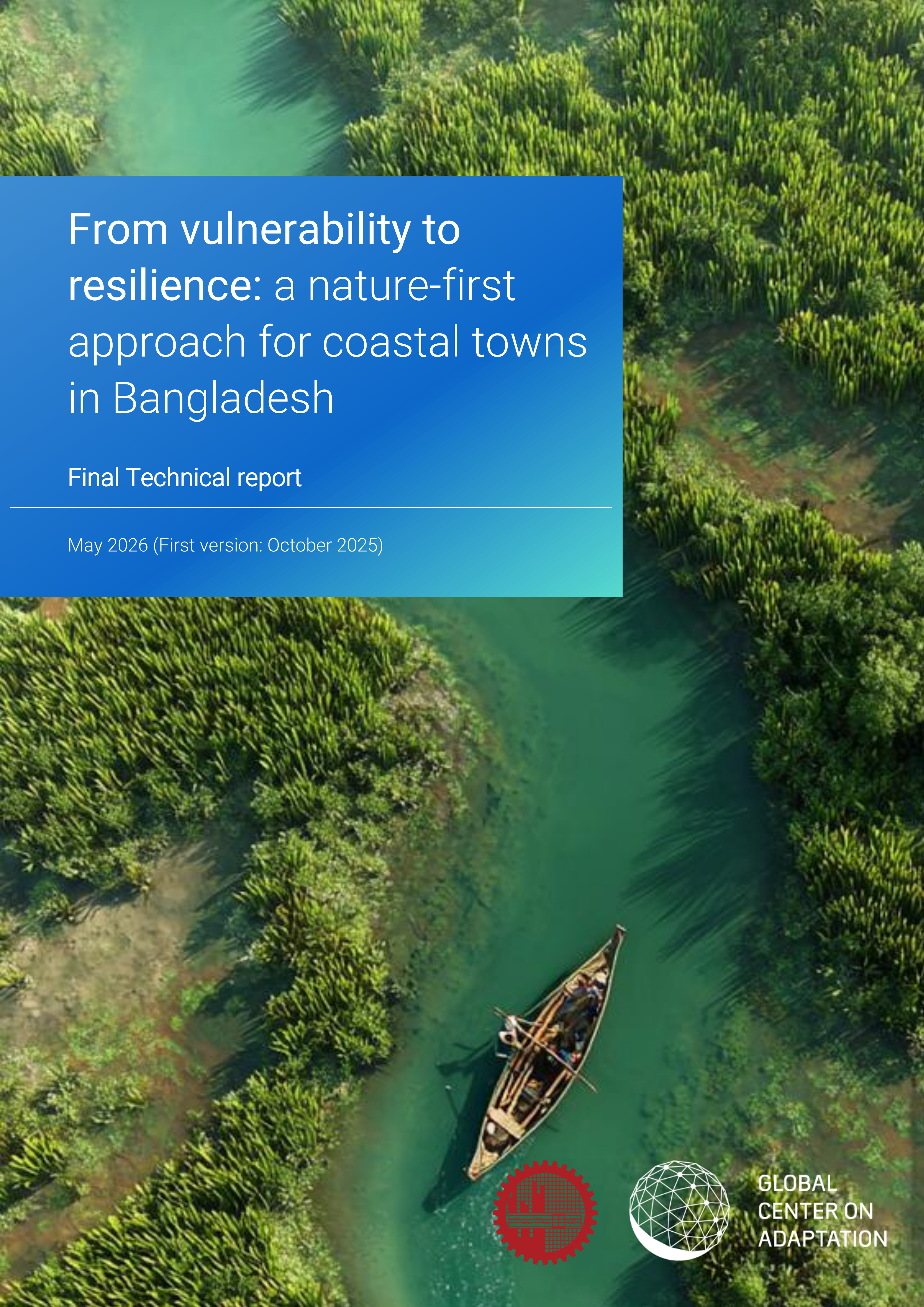

From vulnerability to resilience: a nature-first approach for coastal towns in Bangladesh

Final Technical report

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GLOBAL CENTER ON ADAPTATION

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GLOBAL CENTER ON ADAPTATION

ABOUT THE GLOBAL CENTER ON ADAPTATION

The Global Center on Adaptation (GCA) is an international organization, hosted by the Netherlands, which works as a solutions broker to accelerate action and support for adaptation solutions from the international to the local, in partnership with the public and private sector, to ensure we learn from each other and work together for a climate resilient future.

ABOUT THE INSTITUTE OF WATER AND FLOOD MANAGEMENT, BUET

The Institute of Water and Flood Management (IWFM) plays a vital role in addressing Bangladesh's complex water challenges such as floods, droughts, river erosion, and water scarcity through research, education, and capacity development. Established in 1974 (originally as the Institute of Flood Control and Drainage Research), IWFM supports sustainable water and flood management crucial to the country's socio-economic and environmental well-being.

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Bangladesh's coastal towns are on the frontline of the climate crisis. Rising sea levels, stronger cyclones, salinity intrusion, urban flooding, and erosion continue to threaten the safety, health, and livelihoods of millions of people. Building resilience in these towns requires not only strong infrastructure but also solutions that work with nature rather than against it.

With this in mind, the Local Government Engineering Department (LGED) is proud to support the development of the Nature-based Solutions (NbS) report for the four selected coastal Pourashavas – Bagerhat, Chalna, Morrelganj, and Kuakata. The report is developed to support the Coastal Towns Climate Resilience Project (CTCRP) collaboratively by the Global Center on Adaptation (GCA) and Institute of Water and Flood Management (BUET), in partnership with the Asian Development Bank (ADB), with funding support from the UK Government.

The report provides detailed climate hazard assessments and outlines town-specific NbS options, ranging from mangrove restoration and canal rehabilitation to wetland conservation and eco-park development. It demonstrates that NbS can provide cost-effective, sustainable, and inclusive pathways to address complex challenges such as waterlogging, salinity, and heat stress. It also emphasizes community-driven planning and the critical importance of integrating the perspectives of women, low-income households, and marginalized groups in building truly resilient towns.

LGED is committed to working with all partners to take forward these insights and embed NbS into the country's urban development agenda. By doing so, we can create coastal towns that are not only more resilient to climate risks but also greener, healthier, and more livable for future generations.

Mr. Md. Anowar Hossain

September 2025

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Message : Head Technical Partner

As a low-lying deltaic country in the Global South, Bangladesh is among the most climate-vulnerable countries globally, facing rising sea levels, intensified cyclones, salinity intrusion, and recurring floods that threaten lives, livelihoods, and sustainable development. Bangladesh's coastal region, home to millions, is particularly at risk, with climate hazards like storm surges, sea-level rise, and coastal erosion placing immense pressure on local infrastructure and ecosystems. Strengthening resilience in these areas is essential to protect communities and ensure sustainable growth.

In this light, the Institute of Water and Flood Management (IWFM), BUET, and the Global Center on Adaptation (GCA) have partnered to support the development of Nature-based Solutions (NbS) for urban resilience in coastal Bangladesh. This collaboration forms part of GCA's technical assistance under the Bangladesh Climate and Environment Program, funded by the UK Government. IWFM and GCA have worked together to identify and prioritize NbS interventions across four coastal towns under the Coastal Towns Climate Resilience Project (CTCRP). The initiative is implemented by the Local Government Engineering Department (LGED) with financing from the Government of Bangladesh, the Asian Development Bank (ADB), and technical support from GCA.

