwards
Objective	Identifying research gaps, studying payment for ecosystem services, examining climate change impacts, and conducting workshops on biodiversity conservation in coastal/marine contexts
Ecosystem type	Estuarine, mangroves
Climate change impacts addressed	Restoration of mangrove habitats and biodiversity conservation
Socio-economic outcomes	Engages communities for park management, relying on local labour, eco-tourism services, and awareness efforts, considering them stakeholders. However, conflicts arise because of the unauthorised extraction of mollusc species and timber collection within the sanctuary, despite permitting fishing activities.
Project cost	USD 0.94 million (GEF, 2012)
Monitoring and evaluation	Estimation of the flora and fauna in the EGREE region, monitoring land-use and shoreline changes, and detection of change in the area covered by mangrove aquaculture ponds

Trade-offs/Limitations	Competing land use and rampant land cover change. Surveys revealed the challenge that most people who partly or entirely depend on fuelwood are not willing to stop its use owing to easy availability and low costs of mangrove species.

6.1.3. Urban resilience in Phuentsholing, Bhutan: Integrating NbS in urban planning for DRR

Phuentsholing is a town located in southern Bhutan (Box 3). It is situated on the Himalayan foothills and remains highly vulnerable to annual flash floods, earthquakes, and landslides because of its geographical and climatic conditions (Mukherjee et al., 2022). Susceptibility to these risks, compounded by rapid urbanisation and limited land for development, has highlighted the need for nature-based interventions to enhance urban resilience in the region (Asian Development Bank, 2023).

Box 3. Case study of Phuentsholing, Bhutan

Location	Phuentsholing, Chukha District, Bhutan
Enforcement agencies	Royal Government of Bhutan, Department of Human Settlements (DHS), Phuentsholing Thromde (municipality), Global Environment Facility, and Asian Development Bank (ADB)
Timeline	2013 onwards
Objective	Enhance resilience to climate change impacts and natural disasters, mitigate flood and erosion risks, develop smart urban infrastructures, and promote community vitality and safety (Gupta & De, 2024; Mehta et al., 2023).
Ecosystem type	Urban; riverine
Climate change impacts addressed	Addresses vulnerabilities to flash floods, earthquakes (due to tectonic plate boundaries), landslides, windstorms, and pollution from industrial areas. The risk of mosquito-borne diseases is also noted.
Socio-economic outcomes	Initiatives aim at making Phuentsholing a highly liveable town with enhanced safety, recreational parks, sports facilities, and improved urban infrastructure to support residents and commercial activities
Project cost	USD 63 million (ADB, 2018)
Monitoring and evaluation	The success of projects is evaluated through the Annual Performance Agreement and compliance reports prepared by the DHS. Land-use planning and development activities are periodically reviewed for adherence to environmental and urban development standards.
Trade-offs/Limitations	Limited land for urban development creates continuous pressure owing to rapid urbanisation. The balance between development and environmental conservation presents ongoing challenges.

6.1.4. Living weirs, Thailand: Enhancing water quality and biodiversity in urban waterways

Thailand has been witnessing severe droughts over the past decades. The evolving situation has spurred water management projects and the promotion of research and innovation for local community solutions (Hicks & Mills, 2022). Strategies such as constructing living weirs (low dams built across watercourses using natural materials by community groups) and restoring floodplains are being reimagined to reduce community and ecosystem vulnerabilities, offering benefits in both urban and rural areas (Box 4).

Box 4. Case study of Songkhla and Nakhon Si Thammarat Provinces, Thailand

Location	Khlong-La River, Songkhla Province and Khlong Wang Heep River, Nakhon Si Thammarat Province, Thailand
Enforcement agencies	Office of the National Water Resources - Kingdom of Thailand, GIZ GmbH, with technical support from the United Nations Environment Programme-World Conservation Monitoring Centre (UNEP-WCMC)
Timeline	2016 onwards
Objective	Utilise living weirs made from local materials such as bamboo, sand, coconut coir, and manure as flood buffers, reduce ambient temperatures, mitigate the urban heat island effect, improve groundwater recharge, enhance biodiversity, and foster unity among stakeholders (Srichaiwong et al., 2020).
Ecosystem type	Urban, Riverine
Climate change impacts addressed	Mitigate urban heat island effect, reduce flooding and biodiversity loss, and enhance groundwater recharge
Socio-economic outcomes	Increased crop yields from improved groundwater recharge; enhanced fish habitats leading to better fishing opportunities; and stronger community bonds, income diversity, and food security through collective action (Cowan, 2023).
Monitoring and evaluation	UNEP-WCMC, GIZ, along with local NGOs, and university-backed researchers
Trade-offs/Limitations	The project faced challenges because of a lack of scientific planning, leading to the construction of weirs in inappropriate locations or at incorrect times, which sometimes resulted in damage or destruction of incomplete structures.

A woman cycles home from work along a path regularly flooded by rising sea levels in Demak, Indonesia.

Credit: Dhana Kencana, 2020 / Climate Visuals

6.2. Sub-national initiatives

The following case studies receive backing from state-level or local jurisdictions and are anchored within policy frameworks that emphasise regional climate and nature goals, aligning with the specific geographical needs. They are designed to act as a conduit, linking national strategies with local execution and prioritising areas most susceptible to environmental risks. Each project not only tackles specific environmental challenges but also evaluates the impacts of NbS on local communities, aiming to enhance their adaptive capacities. These projects acquire substantial funding from national or international partners and provide essential administrative support at an ecosystem scale.

6.2.1. Native vegetation of Yamuna floodplains: Policy-supported ecological restoration

The 22-km urban section of the Yamuna River in New Delhi has experienced considerable environmental degradation. The National Green Tribunal (MoEFCC) reviewed the Yamuna River Front Development Plan and proposed several enhancements. Some of the most relevant recommendations included establishing a conservation zone under the Environmental Protection Act, creating the Yamuna Biodiversity Park, and developing wetlands and greenways to improve water quality and aesthetics (Box 5).