We extends sincere thanks to the Asian Development Bank (ADB) for their consistent collaboration throughout the process, with special appreciation to Mr. Kyaw Thu, Task Team Leader (TTL), and Mr. S.A. Abdullah Al Mamun, Co-TTL, CTCRP, ADB. The team also gratefully acknowledges the Local Government Engineering Department (LGED) for their continued engagement and strong commitment to integrating the study's findings into the CTCRP project. Special appreciation is extended to Mr. Md. Mokhleasur Rahman, Project Director, CTCRP; Mr. Ujjal Tripura, Deputy Project Director; Mr. Md. Mafiz Uddin and Mr. Rozdid Ahmmed, former Deputy Project Directors; and Ms. Jobayda Akhter, Senior Assistant Engineer, for their valuable support at various phases of the study.

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Finally, we extend our sincere thanks to the team at the Global Center on Adaptation (GCA) for their strategic guidance, continuous support, and commitment to advancing the Nature-based Solutions agenda in Bangladesh. Special thanks goes to the Global Lead, Infrastructure and NbS, and Country Representative, GCA Bangladesh. Our heartfelt gratitude goes to Mr. Tanim Istiaque for his contributions and dedication, which have greatly enriched this initiative and its outcomes. We sincerely thank Abu Touhid Hossain and Md. Tanvir Rahman Chowdhury for their thoughtful feedback and engagement throughout the process.

We hope this report will serve as a valuable resource for urban planners, practitioners, policymakers, and researchers by providing context-specific insights and cost-effective, actionable interventions to support the effective integration of Nature-based Solutions (NbS) into urban planning and development processes.

Mohammad Asad Hussain, Ph.D.

September 2025

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Background and Rationale

Climate change is reshaping coastlines worldwide, but few places feel its pressures as acutely as Bangladesh's coastal towns. For millions of people, the rising tide is not a distant threat but a daily reality – flooded streets, saline drinking water, heat stress, and disappearing riverbanks. Yet, alongside these challenges lies an immense opportunity: to demonstrate how working with nature can build resilience, restore ecosystems, and secure a safer future.

The Global Center on Adaptation (GCA) is proud to join hands with the Institute of Water and Flood Management – Bangladesh University of Engineering and Technology (IWFM-BUET), the Local Government Engineering Department (LGED), the Asian Development Bank (ADB), and the UK Government to support the integration of Nature-based Solutions (NbS) for climate adaptation in Bangladesh's coastal towns.

The risks are immense. GCA's national stress test of infrastructure systems in Bangladesh already found that coastal flooding events could cause up to €7.4 billion in direct economic damage to the road network by 2050 with wider economic losses and disruptions to livelihoods, food production, and human well-being, with than half of the population in the country living in areas of high climate exposure.

This report, *From Vulnerability to Resilience: A Nature-First Approach for Coastal Towns*, first highlights how these risks are intensifying. Located barely one to one-and-a-half meters above sea level, towns such as Bagerhat, Chalna, Morrelganj, and Kuakata face compound hazards – cyclonic storm surges, tidal flooding, salinity intrusion, heatwaves, and riverbank erosion. Downscaled climate models project monsoon rainfall increases of up to 10 percent by 2055 and a tripling of heatwave durations to more than 36 days per year. Salinity levels may exceed 20 ppt, threatening surface water and food security, while erosion is expected to intensify, displacing communities and damaging vital infrastructure.

Nature-based Solutions can offer a proven pathway to address these risks. By restoring mangroves and wetlands, stabilizing riverbanks with native vegetation, and rehabilitating ponds and canals, NbS reduce disaster risk, support livelihoods, and strengthen biodiversity. For example, mangrove belts can attenuate wave energy by up to 50 percent, reducing coastal erosion. Vegetative slope protection and eco-parks improve urban cooling and enhance water quality while creating green jobs and livelihood opportunities.

Scaling up NbS requires mobilizing financing and aligning policies and stakeholders at all levels. The present work illustrates how bringing together climate analytics, local knowledge, and NbS for climate adaptation can converge to drive real and lasting change. From mangrove restoration in Kuakata to canal rehabilitation in Morrelganj, these interventions are more than technical measures — they are investments in people, livelihoods, and the natural systems that sustain them.

NbS are a cornerstone of adaptation: cost-effective, inclusive, and scalable. They protect lives during disasters, provide water and food security, cool our cities, and create green jobs. Most importantly, they give communities a voice and a role in shaping their own resilience.

This report is more than a set of technical recommendations – it is a call to action. The insights and options presented here can inspire governments, donors, and communities to embed NbS into national planning and to replicate these approaches across climate-vulnerable regions globally.

We thank all our partners for their collaboration and commitment and look forward to continuing this shared mission: turning the power of nature into the foundation of climate resilience.

Adele Cadario
Global Lead, Infrastructure and Nature-Based Solutions
Global Center on Adaptation

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ABBREVIATIONS

Acronyms	Definitions
ADB	Asian Development Bank
BUET	Bangladesh University of Engineering and Technology
CTCRP	Coastal Towns Climate Resilience Project
GCA	Global Center on Adaptation
IWFM	Institute of Water and Flood Management
NbS	Nature-based Solution
SLR	Sea Level Rise

EXECUTIVE SUMMARY

Bangladesh's coastal towns, located within tidal floodplains just 1-1.5 meters above sea level, are among the most climate-exposed urban systems globally. Home to over 35 million people, these towns face compounding climate hazards – cyclonic storm surges, tidal flooding, saline intrusion, heatwaves, and riverbank erosion – intensified by rapid urbanization, inadequate infrastructure, and weak land use regulation. Climate change is accelerating these risks, with the poorest and most marginalized – particularly women, elderly, low-income households, and informal settlers – bearing the greatest burden due to limited adaptive capacity and access to services. This report presents a comprehensive, multi-disciplinary study focused on enhancing resilience and sustainability in the coastal towns of Bangladesh through nature-based solutions (NbS).

NbS solutions are explored across four key pourashavas (towns): Bagerhat, Chalna, Morrelganj, and Kuakata. Each subsequent chapter explores the unique challenges and opportunities within these towns, culminating in a synthesis of key findings and actionable recommendations for stakeholders ranging from local government to marginalized populations. Through evidence, experience, and imagination, the report aims to chart a path toward a more resilient and harmonious future for Bangladesh's coastal communities and similarly vulnerable populations around the world will also be benefited from this study. Using downscaled IPCC climate models, GIS-based vulnerability mapping, and field diagnostics, the assessment revealed:

- Monsoon rainfall may increase by up to 10% by 2055, exacerbating urban flooding, especially where drainage systems are outdated or absent.
- Heatwave durations are projected to triple, reaching over 36 days per year in some towns. In areas where 80–90% of homes have metal roofs, indoor temperatures during heat spells pose severe health risks.
- Over 90% of women in these towns are homebound, making them disproportionately vulnerable to heat stress, unsafe water, and flooding.
- Salinity levels may exceed 20 ppt, threatening surface water quality, agriculture, and food security – particularly in towns without piped water systems.
- Coastal and riverbank erosion, already visible in vulnerable wards, is projected to worsen, displacing communities and damaging vital infrastructure.

While traditional infrastructure like embankments can save lives, they are costly, can disrupt ecosystems, and may fail to adapt to long-term environmental changes. In contrast, Nature-Based Solutions such as restoring mangroves and wetlands enhance resilience by reducing disaster risks, supporting livelihoods, and promoting biodiversity, all while helping to address climate change. The study identifies a wide range of context-specific NbS options, including mangrove afforestation, vegetative slope protection, wetland and canal rehabilitation, pond restoration, eco-park development, and constructed wetlands, all designed to buffer hazards while enhancing co-benefits for biodiversity, livelihoods, and ecosystem health. Planning processes were guided by principles of inclusion, equity, and locally led adaptation, ensuring that the voices and needs of vulnerable communities were embedded in solution design.

Among the four towns, Bagerhat is challenged by non-functional sluice gates, poor drainage maintenance, solid waste mismanagement, and overreliance on groundwater. Proposed NbS include sluice gate rehabilitation, constructed wetlands for leachate filtration, and restoring Pocha Dighi to reduce pressure on aquifers while enhancing safe water access.InChalna, the population suffer from severe riverbank erosion, saline canal systems, and drainage congestion. NbS interventions may include vetiver grass-based slope protection, eco-restoration of Vadra River, tidal gate redesign, and green infrastructure for stormwater regulation and urban cooling.Morrelganj faces persistent flooding due to clogged canals and inadequate drainage, with informal settlements most affected. NbS priorities include pond and canal re-excavation, expansion of rainwater harvesting, and transforming the culturally significant Kuthibari site into a multifunctional eco-park. Kuakata, situated directly on the coast, is at high risk from sea-level rise, salinity, and coastal erosion. Recommended NbS include mangrove reforestation, dune stabilization using native vegetation, floating wetlands, and buffer zones to protect against surges and enhance water security.

The town-wise summary table with possible intervention locations:

SL	Location (Coordinates)	Relevant Climate Impacts	Possible Interventions	Problems Addressed
Bagerhat				
1	Drain near Bus Terminal (22.6734°N, 89.7869°E)	• Monsoon rainfall may increase by ~5%. • Heatwaves may last up to 36 days. • Urban heat island risk with 55% built-up area.	• Drain excavation. • Slab & gate installation. • Community awareness drives.	• Reduces waterlogging in monsoon. • Prevents open drain hazards and blockages. • Minimizes waste-induced flooding.
2	Sluice Gate (South-West, 22.6473°N, 89.8026°E)	• SLR: +23–55 mm by 2050. • River salinity up to 15 ppt. • Flood inundation risk from Pasur River.	• Structural rehabilitation. • Waste bin installation.	• Restores water regulation during high tides. • Reduces backflow flooding in low-lying areas.
3	Under-capacity Sluice Gate (22.6467°N, 89.8019°E)	• Tidal flooding worsens with intensified rainfall. • Peak flow unmanaged due to small vent size.	• Enlarging gate vents. • Connected drain enhancement.	• Increases water discharge capacity. • Prevents market and residential inundation.
4	Three-Vented Sluice Gate (22.6762°N, 89.7841°E)	• Only 1 of 3 vents functional, limiting flow. • Downstream flooding risk	• Full restoration of 3 vents. • Vegetative buffer zones. • Community monitoring.	• Triples flood control efficiency. • Reduces sedimentation and mechanical clogging.
5	Existing Park (Dortana Bridge area)	• 45% households with metal roofs exposed to heat stress. • Warms spell days may increase to 36 days from 11 days causing urban temperature amplification.	• Transforming the park into an Eco-park • Native tree plantation. • Permeable walkways. • Rain gardens.	• Cools urban microclimate. • Enhances infiltration and reduces runoff. • Boosts biodiversity and recreation
Chalna				
6	Assabua Khal (22.595996°N, 89.516341°E)	• Rainfall increase up to 10%. • Saltwater intrusion in 12 canals. • Heatwaves projected to last 36 days.	• Gate repair. • Buffer zone vegetation. • Embankment stabilization.	• Improves stormwater drainage. • Restores upstream-downstream connectivity. • Reduces waterlogging in Wards 7 & 8.
7	Existing Park (near Passur Bridge, 22.6189°N, 89.5113°E)	• 75% households with metal roofs. • 92% of women homebound—high heat exposure.	• Transforming the park into an Eco-park • Native trees. • Biodiversity zones. • Rain gardens & bioswales.	• Mitigates urban heat stress. • Provides safe public green space. • Improves local air and water quality

SL	Location (Coordinates)	Relevant Climate Impacts	Possible Interventions	Problems Addressed
8	Vadra River & Polder 31(22.5952°N, 89.4801°E)	• River drying from gate malfunction Salinity: 16–20 ppt in future Livelihood losses for relocated households	• Tidal gate redesign. • Dredging. • Native aquatic reintroduction.	• Restores river flow and ecology. • Revives freshwater supply and fish habitat. • Strengthens water security for Ashrayan Project.
Morrelganj				
9	Malbahi Khal (22.4530°N, 89.8565°E)	• Flood-prone with >10% rainfall increase. • Poor solid waste disposal exacerbates flooding.	• Canal excavation. • Riparian vegetation. • Drain link reactivation.	• Enhances drainage by unclogging flow paths. • Prevents overflow during monsoon. • Filters runoff through vegetation.
10	Poura Office Pond (22.4515°N, 89.8588°E)	• Salinity affecting surface water (2.1–4 ppt → up to 21 ppt) . • 90% women use pond water for domestic use.	• Bioengineered pond banks. • Rainwater harvesting. • Solar pumps.	• Improves water quality for 200+ households. • Enhances climate-safe water access. • Reduces pressure on saline groundwater.
11	Existing Park (Robert Henry Morrell Kuthi Bari)	• Urban heat island effect. • Lack of biodiversity space. • Encroachment on heritage site.	• Eco park creation. • Pollinator habitats. • Native landscaping.	• Reclaims encroached land. • Boosts recreational and ecological value. • Reduces local temperature stress.
Kuakata				
12	Godaimara Khal (west side)	• SLR: +0.50m in near future. • Wetland fragmentation. • Drainage congestion from dumping.	• Canal re-linking. • Floating wetlands. • Fencing and vegetation buffers.	• Restores natural water flow. • Filters contaminants Reduces illegal dumping.
13	Beach Belt (Mangrove buffer)	• Coastal erosion and storm surges amplified by SLR Storm surge zone from previous cyclones (e.g., Amphan)	• Mangrove afforestation. • Dune stabilization. • Sediment-trapping vegetation.	• Reduces wave energy and erosion. • Shields infrastructure. • Reinforces coastal buffer zones.
14	Wetland near Zhaubon	• Wetland degradation from encroachment. • Loss of native aquatic species. • Salinity affecting biodiversity.	• Wetland restoration. • Bamboo fencing. • Native species reintroduction.	• Revives wetland habitat. • Reduces solid waste infiltration. • Rebuilds aquatic biodiversity.

To move from design to implementation, the report proposes a phased action plan:

- Phase 1: Foundation Building (2025–2027) – Completion of pilot interventions, development of NbS guidelines, and establishment of monitoring systems.
- Phase 2: Expansion and Scaling (2027–2030) – Uptake in all 22 CTCRP towns, integration into masterplans, and mobilization of innovative finance (e.g., PES, green bonds).
- Phase 3: Mainstreaming and Replication (2030–2035) – Institutionalizing NbS across coastal development programs and positioning Bangladesh as a regional leader in ecosystem-based adaptation.

This report demonstrates that Nature-based Solutions are not supplementary, but central to climate-resilient, inclusive, and sustainable urban development. By aligning scientific evidence, local knowledge, and institutional coordination, the work offers a replicable model for transforming how coastal cities adapt to a changing climate – starting in Bangladesh, with relevance far beyond.

1 INTRODUCTION

1.1 Background

Bangladesh, a low-lying deltaic country, is renowned for its vast coastal landscapes, intricate riverine networks, vibrant communities, and natural disasters. The country's coastal zone, spanning approximately 710 kilometers along the Bay of Bengal, is home to over 35 million people, whose lives and livelihoods are intimately linked to the health and productivity of coastal ecosystems. Yet, this region faces an array of formidable challenges, not least of which are the recurrent threats of climate-induced hazards – cyclones, tidal surges, salinity intrusion, and flooding – which have become more frequent and severe with the emergence of climate change.