Box 5. Case study of New Delhi, India

Location	New Delhi, National Capital Territory of Delhi, India
Enforcement Agency	Government of National Capital Territory of Delhi and Government of Uttar Pradesh and its agencies; Delhi Development Authority with the Centre for Environmental Management of Degraded Ecosystems of the University of Delhi (Bhadu & Punia, 2023; Kumar et al., 2019)
Timeline	2002–2010
Objective	• Conservation of keystone and threatened species and preservation of biodiversity in potential urban development areas • Creation of field gene banks for endangered land areas and genetic resources and promotion of environmental education and awareness • Establishment of native communities along the Yamuna River basin in Delhi • Development of wetlands supporting diverse aquatic life in the Yamuna River
Ecosystem type	Urban, Wetlands

Climate change impacts addressed	The ecological diversity within the wetland habitat sustains rich flora and fauna. The high primary productivity contributed by abundant phytoplankton and zooplankton and submerged, floating, and emergent aquatic vegetation attracts a wide range of birds and other benthic fauna and fishes.
Socio-economic outcomes	The biodiversity park inhabits local communities who help in the maintenance of the park, thereby providing livelihood.
Project cost	USD 57.5 million (GoNCTD, 2008)
Monitoring and evaluation	Land and Revenue Department of Uttar Pradesh and Ministry of Water Resources, Government of India
Trade-offs/Limitations	• Collaboration among various stakeholders along with securing timely funding for the extensive restoration • Managing the technical and legal aspects while minimising unintended environmental impacts • Continuous and long-term monitoring of the large-scale site

6.2.2. Restoration of St Inez Creek, Goa: Urban waterway revitalisation

Originating from the paddy fields in Taleigao, St Inez Creek is a 4-km-long channel meandering through downtown Panaji before it drains into the Mandovi River (Ramanathan et al., 2021). The creek holds significant ecological and social value, serving as a vital habitat for diverse wildlife and a focal point for community recreation. However, because of ad-hoc development and encroachment over time, it suffers from neglect and pollution, warranting a holistic rejuvenation approach that combines civil engineering with NbS to restore the creek and foster community engagement (Box 6).

Box 6. Case study of Panaji, Goa, India

Location	Panaji, Goa, India
Enforcement agencies	Corporation of City of Panaji; Imagine Panaji Smart City Development Limited Taleigao Village Panchayat; Greater Panaji Planning and Development Authority; Asian Development Bank (ADB), (Gajjar, 2020)
Timeline	2016 onwards
Objective	Establish citizen-led restoration programmes along the creek, align with national urban development initiatives, enhance waterbody health, and boost climate resilience through natural resource utilisation
Ecosystem type	Urban, Wetlands

Climate change impacts addressed	By remodelling the creek mouth to maintain tidal inflow, water quality can be improved and adverse ecological disturbances and flooding can be prevented.
Socio-economic outcomes	It helped reduce waterborne diseases, increase biodiversity for aquaculture, and enhance opportunities for livelihoods and community engagement. However, temporary disruptions and livelihood impacts might have occurred during construction.
Project cost	USD 25 million
Monitoring and evaluation	Online/Offline surveys to estimate the impact
Trade-offs/Limitations	• Apathy or disinterest among residents • Integration with the City Development Plan encounters hurdles in coordinating actions across various agencies • Focus on 'replacement' rather than 'rehabilitation' of assets, driven by financial constraints

6.2.3. Mullasery Canal restoration project, Ernakulam: Local-led waterway revitalisation

The Mullassery Canal, located in Kochi, Kerala, is a tidal waterway spanning approximately 1 km from the backwaters to the city centre. The Mullassery canal restoration project originated from an urban design competition under the EnteKochi multi-stakeholder initiative, highlighting the importance of blue–green infrastructure (Box 7). Identifying the canal as pivotal for integrated civic development, the project aimed to tackle urban challenges through a participatory approach.

Box 7. Case study of Ernakulam, Kerala, India

Location	Kochi, Kerala, India
Enforcement agencies	Kochi Municipal Corporation, Cochin Smart Mission Limited and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) via Non-National Infrastructure Pipeline Real Estate Joint Venture (Menon & Sharma, 2022)
Timeline	2020 onwards
Objective	• Revitalisation of neighbouring communities through an open design competition and urban laboratory process • Development of participatory surveys for urban planning and redevelopment projects
Ecosystem type	Urban, Coastal
Climate change impacts addressed	Flood mitigation and identification and resolution of issues such as solid waste disposal and weed growth affecting water flow in Mullassery canal

Socio-economic outcomes	Increased social resilience through community participation. Proposal for the creation of more public spaces along the waterfront to restore lost connectivity with the city's water bodies.
Project cost	USD 8.3 million (The Hindu Bureau, 2024)
Monitoring and evaluation	Ongoing urban laboratory process involving participatory surveys
Trade-offs/Limitations	The project, initially planned for 3 months in 2022, faced administrative delays, resulting in only half of the work being completed by April 2024 (The Hindu Bureau, 2024)

6.2.4. Metro Colombo Urban Development Project, Sri Lanka: Urban food resilience and water management

The Beddagana Wetlands in Colombo, declared a Wildlife Sanctuary in 1985, have been experiencing rapid degradation, resulting in reduced water storage and increased flood risks (World Bank, 2016). As part of the Metro Colombo Urban Development Project, a Wetland Park has been developed to enhance flood resilience (Box 8).

Box 8. Case study of Colombo, Sri Lanka

Location	Sri Jayawardenapura Kotte, Colombo, Sri Lanka
Enforcement agencies	Sri Lanka Land Development Corporation, Colombo Municipal Council (Hewawasam & Matsui, 2020). Funded by World Bank, International Bank for Reconstruction and Development
Timeline	2012 onwards
Objective	Increase urban resilience and reduce flood impacts through the development of wetlands, improvement of the natural flood reduction network, and enhancement of green and blue infrastructure
Ecosystem type	Urban, wetlands, coastal, riverine
Climate change impacts addressed	The initiatives address the impacts of flash floods, particularly during the Southwest monsoon; river flooding; and other hydro-meteorological hazards exacerbated by climate change.
Socio-economic outcomes	The enhancement of green cover and the conservation of wetlands are aimed at reducing disaster risks, improving recreational spaces and potentially generating income through tourism and recreation.
Project cost	USD 321 million (MCUDP, 2020)
Monitoring and evaluation	Urban Development Authority, Colombo

Trade-offs/Limitations	Potential trade-offs include balancing urban development with environmental conservation, managing public access to natural areas without degrading them, and ensuring long-term sustainability and maintenance of the infrastructure.

6.2.5. Sweet City, Costa Rica: Urban green space development for community well-being

Curridabat is Costa Rica's largest urban agglomeration and has about 77,000 inhabitants. It grapples with social and ecological challenges, such as reduced drainage capacity and fragmented urban vegetation cover, stemming from unplanned densification and informal settlements. In response, the Sweet City programme was launched in 2015, addressing these challenges comprehensively and achieving notable success in public policy implementation (Box 9).