In response to these challenges, there is a growing recognition, both within Bangladesh and globally, of the urgent need to enhance the resilience of coastal communities. Traditional engineered solutions, while vital, are increasingly deemed insufficient or unsustainable in isolation. As such, the paradigm is shifting towards innovative, holistic strategies that harmonize human needs and environmental conservation. Among these, Nature-Based Solutions (NbS) have emerged as a promising approach, exploiting the inherent strengths of natural systems to mitigate hazards, restore ecological balance, and fortify communities against shocks and stresses.

Against this backdrop, the Asian Development Bank (ADB) has launched the Coastal Towns Climate Resilience Project (CTCRP) in Bangladesh. The CTCRP is a pioneering initiative designed to enhance the resilience of coastal towns or secondary-level cities officially termed as "Pourashava" by integrating climate adaptation, disaster risk reduction, and sustainable urban development. Central to the project is the adoption of Nature-Based Solutions, which complement traditional infrastructure by harnessing the protective and restorative functions of coastal ecosystems—such as mangroves, wetlands, and natural drainage systems.

The Global Center on Adaptation (GCA), in partnership with Bangladesh University of Engineering and Technology (BUET), has provided technical support to the Coastal Towns Climate Resilience Project (CTCRP) in Bangladesh, particularly in advancing climate resilience and the prioritization of Nature-Based Solutions (NbS).

During this support to 22 vulnerable coastal towns under the CTCRP project, GCA has worked closely with the Local Government Engineering Department (LGED) and ADB to assess climate risks and prioritize adaptation solutions. A key focus is the piloting of NbS interventions in four towns, Bagerhat, Chalna, Morrelganj, and Kuakata, where GCA helps identify, design, and implement nature-based approaches that complement traditional infrastructure. Beyond technical design, GCA is deeply engaged in community-led adaptation, through the residents of informal settlements in three towns to develop People's Adaptation Plans. These plans are informed by participatory mapping and profiling of climate threats, ensuring that investments under the CTCRP directly address the priorities and vulnerabilities of marginalized groups.

GCA and BUET also built institutional capacity, strengthening the ability of municipal officials to plan, manage, and maintain climate-resilient infrastructure. This includes targeted training and knowledge-sharing to ensure local ownership and sustainability of NbS investments.

1.2 Report objective

The objective of this report is to detail the NbS adaptation and resilience measures to address key climate risks to the four coastal towns under the Coastal Towns Climate Resilience Project (CTCRP): Bagerhat, Chalna, Morrelganj, and Kuakata. This report serves as both an implementation guide and a practical roadmap for the technical, institutional, and community-led NbS pathways in the four pilot towns. A rigorous, multi-disciplinary methodology supported by participatory field investigation and extensive stakeholders' consultation guided the recommendations documented in the report.

1.3 Report structure

This report is structured as follows:

- Chapter 2 illustrates the summarized findings from the 22 coastal Pourashavas (towns).
- Chapters 3 to 6: Illustrates the proposed NbS solutions for Bagerhat, Chalna, Morrelganj, and Kuakata Pourashava. These chapters also include a brief overview of the climate risks faced by the towns.
- Chapter 7: lays the pathways to scale up NbS across the 22 Pourashavas.
- Chapter 8: gives a conclusion and way forward.

2 FUTURE CLIMATE AND IMPACTS

This chapter synthesizes the findings of a comprehensive climate analytics and risk assessment for 22 coastal Pourashavas (towns) in Bangladesh. Projections for the coming decades indicate a future characterized by more extreme weather events, including intense rainfall, devastating storm surges, and prolonged heatwaves. These climatic shifts will have cascading impacts on critical infrastructure, water security, land stability, and public health. The analysis presented herein distills complex climate projections into simple, layman-friendly insights, providing an evidence base for the urgent policy interventions required to build a resilient future for coastal Bangladesh.

2.1 The Projected Climate Future of Coastal Bangladesh

The coastal region is facing a multifaceted and intensifying climate threat. The primary drivers of this increased risk are significant changes in precipitation patterns, rising sea levels, and escalating temperatures.

Intensifying Rainfall and Flood Risk: Climate models project a significant increase in annual mean precipitation across most coastal towns, with areas like Bhedarganj, Kalaroa, and Zanjira expected to see particularly substantial increases. More critically, extreme rainfall events will become more frequent and severe. The number of days with extremely heavy rainfall is projected to increase by over 60% in some areas (e.g., Bakerganj, Banaripara) by the late 21st century, a trend that will overwhelm existing urban drainage capacities and lead to severe, prolonged waterlogging. This localized flooding will be compounded by increased discharge in the Ganges-Brahmaputra-Meghna (GBM) river system. The hexagonal shape in Figure 2.1 represents the projected maximum water levels (in meters PWD) for three representative stations: Rayenda (Gorai-Madhumati), Alaipur Khal (Bagerhat), and Chalna (Rupsa-Pasur), across return periods of 2.33 years, 20 years, 50 years, and 100 years. A clear increasing trend in water levels is observed with longer return periods, reflecting the impact of more extreme hydrological events. The Meghna and Brahmaputra basins are projected to see discharge increases of up to 31%, severely heightening riverine flood risk in the northeastern and central districts.

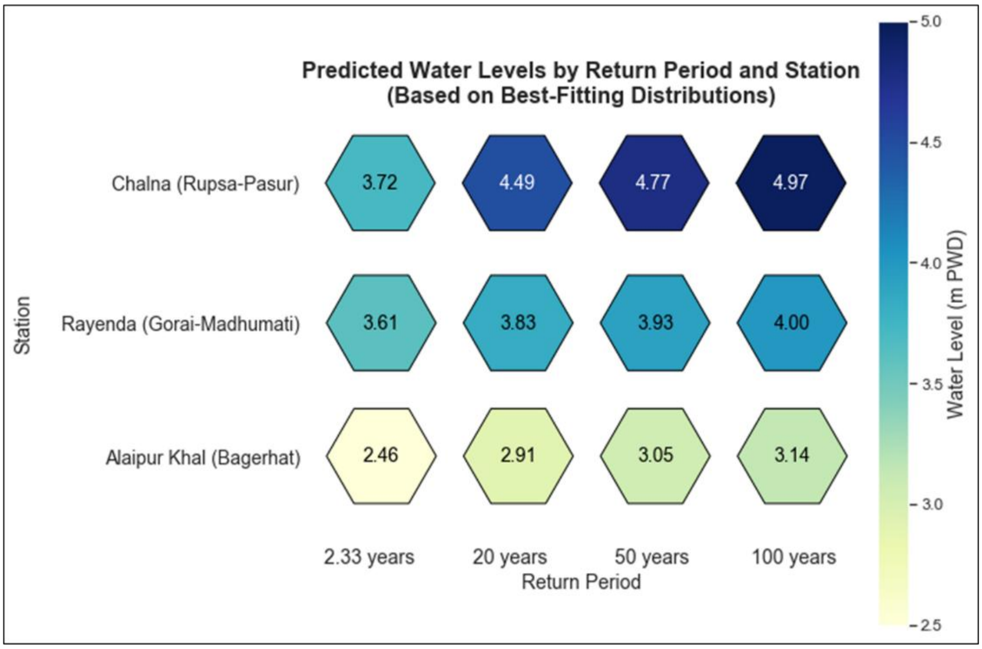

Figure 2.1: Predicted water level at three vital coastal locations for different return periods

Rising Sea Levels and Storm Surge Threats: Sea-level rise (SLR) presents an escalating threat to the coastal Bangladesh. Projections indicate a potential rise of up to 0.84 meters along the Bangladesh coast by 2100. This will dramatically amplify the destructive power of cyclonic storm surges. An SLR of just 0.7 meters is projected to place vast new areas of the south-central coast under "very high" risk of inundation. The devastating impacts of recent cyclones like Amphan (2020) and Yaas (2021) offer a glimpse into a future where such events are more frequent and their consequences far more severe due to a higher baseline sea level (Figure 2.2).

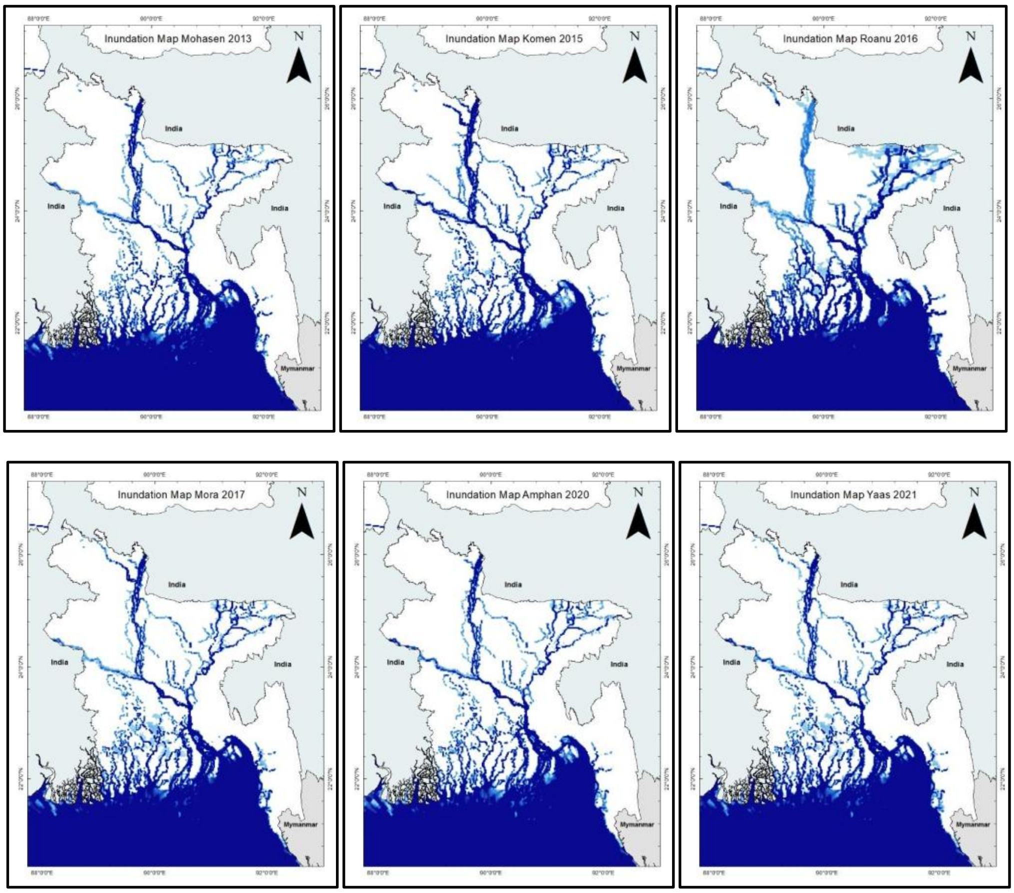

Figure 2.2: Storm surge inundations are shown for cyclones from the last decades

Escalating Urban Heat Stress: The coastal region is projected to experience a dangerous increase in extreme heat. The duration of heatwaves is expected to rise dramatically, even by 40 additional days in some places. By the end of the century, many areas could face over 100 heatwave days annually, with some, like Kalaroa, potentially exceeding 200 days under high-emission scenarios. Furthermore, night-time temperatures are projected to increase by more than 3°C in some locations, limiting the potential for crucial overnight cooling and creating significant public health risks for heat-related illnesses, particularly among the elderly, women, children, and outdoor workers. The changing climate hazard pattern of the 22 coastal towns in the near future (2055) are shown in the following table.

Coastal Towns	Increase in Monsoon Rainfall (%)	Urban Flood and Inundation Risk	Predicted Salinity (ppt)	Erosion Risk	Warm Spell Increase (days)
Bagerhat	5	High	11-15	High	26
Bakerganj	5	Low	2-4	Moderate	27
Banaripara	12	Low	2-4	Moderate	23

Coastal Towns	Increase in Monsoon Rainfall (%)	Urban Flood and Inundation Risk	Predicted Salinity (ppt)	Erosion Risk	Warm Spell Increase (days)
Betagi	3.5	High	5-10	Moderate	40
Bhederganj	18	Moderate	1-2	Low	23
Burhanuddin	7.5	Moderate	5-10	Low	25
Chalna	10	High	16-20	High	25
Charfasson	7	Low	11-15	Low	35
Gauranadi	17	Low	2-4	Low	23
Jajira	18	Moderate	0-1	Low	23
Jhalakati	11	Low	2-4	Moderate	27
Kalaroa	13	Low	16-20	Low	26
Kuakata	6	High	11-14	High	22
Lalmohan	7	Moderate	5-10	Low	25
Mehendiganj	18	Low	4-5	High	25
Morrelganj	10	High	5-10	High	27
Muladi	18	Low	2-4	Moderate	25
Nalchity	15	Low	2-4	Moderate	26
Paikgachha	10	Moderate	16-20	Low	26
Patharghata	7	High	16-20	High	43
Patuakhali	7	Moderate	4-5	Moderate	40