Box 9. Case study of Curridabat, Costa Rica

Location	Curridabat, San José, Costa Rica
Enforcement Agency	Municipality of Curridabat, civil society organisations, private firms, not-for-profit organisations, and city residents/resident associations
Timeline	2015–2020
Objective	• Restore biodiversity and build a resilient city by recovering public and private urban spaces in disuse to create green spaces for recreation and improve the health and well-being of residents. • Extend citizenship to pollinators, trees and native plants, and other flora and fauna that coexist within the urban space (Greenfield, 2020) • Enhance wetlands to boost biodiversity and mitigate flood risk • Promote soil health through biodiverse vegetation and organic farming for climate change mitigation • Enhance water management through sustainable drainage, construction of riverfront parks, and springwater recovery for climate change mitigation
Ecosystem type	Urban, wetlands
Climate change impacts addressed	Reduction of urban heat islands, increase in green spaces, and encouragement of pollinator biodiversity
Socio-economic outcomes	Green space improvements have led to the uptake of organic farming practices, motivating citizen participation.
Project cost	USD 45 million

Monitoring and evaluation	Monitoring/evaluation reports and availability of a web-based monitoring tool
Trade-offs/Limitations	• Complexity of land fragmentation, which stems from political boundaries, uncoordinated development, and transportation limitations • Insufficient data on groundwater usage and soil quality hinder development of targeted solutions

6.2.6. Blue-Green Masterplan (2041) of Delhi: Integrating green and blue spaces into urban planning

Delhi boasts of abundant natural and man-made green and blue assets, including the Aravalli Ridge, the Yamuna River, forests, parks, and lakes, which form an interconnected network crucial for the city's infrastructure (Delhi Development Authority, 2021). The city's masterplan outlines a strategy to enhance this green–blue infrastructure by increasing the area of natural assets and incorporating planned green spaces into new development projects (Box 10).

Box 10. Case study of Delhi, National Capital Territory, India

Location	New Delhi, National Capital Region, India
Enforcement agencies	Delhi Development Authority (Singh, 2022)
Timeline	2023 onwards
Objective	• Develop an integrated approach to environmental strategies within the broader urban context, aligning with transport, heritage, and industries to address overall environmental challenges • Recognise and address existing gaps in environmental strategies, particularly focussing on the rejuvenation of Yamuna floodplains through greenways and public waterfronts • Implement a comprehensive framework that treats green and blue assets as essential infrastructure, emphasising pollution control • Protect and enhance natural assets with public interfaces, create new city-level green–blue assets, and promote greening of plots/buildings with the introduction of the Green–Blue Factor
Ecosystem type	Urban, Floodplains
Climate change impacts addressed	Mitigation: Pollution control and carbon sequestration Adaptation: Urban flood management, groundwater retrenchment, and reduction in urban heat island effect
Socio-economic outcomes	Community well-being, potential increase in economic opportunities, and improved quality of life

A man tends to his rooftop garden in Kolkata, India, demonstrating a second-degree solution to capturing rooftop runoff to prevent urban flooding while promoting local produce.

Credit: Sudip Maiti, 2018 / Climate Visuals Countdown

6.3. Community-driven initiatives

The projects showcased below demonstrate the critical role of local communities in the planning, management, and implementation of NbS, emphasising the power of grassroots engagement and local knowledge. Spanning both urban and coastal regions globally, these community-led initiatives tackle environmental challenges through diverse efforts, including endangered species conservation, mangrove regeneration, and construction of community gardens. These strategies not only promote biodiversity and social cohesion but also illustrate the effectiveness of bottom-up approaches in urban environmental governance.

6.3.1. Female-led turtle conservation, Odisha: Community-driven marine conservation initiatives

Odisha, nestled along India's eastern coastline, grapples with environmental challenges amidst its natural wealth, including the critical olive ridley turtle nesting sites (Box 11). Samudram Women's Federation works in the state uniting several women's self-help groups across 50 villages (United Nations Development Programme, 2012). They aim to empower marginalised women while conserving Odisha's biodiversity, notably the endangered turtle habitats.

Box 11. Case study of Odisha, India

Location	Ganjam, Odisha, India
Enforcement agencies	The Samudram Women's Federation supported by the Odisha Marine Resource Conservation Consortium, Odisha Traditional Fish Workers' Union, United Artists Association supported by Greenpeace and World Wildlife Fund (India), Odisha University of Agriculture and Technology, Central Institute of Fisheries Education, Ford Foundation, International Council of Agricultural Research, Coastal Marine Fisheries Research Institute (Government of India), and Berhampur University funded by Equator Initiative (United Nations Development Programme) and Conservation International.
Timeline	1993 onwards
Objective	Monitoring turtle population size, protecting and reintroducing young turtles, restoring habitats, advocating against extractive industry practices, constructing artificial reefs for coastal protection, promoting seaweed cultivation for climate change awareness and income generation, and empowering female members through sustainable fishing practices and economic opportunities (Sharma & Pandey, 2020).
Ecosystem type	Coastal

Climate change impacts addressed	• Seaweed cultivation positively impacts climate change mitigation, potentially enhancing carbon sequestration • Reported income increases and female empowerment strengthen community resilience • Positive ecological effects include increased turtle populations and artificial reefs discouraging destructive fishing
Socio-economic outcomes	Doubling their annual income, from USD 458 in 2004 to USD 967 in 2009, largely because of agar-agar sales
Monitoring and evaluation	Partakes in turtle population monitoring efforts tracking both adults and eggs
Trade-offs/Limitations	Impediments in seeking legal recognition of the artificial reef zone as a biodiversity heritage site

6.3.2. Mangrove regeneration, Sunderbans: Community efforts mangrove conservation

The Sundarbans, home to Asia's largest mangrove forests and a unique tiger population, face significant ecological threats amidst its invaluable biodiversity. Rising salinity, tidal velocity, commercial exploitation, and human encroachment pose formidable challenges to the sustainability of mangroves in this critical region (Hazra et al., 2021). In this context, the Sundarbans Biosphere Reserve addresses the pressing need for mangrove conservation and community resilience in the Sundarbans (Box 12).

Box 12. Case study of Sundarbans Biosphere Reserve, India and Bangladesh

Location	Gosaba, West Bengal, India; Karamjal, Khulna, Bangladesh (Ranjan, 2019)
Enforcement agencies	Caritas India, Gram Panchayats, community-based organisations; non-governmental organisations
Timeline	2000 onwards
Objective	Mitigate disaster risk, highlight the importance of conservation and mangrove management involving local communities, and address policy issues for effective mangrove conservation
Ecosystem type	Mangroves
Climate change impacts addressed	Counteract rising salinity, tidal velocity, commercial exploitation, and human encroachment
Socio-economic outcomes	Community-based mangrove regeneration is expected to increase workdays, enhance local biodiversity, promote unity and cooperation within the community, and boost ecotourism in the Sundarbans.