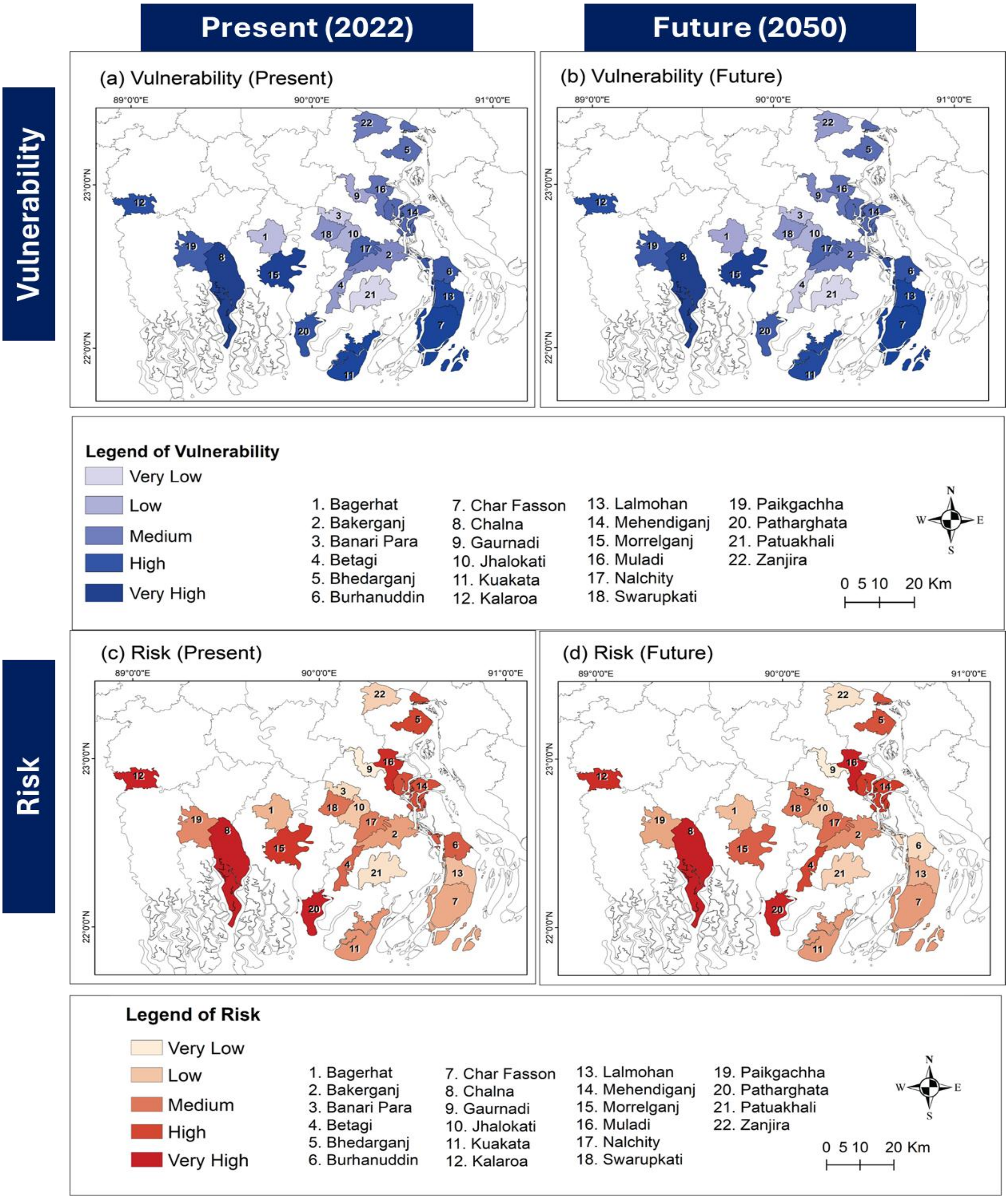

Figure 2.3: Vulnerability and risk index Map for present and future

Climate vulnerability is not uniform across the coastal towns (Figure 2.3). A detailed assessment reveals distinct geographical and temporal patterns of risk.

- Present Day: Towns such as Chalna, Morrelganj, Kuakata, Burhanuddin and Patharghata currently exhibit high levels of vulnerability. The highest-risk areas, considering both exposure and socio-economic factors, include Chalna, Patharghata, and Kalaora.

- Future Projections (2050): By mid-century, vulnerability is projected to intensify and spread. Towns like Char Fasson, Zanjira, and Morrelganj are expected to transition into high or very high vulnerability categories. The risk level is also projected to escalate significantly in towns such as Gaurnadi, Mehendiganj, and Muladi. This spatially explicit data is crucial for prioritizing and targeting adaptation investments where they are most needed.

2.2 Cascading Impacts on Urban Systems and Livelihoods

The projected climatic changes will trigger a series of interconnected consequences that threaten the stability and viability of coastal urban centers.

- Erosion and Unplanned Urbanization: Riverbank erosion is already causing significant land loss, threatening homes, infrastructure, and agricultural land in numerous Pourashavas. Mehendiganj and Chalna are among the most severely affected. This physical loss of land is compounded by unsustainable land use practices. Rapid, often unplanned urbanization in towns like Kuakata and Morrelganj has led to the conversion of vital green spaces and agricultural lands into built-up areas, reducing the natural landscape's capacity to absorb rainfall and buffer against floods.
- Critical Infrastructure Under Strain: Most of the coastal towns lack formal, functioning solid waste management systems. This widespread issue leads directly to the clogging of drains, which is a major driver of urban flooding. Climate change will exacerbate this problem. More intense rainfall will overwhelm already inadequate drainage systems, while rising sea levels and frequent floods threaten to contaminate land and water with waste from unprotected disposal sites. This challenge, however, also presents an opportunity for innovative solutions. Projections indicate significant potential for biogas generation from municipal solid waste in towns like Bagerhat and Morrelganj, offering a path towards sustainable waste management and renewable energy.
- The Growing Water Crisis: Access to safe drinking water is severely threatened by increasing salinity. In one of the aquifers, 100% of Chalna and 97% of Morrelganj already have salinity levels (EC) exceeding national drinking water standards. This problem is set to worsen as sea-level rise and increased groundwater extraction drive further saline intrusion into coastal aquifers. Ensuring a reliable supply of fresh water will require significant investment in climate-resilient technologies such as managed aquifer recharge (MAR), protected pond systems, and rainwater harvesting.

3 BAGERHAT POURASHAVA

3.1 Context

Bagerhat Sadar Pourashava, a historic town and district-level urban center, is experiencing rapid urbanization that has significantly altered its natural landscape. The loss of ponds, wetlands, and natural drainage channels due to indiscriminate land filling and encroachment has diminished the town's ability to manage stormwater, leading to frequent waterlogging and urban flooding, especially during the monsoon season.

The current drainage system, reliant on an outdated network of small, open drains, is inadequate to handle the increased runoff from impervious urban surfaces. Existing canals are silted, encroached upon, and poorly maintained. Encroachments into drainage channels, indiscriminate dumping of solid waste, and a lack of community awareness further compound the problem. Climate change has intensified rainfall patterns, increasing the risk of extreme flooding events. The filling of ponds and wetlands not only worsens drainage issues but also threatens water supply systems.

Water from Pocha Dighi is not used for municipal supply due to fish cultivation, leaving the surface water infrastructure unused, and the Pourashava relies on groundwater from Saira Point to meet its water demand, putting excessive pressure on the groundwater. Additionally, the discharge of untreated sewage into natural rivers like the Pasur is polluting freshwater sources, creating health and environmental hazards. Under this backdrop, this proposal addresses a nature-based approach to enhance drainage and flood management, restore natural ecosystems, and improve the resilience of Bagerhat Pourashava.

3.2 Climate risk assessment

Bagerhat Pourashava has a population of around 55,000, with an equal male-female ratio, and is highly vulnerable to climate change. While the overall climate-driven vulnerability is classified as medium, human-driven vulnerability is high due to rapid urbanization, inadequate infrastructure, and limited access to essential services. The town's 55% built-up area intensifies the urban heat island effect, exacerbating the impacts of rising temperatures and prolonged heatwaves.

By 2055, the duration of warm spells is projected to increase from 11 to 36 days, severely affecting indoor environments – especially for women, 90% of whom remain homebound throughout the day. Households with metal sheet roofs, comprising 45% of the total, are particularly exposed to dangerous indoor heat levels. Combined with only 50% of households having safe sanitation, these conditions elevate health risks, particularly among women, the elderly, and children.

Flooding and drainage congestion are worsened by poor maintenance and encroachment of natural drainage systems, while salinity intrusion threatens water security and agriculture. Surface water remains underutilized, placing unsustainable pressure on groundwater reserves. Riverbank erosion along the Bhairab River is already causing damage to physical assets and threatens displacement of low-income communities.

Although Bagerhat is in a low cyclone hazard zone, it remains highly exposed to storm surge-induced inundation, further endangering critical infrastructure and disrupting livelihoods. Summary of key climatic hazards for Bagerhat Pourashava is shown in the following table. These compounding risks call for urgent, inclusive, and gender-sensitive adaptation strategies to safeguard both people and infrastructure in this climate-fragile urban center.