Monitoring and evaluation	• Studying tidal velocities and salinities and addressing potential plantation site issues prior to regeneration efforts • Advocating for multi-species plantation and scientific selection of species based on environmental conditions
Trade-offs/Limitations	Need for natural recovery before plantation, the importance of long-term protection and maintenance of new plantations, and a ban on harmful practices such as shrimp farming expansion at the expense of mangroves

6.3.3. Rooftop farming, Cairo, Egypt: Urban agriculture driven by community participation

Since the 1950s, the Greater Cairo Metropolitan Region (Box 13) has witnessed an unparalleled surge in informal urbanisation across fertile agricultural areas, resulting in a fragmented terrain and accompanied by substantial socio-economic repercussions (Youssef et al., 2020). As socio-economic conditions in Cairo's informal settlements worsen with increasing climate vulnerabilities, adaptation measures needed to be linked to income generation. To address this issue, the rooftop farming project was initiated in 2014 to encourage community members to grow their own food and reduce dependency on the market (Prinz, 2017).

Box 13. Case study of Cairo, Egypt

Location	Ezbet-al Nasr, Cairo, Egypt
Enforcement agencies	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in collaboration with Shaduf, a local social enterprise (Kamel & El Bilali, 2022)
Timeline	2014–2017
Objective	Regulate micro-climate in densely populated areas, reduce the urban heat island effect, increase green cover, promote sustainable urban farming practices, and empower residents through capacity building and knowledge sharing
Ecosystem type	Urban, Building Rooftops
Climate change impacts addressed	Adapting to heatwaves and urban heat island effect, improving living conditions, and reducing air quality issues
Socio-economic outcomes	Reduced vulnerability to food price fluctuations, development of economic benefits from increased agricultural production and knowledge exchange for local communities

Monitoring and evaluation	The impacts suggest some level of monitoring and evaluation, focussing on climate adaptation, food security, income generation, social cohesion, and increased awareness of nature-based solutions.
Trade-offs/Limitations	Technical and managerial challenges were acknowledged and the necessity for continuous improvement in policy and practice was highlighted to better manage urban water and agricultural systems.

6.3.4. Coral gardening, Vanuatu: Community-based coral reef restoration

Vanuatu is an archipelagic nation nestled in the Southwest Pacific Islands. It is frequently affected by intensified climate-induced hazards, such as tropical cyclones and storm surges, and suffers from slow-onset events including ocean acidification, which pose direct threats to Vanuatu's life-sustaining coral reefs (Waiwai et al., 2023). To address this challenge, the coastal communities have taken up this coral gardening initiative to propagate healthy corals (Box 14).

Box 14. Case study of Shefa Province, Vanuatu

Location	Pele, Shefa Province, Vanuatu
Enforcement agencies	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) with Vanuatu's Nguna-Pele Marine and Land Protected Area Network (Komugabe-Dixson et al., 2019)
Timeline	2014–2017
Objective	Implement climate change adaptation measures for coral reefs through coral gardening, contributing to the restoration of damaged coral reefs, enhancing eco-tourism revenue, and supporting community-based climate adaptation
Ecosystem type	Coral reefs, Marine
Climate change impacts addressed	Addressed ocean acidification, increased ocean temperatures, sea-level rise, and extreme weather events such as hurricanes and tropical cyclones
Socio-economic outcomes	• Plantation of over 3000 coral fragments, stabilising eroding coastlines and improving local food security through increased abundance of coral-associated fish • Generation of sustainable income flows for seven island villages, with funds reinvested in local adaptation and environmental management projects • Empowerment of village women and girls in marine climate adaptation activities

Monitoring and evaluation	Coral fragments were monitored for growth and resilience, particularly against Cyclone Pam. Education programmes engaged over 500 youths in comprehensive coastal management.
Trade-offs/Limitations	Reliance on eco-tourism for project funding, which can be susceptible to fluctuations in tourism, and the challenges of scaling up coral gardening efforts to address widespread reef damage

6.3.5. Building with Nature, Indonesia: Community-centric coastal protection

Having one of the longest coastlines in the world, Indonesia is extremely vulnerable to rising sea levels and sinking land and has lost about 78% of its natural barrier, mangroves (Oliver, 2020). 'Building with Nature' is a holistic concept that integrates nature's services into water and marine engineering, avoiding traditional infrastructure such as sea walls and levees (Box 15), prioritising adaptability and environmental benefits such as carbon storage and biodiversity (Tonneijck & van der Goot, 2022).

Box 15. Case study of Demak, Central Java Province, Indonesia

Location	Demak, Central Java Province, Indonesia
Enforcement agencies	Public–private partnership with the Government of Indonesia, Wetlands International, and Ecoshape, (Wilms et al., 2017) funded by the World Bank, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany) as part of the International Climate Initiative
Timeline	2012 onwards
Objective	Increase resilience of 20 km of coastline with mangrove rehabilitation
Ecosystem type	Mangrove; Coastal
Climate change impacts addressed	Natural mangrove regeneration through semi-permeable brushwood structures, which mimic the roots of mangroves. This slowed the scouring currents and trapped sediment, thereby addressing coastal erosion. Aquaculture ponds donated by the villagers were re-engineered to connect with the ocean.
Socio-economic outcomes	• Improving aquaculture livelihoods through sustainable practices and mangrove conservation. • Coastal field schools trained farmers, resulting in increased yields and improved resilience. • Associated mangrove aquaculture further enhanced productivity and provided alternative livelihoods.
Finance	USD 400 million (World Bank, 2022a)
Monitoring and evaluation	Project monitoring and evaluation occur post-monsoon, informing design updates for coastal safety and socio-economic measures (mangrove count, sediment bed level, and water level).

6.3.6. Restored riverine areas in Rohingya Camps, Bangladesh: Rehabilitation of water systems and natural areas with refugee settlements

With a population of 978,003 individuals, Rohingya camps in Bangladesh are one of the largest refugee camps in the world (UNHCR, 2024). Majority of the refugees inhabit provisional camps atop hills in Cox's Bazar, lacking sufficient water and sanitation amenities. This has led to frequent outbreaks of diseases such as cholera, typhoid, and diarrhoea (Akhter et al., 2020). To combat this, the Center for Natural Resource Studies in Bangladesh, in partnership with the United Nations High Commissioner for Refugees, devised a comprehensive technical blueprint employing NbS to rehabilitate deteriorated riparian ecosystems (Box 16).

Box 16. Case study of Chittagong, Bangladesh

Location	Ukhiya, Chittagong, Bangladesh
Enforcement agencies	Center for Natural Resource Studies and United Nations High Commissioner for Refugees (Jalal et al., 2023)
Timeline	2019 onwards
Objective	• Develop the socio-ecological resilience of the Madhur Chhara watershed with support from environmental specialists and hydrologists • Meet local challenges within the Sustainable Development Goals framework through equal prioritisation of ecosystem preservation and human well-being
Ecosystem type	Coastal, Highland Riparian
Climate change impacts addressed	Micro-climate regulation, carbon sink, reduced flooding and landslides, reduced drought effects, crop diversity / farming systems. Stable riverbanks mitigate erosion, enhance soil fertility, and reduce landslides.
Socio-economic outcomes	Improved water availability and reduced waterborne diseases. Green cover in denuded lands, plant-based food diverse systems, livelihood enhancement, reduced extreme events such as floods and droughts, conservation of agriculture practices, and a 123% increase in wildlife.
Project cost	USD 0.44 million
Monitoring and evaluation	Tracking research progress, assessing the effectiveness of payment for ecosystem services, national workshops on coastal/marine biodiversity conservation
Trade-offs/Limitations	Need for extensive financial resources and ensuring consistent stakeholder engagement for effective restoration efforts in refugee camps

Residents walk past the ruins of buildings along the eroded coastline at Bommiarpalayam, Puducherry. India's eastern coast, shaped by monsoons, faces high longshore drift, making it highly dynamic and vulnerable to coastal erosion.

Credit: Pattabi Raman / Climate Visuals

6.4. Issue-specific interventions

The following section comprises case studies that address specific environmental issues through targeted interventions such as ecosystem restoration, biodiversity conservation, and DRR. Many of these projects are supported by international organisations to mobilise ground-level action.

6.4.1. Conservation

These initiatives are primarily aimed at conserving or restoring ecosystems, with a strong focus on biodiversity, habitat protection, and ecological health. Along the coasts, there is a significant impetus for mangrove conservation through community restoration efforts. Multiple stakeholders, including government agencies, NGOs, and local communities, are key to the enforcement of such projects to enable long-term ecosystem resilience.

6.4.1.1. *Mangrove restoration, Ecuador: Ecosystem recovery project aimed at mangrove habitats for coastal protection*

Historical mangrove degradation in Ecuador has been mainly linked to the expansion of shrimp aquaculture. The Custody and Sustainable Use of Mangrove Agreements (Acuerdos de Uso Sustentable y Custodia del Manglar) was established in 1999, acknowledging the rights and customary practices of communities residing in or reliant upon mangrove ecosystems for sustenance (López-Rodríguez, 2021). In recent years, mangrove restoration efforts in Ecuador, particularly in Esmeraldas and El Oro provinces, have led to noticeable land recovery (Box 17). This progress is attributed to conservation initiatives and sustainable-use agreements implemented in key ecological reserves (Morocho et al., 2022).

Box 17. Case study of Ecuador

Location	Esmeraldas, Manabí, Guayas, El Oro, Ecuador
Enforcement agencies	Conservation International Ecuador, Coastal Fisheries Initiative in Latin America
Timeline	1998 onwards
Objective	Protect and sustainably manage mangrove ecosystems despite the challenges posed by deforestation and the expansion of shrimp farming
Ecosystem type	Mangroves
Climate change impacts addressed	Land recovery from coastal erosion and carbon sequestration
Socio-economic outcomes	• Empower local communities through custody agreements covering an extensive area • Ensure sustainable extraction of mangrove resources • Ensure that over 40% of mangroves are conserved (Morocho et al., 2022; Rodríguez, 2018).

Project cost	USD 25 million (IUCN & CI Ecuador, 2016)
Monitoring and evaluation	Utilises remote sensing and Geographic Information System tools to evaluate changes in mangrove cover over a 20-year period, identifying areas of loss and recovery and evaluating the effectiveness of conservation efforts
Trade-offs/ Limitations	Despite recovery efforts, mangrove loss remains constant with continued threats from shrimp farming expansion, agriculture, and construction.

6.4.1.2. Nature-Positive Business for Climate Critical Ecosystems, Fiji and Solomon Islands: Business-led initiatives promoting conservation and restoration in biodiversity-rich areas

Situated in the South Pacific Ocean, the Solomon Islands and Fiji are biodiverse regions known for their volcanic landscapes and rich cultural heritage (WWF, 2021a, 2021b). They are critical conservation hotspots and host the Southern Hemisphere's third-longest barrier reef, the Great Sea Reef, and the richest birdlife in Western Polynesia (Box 18). World Wildlife Fund's efforts in these regions demonstrate a business-led approach to preserving and restoring vital habitats, in addition to building community resilience against ecological degradation (WWF, 2024).

Box 18. Case study of Fiji and Solomon Islands

Location	Macuata and Ba Province, Fiji; Western Province, Solomon Islands
Implementation / Funding authority	World Wildlife Fund Pacific, Matanataki Pte Ltd, Strongim Bisnis. and local stakeholders for implementation in Fiji; Locally Managed Marine Area Network and Western Province Fisheries in Solomon Islands
Timeline	2022 onwards
Objective	• Restore and manage mangroves through soil restoration, sustainable resource use for enhanced livelihoods and food security, integration of mangrove and fisheries farming management, and implementation of culture-based solutions, including establishing indigenous and community-protected areas • Creation of nature-positive business models in Fiji and sea grapes in Solomon Islands are the focus (Châles, 2023; Seidl et al., 2024).
Ecosystem type	Mangroves, Coral reefs
Climate change impacts addressed	Protection of coastal edge, sea level rise impacts on the coastal communities, and reduction in ocean acidification by reef restoration
Socio-economic outcomes	Livelihood diversification as well as skill enhancement through mangrove plantation trainings.
Project cost	USD 0.68 million

6.4.1.3. East Kolkata Wetlands, Kolkata: Ecosystem services and livelihoods through wetland conservation

The East Kolkata Wetlands (EKW), covering 12,500 hectares, feature a network of water bodies that are part of the Gangetic Delta draining into the Bay of Bengal (Box 19). The area processes 900 million litres of sewage daily from Kolkata, which lends organic matter for fish, vegetable, and rice cultivation. This natural treatment system saves the city nearly INR 4,680 million annually in sewage treatment costs and helps reduce GHG emissions (EKWMA & WISA, 2021). However, EKW faces severe threats from urbanisation and industrial pollution, which compromise its capacity to maintain these functions.

Box 19. Case study of Kolkata, West Bengal, India

Location	Kolkata, West Bengal, India
Enforcement agencies	Managed by a network of local communities and supported by East Kolkata Wetlands Management Authority and East Kolkata Wetlands Development Society (Mundoli et al., 2023; Roy-Basu et al., 2020); National Wetlands Authority and Kolkata Municipal Corporation
Timeline	2002 onwards
Objective	• Implementing nature-based solutions for wastewater management • Sewage water treatment for a healthy circular economy • Providing sustenance and livelihood to 150,000 people through pisciculture and agriculture
Ecosystem type	Urban, Wetlands
Climate change impacts addressed	• Reduce Kolkata's carbon footprint by approximately 3500 tonnes of CO2 annually, equivalent to 60% of the city's emissions. • Function as a sponge, recharging groundwater, storing water for agro-economic activities, and contributing to soil quality improvement and erosion control
Socio-economic outcomes	• Employment opportunities in pisciculture and agriculture • Supporting livelihood of the local community
Project cost	USD 0.24 million
Monitoring and evaluation	Consistent surveillance of waterbird numbers is performed using established protocols from the Asian Waterbird Census at key gathering locations. The West Bengal Pollution Control Board conducts monthly assessments to monitor the quality of water. Current wetland monitoring focusses on land-use changes via remote sensing and assessment of water quality parameters and fish production.
Trade-offs/Limitations	Key knowledge gaps include understanding climate vulnerability, mitigating risks, assessing heavy metal impacts on food production, and studying the effects of soil and plastic waste on the wetland environment.