Climate Hazards	Analysis	Predictions (Near future - SSP245 & SSP370)	Climate Driven Vulnerability	Human Driven Vulnerability and Community impacts
Rainfall	Annual rainfall is close to 1650 mm	Monsoon rainfall might increase by almost 5%	More frequent flooding, impacting physical assets and communities	Higher risk of waterborne diseases, given only 50% toilet comes with safe disposal with flushing water
Temperature	Average maximum temperature is close to 33°C	may increase by 0.8°	Impact human health especially of vulnerable population	55% of the pourashava is built environment, which will make the extreme temperature and heatwave worse. They may create urban heat island effect, exacerbating heat wave
	Maximum of maximum temperature is 37°C	may increase by 0.6°	It may also impact water resources and agricultural productivity	
Heatwave	Warm spell duration close to 11 days	May increase to 36 days	increased mortality rates, particularly among elderly and vulnerable populations	Prolonged heat waves can lead to increased mortality rates, particularly among elderly and vulnerable populations. 45% of households having metal sheet roofs will feel the heat wave more intensely
			May strain healthcare systems, reduce productivity, and damage physical assets	Almost 90% of the women spend whole day at home, who are extremely vulnerable to heatwave
Sea Level Rise	3.6-4.5 mm per year	23 to 50 mm for conservative scenario and 27 to 55 mm for worst case scenario	Saltwater intrusion into the 88 km drainage system, which are used as a freshwater source	Settlements and infrastructure in low-lying zones will be highly affected. Inadequate embankments, increase exposure to flooding and salinity intrusion will be impact both lives and livelihood.
			Erosion of Bhairab riverbanks	
			Flooding of low-lying areas alongside the river	
River Salinity	5.1 to 10 ppt	May increase to 11-15 ppt	Reduced access to freshwater and agricultural productivity	Over-extraction of freshwater and unsustainable land use worsen salinity, threatening livelihoods and food security.
			Negative impact on freshwater ecosystems	

Climate Hazards	Analysis	Predictions (Near future - SSP245 & SSP370)	Climate Driven Vulnerability	Human Driven Vulnerability and Community impacts
River Erosion	Significant erosion	Likely to worsen in the future	Damages to physical asset, like roads and buildings	Deforestation and removal of vegetation along riverbanks, which increases surface runoff and destabilizes soil, making riverbanks more susceptible to erosion
Cyclone & Storm Surge	Low hazard zone for cyclone, very vulnerable to cyclone-based inundation	Likely to remain low hazard zone in the future for cyclone, cyclone based Inundation will increase in the future	Significant damages to human life and physical asset long-term economic impacts and population displacement Disruption of essential services	Degradation of mangroves and weak embankments reduce natural protection, causing greater flooding, economic loss, and service disruption

3.3 Nature-based Solutions for Bagerhat Pourashava

3.3.1 Addressing the inadequate maintenance of the drainage

Several parts of Bagerhat Pourashava are facing issues due to the poor maintenance of their drainage systems (Figure 3.1 and Figure 3.2). One such poorly maintained drain is located at latitude 22.6734° N and longitude 89.7869° E. Local residents have reported that drainage slabs and gates have been stolen, leaving the channels exposed and hazardous. Additionally, there is no allocated budget for routine cleaning and maintenance of these drainage systems, leading to blockages and an elevated risk of urban flooding. Immediate intervention is necessary to restore proper functionality and safeguard public health and safety.

Figure 3.1: The dropped red pin shows the Google map location of the site (left) and Collapsing drainage slab (right)

Figure 3.2: ill-maintained drain with an improper sluice gate (left) and an open drainage system (right)

Proposed NbS for the Drainage Site

- Excavation of Clogged Drains: Clogged drains should be excavated to remove accumulated silt, debris, and waste, ensuring smooth water flow and preventing waterlogging and flooding.
- Formation of Local Volunteer Groups: Small volunteer teams can be formed with enthusiastic local students and youth groups to assist in community-led drainage clean-up drives, promoting civic responsibility and environmental stewardship.
- Public Awareness on Waste Disposal: Awareness campaigns should be initiated to discourage the disposal of plastics and polythene into the drainage system, as these materials obstruct water flow and cause blockages.
- Assessment and Regulation of Inlet-Outlet Ratios: A technical evaluation should be conducted to ensure that the inlet and outlet capacities of the drains are balanced, thereby improving drainage efficiency and reducing water stagnation.
- Installation of Proper Drainage Covers and Gates: All drainage channels should be secured with durable slabs and gates to prevent accidents, unauthorized access, and further theft.

3.3.2 **Rehabilitation of sluice gate**

In Bagerhat, a sluice gate located at latitude 22.6473° N and longitude 89.8026° E, which once played a crucial role in regulating floodwater, has been non-functional for several years (Figure 3.3). As a result, during high tide and flood events, nearby roads and homes are often flooded, leading to significant hardship and property damage for the local community. The lack of effective flood control measures has heightened the area's vulnerability to disaster-related impacts.

Figure 3.3: Dead sluice gate (left) and clogging due to the dead sluice gate (right)

Proposed NbS for the Inactive Sluice Gate

- Provision of Roadside Waste Bins: To address the accumulation of plastic and polythene waste, which often blocks drainage systems and water control structures, adequate waste bins should be installed along roadsides. This will encourage proper waste disposal and reduce blockages that exacerbate flooding.
- Rehabilitation of the Sluice Gate: The existing sluice gate should be repaired and made fully operational to restore its function in controlling floodwater and protecting adjacent areas from tidal and riverine flooding. It'll not only improve the drainage system but also enhance the water flow.

3.3.3 Addressing the under-capacity of the sluice gate

An operational sluice gate, located at latitude 22.6467° N and longitude 89.8019° E near the local market of Bagerhat Pourashava, is currently insufficient to cope with the volume of water during flood tides (Error! Reference source not found.). As a result, nearby roads and residential areas frequently experience inundations. Despite being functional, the limited capacity of the structure does not provide effective flood protection, presenting ongoing risks to the local community.

Figure 3.4: Under-capacity functional sluice gate

Proposed NbS for the under-capacity functional sluice gate

To effectively mitigate flooding in the surrounding areas, the capacity of the sluice gate should be increased. This may involve widening the gate openings or enhancing the drainage infrastructure connected to it, ensuring that it can accommodate larger volumes of water during flood tides and prevent waterlogging in nearby residential and market areas.

3.3.4 **Restoring the three-Vented Sluice Gate**

The sluice gate, located at latitude 22.6762° N and longitude 89.7841° E near the local market in Bagerhat Pourashava, is a three-vented structure intended for floodwater regulation (**Error! Reference source not found.**). However, only one of the three vents is currently operational, with the other two nonfunctional. This limited functionality significantly diminishes the gate's effectiveness, rendering it inadequate to manage floodwaters during high-tide events. As a result, nearby areas often experience flooding, posing risks to both infrastructure and local livelihoods.

Figure 3.5: Partially functional three-vented sluice gate

Proposed NbS for Partially Functioning Three-Vented Sluice Gate

- Restore the full functionality of the sluice gate: To restore the full functionality of the sluice gate and enhance flood control capacity, all three vents must be repaired and made operational. This will enable efficient water discharge, reduce flood risk, and improve the resilience of the surrounding community.
- Vegetative buffer zones around sluice structures: Establishing vegetative buffer zones using native grass and plants around the sluice gate area can reduce erosion, filter runoff, and prevent sedimentation that clogs gate mechanisms.
- Community-based monitoring and maintenance groups: Form local volunteer or youth groups trained in basic sluice gate inspection and debris removal. This community engagement ensures early detection of blockages or malfunctions and promotes long-term stewardship.
- Riparian reforestation upstream and downstream: Planting trees and shrubs along riverbanks near the sluice gate improves soil stability, reduces siltation, and enhances the natural water regulation capacity.