6.4.1.4. *Bhitarkanika Mangroves, Odisha: Mangrove ecosystem conservation for biodiversity coastal protection*

Spanning 65,000 hectares along the Odisha coast, the Bhitarkanika Mangroves lie between the Brahmani and Baitarani Rivers nurtured by over two decades of conservation efforts. Recognised as both a vital wildlife sanctuary and an important coastal wetland, Bhitarkanika is home to the world's largest known sea turtle nesting beach and the highest density of saltwater crocodiles in India (Box 20). However, intense human activity is degrading the mangroves. Around 300 villages, primarily engaged in paddy farming, border the area (Pandav et al., 2002). Recent constructions such as embankments and aquaculture farms have increased salinity altering the landscape and reducing its suitability for traditional uses. Moreover, a rise in the number of in-migrants from regions near West Bengal has led to deforestation and strained local resources, disrupting the ecological balance.

Box 20. Case study of Bhitarkanika Conservation Area, Rajnagar, Odisha, India

Location	Bhitarkanika Conservation Area, Odisha, India
Enforcement agencies	Rajnagar Wildlife Division - State Forest Department, State Pollution Control Board, Department of Water Resources of Odisha, United Nations Development Programme, Food and Agriculture Organization
Timeline	1952–2002
Objective	Preservation of mangrove ecosystems, wildlife conservation, and sustainable resource management
Ecosystem type	Mangroves
Climate change impacts addressed	Mitigation of devastating cyclones and tidal surges and conservation of biodiversity by setting up waterbird habitats and breeding grounds for brackish water and estuarine fish fauna (Barik et al., 2016)
Socio-economic outcomes	Traditional sustainable harvesting of food, medicines, tannins, fuel wood, construction materials, honey, and fish, balancing ecosystem conservation with human needs
Monitoring and evaluation	Regular assessments of wildlife populations, habitat health, and the impact of conservation measures as part of the Ramsar Convention
Trade-offs/Limitations	Potential threats from population pressures and encroachment and the need for balancing conservation with local livelihoods

6.4.1.5. *Kadamakurdy Redevelopment Project, Kochi: Habitat restoration and sustainable development*

The Kochi Municipal Corporation conducted a spatial analysis of the mangrove areas under its jurisdiction, with a sharp decrease of 14% in coverage from 2013 to 2017. However, 2.5 km^2 of new mangrove areas were established during this period (K M et

al., 2020). The loss of mangrove vegetation poses a severe threat, underscoring the need for targeted conservation efforts to preserve the ecological and economic benefits provided by mangroves in urbanising regions (Box 21).

Box 21. Case study of Kadamakudy, Kochi, Kerala, India

Location	Kadamakudy, Kerala, India
Enforcement agencies	Cochin University of Science and Technology, Department of Town and Country Planning, International Council for Local Environmental Initiatives [South Asia], Deutsche Gesellschaft für Internationale Zusammenarbeit, Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, Germany
Timeline	2013 onwards
Objective	Protection and restoration of wetlands for paddy and shrimp cultivation Redevelopment of blue–green infrastructure (BGI) in urban planning and development Development of a scientifically informed and participatory local biodiversity strategy and action plan (Sánchez & Govindarajulu, 2023)
Ecosystem type	Urban, Wetlands, Mangroves
Climate change impacts addressed	Flood mitigation through BGI redevelopment
Socio-economic outcomes	• Protection of wetlands for agriculture • Development of a 'sponge city' to absorb and mitigate floods • Integration of climate change perspectives with Sustainable Development Goals • Preservation of traditional Pokkali cultivation

6.4.1.6. Mangrove conservation, Mumbai: Initiatives to enhance urban biodiversity and flood resilience

Mumbai, originally comprising several islands in 1670, retains only about 60% of its mangrove cover compared with a decade ago, primarily because of urban expansion and pollution from industrial zones and sewage discharge (Karelia, 2021). The city is home to 15 of the 35 mangrove species found in India, especially those resilient to pollution and salinity (Sarkar, 2017). To maintain these critical habitats and biodiversity, community participation and enforcement of legal protections are crucial in the rapidly expanding metropolis (Box 22).

Box 22. Case study of Mumbai Coast, Maharashtra, India

Location	Vasai Creek, Thane Creek, Manori and Malad, Mahim-Bandra, Versova, Sewree, and Mumbra-Diva, Maharashtra, India

Enforcement agencies	Various government bodies, local non-governmental organisations (NGOs), and community initiatives under Soonabai Pirojsha Godrej Foundation (Azeez et al., 2022; Shyam, 2016)
Timeline	2010 onwards
Objective	Conserve and restore the mangrove ecosystems in Mumbai, highlighting their ecological and socio-economic importance, addressing challenges posed by urbanisation, and enhancing government and community efforts to protect these vital coastal buffers
Ecosystem type	Mangroves
Climate change impacts addressed	Protection against coastal erosion, storm surges, and tsunamis, contribution to soil/sediment accretion, and serving as a natural barrier safeguarding the coastline and supporting biodiversity
Socio-economic outcomes	Supporting livelihoods through fisheries and other marine resources, potential for medicinal and research purposes, and offering opportunities for eco-tourism and education about coastal ecosystems
Monitoring and evaluation	Monitoring and evaluation by local communities and NGOs
Trade-offs/Limitations	Challenges include balancing urban development with environmental conservation, overcoming legal and regulatory hurdles, ensuring sufficient funding and resources for conservation projects, and addressing pollution and habitat destruction

6.4.1.7. Greening and Conserving Mangroves, Pirojshanagar, Mumbai

Godrej's Pirojshanagar Mangroves in Vikhroli, Mumbai, cover a 2,000-acre urban forest that exemplifies scientific management for research, conservation, and public awareness (Box 23). These mangroves protect Mumbai's eastern shoreline from erosion, storms, and cyclones while supporting the livelihoods of local fisher folk who rely on the healthy mangrove ecosystem for their sustenance.

Box 23. Case study of Vikhroli, Mumbai, Maharashtra, India

Location	Vikhroli-Mumbai, Maharashtra, India
Implementation / Funding authority	Godrej and Boyce Manufacturing Company Limited
Timeline	2010 onwards
Objective	Focussed on the conservation of this ecologically sensitive area, bringing all areas with mangrove cover under protection

Ecosystem type	Mangroves, Urban, Coastal
Climate change impacts addressed	Conserves the mangroves through a three-pronged approach of research, conservation, and awareness-raising.
Socio-economic outcomes	Increased awareness and engagement among citizens, scientists, and stakeholders, fostering a sense of responsibility towards the preservation of the city's mangroves.
Finance	USD 62 million
Trade-offs/Limitations	• Challenges in planning and implementation arise because of the varying degrees of degradation and slow growth of mangroves, which require at least 20 years to establish. • Stakeholder engagement is crucial for visibility and conservation, demanding expertise in mangrove ecosystems, hydrology, and geology for suitable species selection and site preparation.

6.4.1.8. Floating Islands, Indore: Pond restoration through green technology

Indore, acclaimed as India's cleanest city, is now focussing on restoring its polluted lakes and ponds. The Police Training College spearheads this initiative with the rehabilitation of Nalanda Sarovar, a 10,000 sq ft pond on its grounds (Clean Water, 2019). Deterioration from the presence of algae and decaying organic materials has necessitated this project. This restoration not only rejuvenates a vital urban water body but also serves as a blueprint for sustainable environmental management in Tier-II cities (Box 24).

Box 24. Case study of Nalanda Sarovar campus, Indore, India

Location	Indore, Madhya Pradesh, India
Enforcement agencies	Implemented by Clean-Water (Sustainable Water Technologies Private Limited), Police Training College
Timeline	2019
Objective	Improve the quality of the water in the pond and reverse the eutrophication
Ecosystem type	Urban, Ponds
Climate change impacts addressed	• Decrease in water contamination and the ecological health of aquatic ecosystems. • Addressing pollution to improve the provision of ecosystem services vital to these aquatic environments by installing floating islands.

Socio-economic outcomes	• Hybrid technologies such as floating islands and bio-filters for pond restoration can spur technological innovation and knowledge transfer within the community. • Local organisations and entrepreneurs may develop expertise in water management technologies, leading to new business opportunities and economic growth.
Governance	Water quality testing, nutrient analysis, observation and monitoring, sludge removal, fish population assessment, and installation and monitoring of bio-filters and aeration systems
Finance	Although floating islands and other technologies used for restoration may require minimal maintenance, there is still some level of ongoing upkeep needed to ensure the effectiveness of the interventions.

6.4.2. DRR

These projects specifically address disaster mitigation, resilience, or recovery through NbS, showcasing the role of ecosystems in reducing disaster risk. Mainstreaming ecological integrity and water quality and enhancing local resilience to regional disasters are critical to the sustainability and resilience of coastal settlements. Importantly, they highlight that although DRR is necessary after the occurrence of a disaster, such projects are responsible for building capacity and infrastructure pre-emptively for the community.

6.4.2.1. Red Cross mangrove restoration, Vietnam: Mangrove reforestation for storm protection

Vietnam, with its extensive 3,444-km coastline, is increasing its forest cover to 45% by 2030, focussing on mangrove afforestation in protected areas. The country has been facing various environmental challenges including a 20-cm sea-level rise over the last 50 years and has intensified efforts to enhance coastal forest quality, particularly mangroves, to reduce erosion, flooding, and salinisation (Box 25). In Thai Binh, a province in the Red River Delta, efforts to improve mangrove coverage have been hindered by poor species selection and inappropriate planting (Aouinti, 2022).

Box 25. Case study of Coastal Vietnam

Location	Thai Binh, Thai Binh Province, Vietnam
Implementation / Funding authority	Vietnam Red Cross with support from Danish Red Cross and Japanese Red Cross Societies
Timeline	1994–2010
Objective	Addressing the loss of coastal protection by restoring mangroves to safeguard sea dykes, reduce flooding risk, and protect livelihoods
Ecosystem type	Mangroves, Coastal

Climate change impacts addressed	Mitigation of typhoons, storm surges, sea-level rise, and flooding, in response to Vietnam's vulnerability to extreme weather events
Socio-economic outcomes	Direct benefits to 3,50,000 people and indirect benefits to 2 million Reduction in damages caused by typhoons, leading to economic savings. Increased aquaculture product yields by more than 200%. Reduced flood and sea dyke damage in communities during storms, with avoided damages estimated at USD 68,370 to USD 252,840
Finance	USD 8.9 million
Monitoring and evaluation	Continuous monitoring of mangrove area increase from 1999 to 2013 Longitudinal comparison of damages caused by typhoons before and after the project External evaluation conducted to assess the project's performance, progress, and sustainability
Trade-offs/Limitations	Limited data constraints for before and after comparisons and challenges in the availability of data for impact assessment

6.4.2.2. Triple Benefit Programme, Myanmar: Multi-faceted approach targeting DRR, climate change adaptation, and sustainable livelihoods

In Myanmar, the community forestry programme initiated in 1995 aims to empower local communities through sustainable forest management and various forestry models (Khaine et al., 2019). The Triple Benefit Programme addresses local needs, promotes conservation, explores the generation of cash and non-cash benefits, and assesses current benefit-sharing mechanisms based on existing community forestry experiences and regulations to build ecosystem resilience (Box 26).

Box 26. Case study of Myanmar

Location	Kachin and Shan States, Mandalay, Magway, Ayeyarwady Divisions, Myanmar
Enforcement agencies	Danish International Development Agency (Strategic Partnership), World Wildlife Fund (Kenya, Uganda, Madagascar and Myanmar)
Timeline	2022 onwards
Objective	Enhanced local partners' ability to design and advocate for NbS, according to the IUCN Standard with expert guidance and tools for NbS implementation and community consultations
Ecosystem type	Tropical rainforests

Climate change impacts addressed	Enhanced the community forestry programmes, with benefit sharing mechanisms to prevent deforestation and forest degradation
Socio-economic outcomes	• Livelihood diversification and green job creation while ensuring safeguards for people and nature • Sustainable management schemes and equitable benefit distribution
Finance	USD 10 million

6.4.2.3. Kathmandu Valley Ecological Urban Renewal Project, Nepal: Urban renewal integrating green spaces for enhanced resilience against natural disasters

Kathmandu Valley, home to three million people and encompassing 18 municipalities, has historically practised sustainable living, harmoniously integrating nature preservation, cultural retention, and economic growth (Cities Development Initiative for Asia, 2023). However, rapid urban expansion has led to challenges such as land fragmentation and the degradation of ecological and cultural assets, exacerbating vulnerability to earthquakes and climate-related disasters. Efforts are being taken to leverage NbS with urban planning to build urban resilience (Box 27).

Box 27. Case study of Kathmandu, Nepal

Location	Kathmandu, Central Hill Zone, Nepal
Enforcement agencies	The Kathmandu Urban Development Project, High-Powered Committee for Integrated Development of the Bagmati Civilization; funded by ADB, World Bank and Deutsche Gesellschaft für Internationale Zusammenarbeit
Timeline	1993 onwards
Objective	Improve productivity and the urban environment, ensure the sustainability of investments through environmental improvements, and increase local resource mobilisation. Integrate ecosystem-based approaches for disaster risk reduction and climate change adaptation (Pokhrel, 2019; Poudel et al., 2023, 2023).
Ecosystem type	Urban, Mountain, Riverine
Climate change impacts addressed	The Kathmandu Metropolitan City Risk Sensitive Land Use Plan address risks from earthquakes, floods, landslides, air pollution, and other climate change-related hazards intensified by deforestation, riverine pollution, and loss of agricultural land.
Socio-economic outcomes	Initiatives aim at improving liveability, reducing socio-economic vulnerabilities (especially among the urban poor), and enhancing community well-being through the integration of blue–green infrastructure and other resilience measures

Project cost	USD 12 million
Trade-offs/Limitations	Trade-offs include balancing rapid urban development and environmental conservation and managing limited resources to address the comprehensive needs of a growing population amid escalating climate risks.

6.4.2.4. Resilience efforts in Barishal, Bangladesh: Community and ecosystem resilience to flooding

Kutubdia Island in Bangladesh is rapidly eroding into the sea, exacerbated by climate change, threatening both the land and livelihoods of its residents. Many people have been forced to relocate, while those remaining struggle with the changing landscape. The situation is a stark example of the broader climate migration issues facing Bangladesh, indicating that up to 13.3 million people could be displaced by 2050 owing to environmental changes (Imtiaz, 2021). Resilience efforts in the region highlight the need for early integration of NbS into the urban planning process (Box 28).

Box 28. Case study of Barishal, Bangladesh

Location	Kutubdia, Barishal, Bangladesh
Enforcement agencies	Barishal District Administration, Barishal City Corporation, 'Barisal-Problem and Prospects' Facebook civic engagement group and funding from Kreditanstalt für Wiederaufbau (KfW) Development Bank
Timeline	2015 onwards
Objective	Making Barishal climatically resilient and environmentally sustainable, reducing waterlogging through natural drainage restoration, enhancing naval transportation, and improving public health and well-being (Mukherjee et al., 2022)
Ecosystem type	Urban, Riverine, Coastal
Climate change impacts addressed	Sagardi Canal Development (2015), Climate Change Adaptation for Urban Areas Programme (2016), and Jail canal restoration (2016) address building resilience to cyclones, flooding (waterlogging, riverine/monsoon floods, and storm/tidal surges), salinity intrusion, and riverbank erosion, with a focus on drainage congestion, solid waste management issues, and encroachment of water bodies.
Socio-economic outcomes	Restoration efforts focus on improving disaster resilience, infrastructure, and health outcomes for the community.
Governance	'Barisal-Problem and Prospects' Facebook group for community feedback suggests some level of civic engagement.
Project cost	USD 40 million (KfW, 2018)

Monitoring and evaluation	The condition of the Jail canal was assessed through newspaper article reviews and interviews, indicating some level of monitoring. However, detailed processes for ongoing evaluation of resilience measures are not provided.
Trade-offs/Limitations	The resettlements in canal areas after initial clean-ups indicate challenges in sustaining the benefits of resilience measures. Limitations include a lack of development guidelines, poor local awareness, and the need for continuous community participation.

6.4.2.5. Tampara Wetland Conservation Project, Odisha: Protection and restoration of a Ramsar site to maintain its ecological integrity and water quality

The Tampara freshwater wetland in Chatrapur, Odisha, was declared a Ramsar site in 2022. It is a 300-hectare biome that has experienced significant degradation owing to landscape changes, increased agriculture, and construction (Verma, 2023). These factors have led to reduced wetland area, disrupted hydrological regimes, and heightened salinisation risks. The Tampara Wetland Conservation Project is a 3-year initiative focused on the sustainable management and restoration of the wetland to enhance the resilience of 12,000 households to water-induced disaster risks (Box 29).

Box 29. Case study of Chatrapur, Odisha, India

Location	Chatrapur, Odisha, India
Enforcement agencies	Pallishree Limited, Chilika Development, Panchayats in Chatrapur Block, Ganjam District funded by Government of India
Timeline	2022 onwards
Objective	Upscaling and mainstreaming Eco-DRR approaches into practice and policymaking for building community resilience to water-induced disaster risk covering 12,000 households (about 60,000 people) (Mishra & Mohapatra, 2023; Ojha & Rout, 2022).
Ecosystem type	Peri-urban; Freshwater Wetlands
Climate change impacts addressed	Eco-DRR through wetland basin hydrological restoration to improve resilience against storm surges, coastal erosion
Socio-economic outcomes	Government-supported programmes have enhanced community-based wetlands management, establishing 15 organizations, 11 task force groups, and over 800 women in self-help groups. Sensitizing 18,000 community members on Eco-DRR, these efforts restored nearly 450 hectares of wetlands and promoted sustainable livelihoods among local fishermen.
Finance	USD 4 million (Patnaik, 2016)

Monitoring and evaluation	Integrating Eco-DRR into their Gram Panchayat Development Plan, ensuring scientific assessments of wetlands with landscape assessments, sectoral plan review with community members

6.4.2.6. Shenzen Sponge City, China: National programme for urban water retention and flood control

For many years, China, with its large population, has grappled with enduring water scarcity and destructive floods. In response, the concept of sponge cities—incorporating natural, green infrastructure into urban drainage systems to absorb, store, and cleanse rainwater—was introduced in the early 2010s to alleviate urban pressures from these challenges (Han et al., 2023). Generally, there has been an evolution from 'grey to green' infrastructures (Box 30). Creating a sponge city addresses four critical water challenges in densely populated areas of China: excess water, scarcity, pollution, and turbidity (Rau, 2022).

Box 30. Case study of Shenzhen, People's Republic of China

Location	Shenzhen, China
Implementation / Funding authority	Public–private partnership with Shenzhen Government (Wang et al., 2022)
Timeline	2016 onwards
Objective	Enhance the city's ability to absorb, store, and release rainwater through urban facilities, thereby controlling stormwater runoff, improving the urban water environment, saving water resources, and ensuring no water accumulation during light rains and minimising waterlogging during heavy rains
Ecosystem type	Urban, Riverine
Climate change impacts addressed	Overcoming waterlogging issues due to heavy rains through stormwater management in the context of rapid urbanisation, exacerbated by climate change.
Socio-economic outcomes	Enhancement of urban liveability and promotion of overall resilience and economic stability
Finance	USD 206 million
Trade-offs/Limitations	'Interim Measures' policy faces challenges because of the complexity of the water ecological environment, insufficient monitoring data, and the need for a more systematic and mature sponge city construction standard policy system. Public participation and coordination among various stakeholders are areas for improvement.