3.3.5 Managing Solid Waste

A designated solid waste dumping site has been proposed and is currently in use by Bagerhat Pourashava for the disposal of all municipal waste (Error! Reference source not found.). This area is also part of the Coastal Towns Climate Resilience Project (CTCRP), providing a valuable opportunity to incorporate climate-smart waste management practices. However, the unmanaged dumping of waste poses significant risks, including leachate contamination, air pollution, and the degradation of nearby ecosystems

Figure 3.6: Unmanaged dumping of solid waste in the proposed location

Proposed NbS for solid waste management

- Establishment of a green buffer zone: Plant native trees, shrubs and moss around the perimeter of the dumping site to act as a natural buffer. This will reduce odor dispersion, capture dust, and protect nearby ecosystems from windblown waste.
- Composting organic waste on-site: Introduce decentralized composting units within or near the dumping site to manage organic waste sustainably. This reduces landfill volume and produces compost for local agricultural use.
- Leachate management through constructed wetlands: Implement constructed wetlands to naturally filter leachate before it reaches nearby water bodies or aquifers. These eco-engineered systems use

native wetland plants to absorb, transform, and break down pollutants, thereby reducing contamination risks and improving water quality.

- **Segregation and recycling initiatives:** Promote community-based waste segregation at the source and establish small-scale recycling units. Local participation can be incentivized through awareness programs and community-led waste banks.
- **Ban on open dumping of hazardous waste:** Enforce strict regulations against the disposal of hazardous or non-biodegradable waste, and introduce designated collection points for e-waste, batteries, and chemicals.

3.3.6 Utilizing Surface Water Supply System

The Bagerhat Water Treatment Plant, located at latitude 22.6588° N and longitude 89.7845° E, operates a dual water supply system – surface water and groundwater. Surface water is intended to be drawn from Pocha Dighi (latitude 22.6538° N, longitude 89.7771° E) during the dry season, but the pond is currently used primarily as a retention basin during the wet season. Due to its use for fish cultivation, water from Pocha Dighi (pond) is not utilized for municipal supply (**Error! Reference source not found.** and **Error! Reference source not found.**). As a result, the fully developed surface water supply infrastructure remains unused, and the Pourashava's entire water demand is met by extracting groundwater from Saira Point. This has resulted in excessive groundwater withdrawal, leading to unsustainable groundwater mining.

Figure 3.7: Pocha Dighi (left) and its locations on the Google Map (right)

Figure 3.8: Ground water treatment plant (left) and surface water treatment plant (right)

Proposed NbS for Water Supply System

- Integrated use of surface and groundwater (conjunctive use): Develop a balanced water use strategy by integrating both surface and groundwater sources based on seasonal availability. Use Pocha Dighi as the primary source in the dry season and groundwater during emergencies only.
- Restoration and designation of Pocha Dighi for potable use: Restrict or relocate fish cultivation activities to alternative ponds and designate Pocha Dighi solely for municipal water supply. Implement buffer zones around the Dighi to protect it from contamination.
- Catchment area conservation and rainwater harvesting: Enhance catchment protection of Pocha Dighi through afforestation and rainwater harvesting to increase surface water retention capacity and recharge the aquifer naturally.
- Public awareness and stakeholder engagement: Conduct campaigns to inform the local population about the risks of groundwater overuse and the importance of shifting toward sustainable surface water use.
- Monitoring and regulation of groundwater extraction: Install water meters and enforce limits on groundwater abstraction through municipal regulation, especially during the dry season.
- Rehabilitate and maintain water infrastructure: Ensure that the existing surface water system infrastructure (pipelines, pumps, treatment units) is regularly maintained and fully operational to allow seamless switching from groundwater to surface water.
- Using plants to clean and purify water: Using specific plants known for their ability to absorb or degrade pollutants in water, such as water hyacinth, reed beds, or cattails. These plants can help remove heavy metals, excess nutrients, and other pollutants from the water of the Dighi.

3.3.7 **Potential Eco Park near Dortana Bridge**

Near the Dortana Bridge, a large, underutilized area with significant potential for the development of an Eco Park was identified (Error! Reference source not found.). With proper planning, this space can be transformed into a sustainable green area that will provide numerous environmental and social benefits.

An Eco Park in this location could help increase green cover, providing much-needed vegetation to cool the surrounding area, reduce the urban heat island effect, and improve the overall climate resilience of the region. The park could also support groundwater infiltration by incorporating permeable surfaces, such as natural walkways, rain gardens, and bio-swales, which would allow rainwater to seep into the ground and recharge the local aquifer. In addition to its environmental benefits, the Eco Park would serve as a recreational space for the community, offering a healthy and pleasant environment for residents to engage in outdoor activities. It would also improve air quality by absorbing carbon dioxide and other pollutants, contributing to better public health. By carefully planning and integrating sustainable landscaping practices, this Eco Park can become an important asset for the area, enhancing both the quality of life for residents and the environmental health of the surrounding ecosystem.

Figure 3.9: Bagerhat Pouroshava Park

4 CHALNA POURASHAVA

4.1 Context

Chalna Pourashava, located in Dacope Upazila and within Polder 32, faces significant challenges in drainage and flood management. The Pourashava lacks a well-planned and efficient drainage system, resulting in frequent urban flooding during rainfall events. Some open channel drains suffer from the lower invert levels than the outlet – causing stagnant water and poor flow. Moreover, the limited capacity of water control structures, such as the single-vent sluice gates, constrains the discharge of stormwater and exacerbates flooding risks. Rapid urbanization, climate change, and the lack of regular maintenance further compound these issues. Chalna Pourashava is making commendable efforts to preserve and utilize existing ponds and water bodies for rainwater harvesting, flood mitigation, and drinking water supply.

4.2 Climate Risk Assessment

Chalna Pourashava is highly vulnerable to both climate-driven and human-driven risks. With a population of 16,000 and a near-equal male-female ratio, the town faces escalating threats from rising temperatures, intensified heatwaves, frequent flooding, river erosion, and salinity intrusion. The Chunkuri and Passur rivers, along with 12 canals and 3.5 km of drainage systems, are under increasing stress from sea-level rise and salinity, undermining freshwater access and agricultural productivity.

By 2055, monsoon rainfall is projected to rise by 10%, and warm spells may stretch up to 36 days – amplifying the urban heat island effect. Over 75% of households have metal sheet roofs, and nearly 92% of women spend most of their time indoors, placing them at high risk of heat-related health issues. The absence of a piped water supply system further compounds the burden, especially on women responsible for water collection.

Riverbank erosion along the Chunkuri and Passur rivers threatens transport routes, housing, and livelihoods. Additionally, 74% of households rely on wood for cooking fuel, contributing to deforestation and worsening the town's heat exposure. With 21% of working men involved in agriculture, salinity and flood-related crop failures directly affect income and food security. The following table summarizes the key effects of climatic hazards in Chalna. The intersecting challenges highlight the need for inclusive, climate-resilient infrastructure planning, and gender-responsive adaptation strategies to protect vulnerable communities in Chalna.

Climate Hazards	Analysis	Predictions (Near future - SSP245 & SSP370)	Climate Driven Vulnerability	Human Driven Vulnerability and Community impacts
Rainfall	Annual rainfall is close to 1646 mm	Monsoon rainfall might increase by almost 10%	More frequent flooding, impacting physical assets and communities	Higher risk of waterborne diseases, given only 50% toilet comes with safe disposal with flushing water
Temperature	Average maximum temperature is close to 32°C	may increase by 0.8°	Impact human health especially of vulnerable population	74% of the pourashava use wood as source of cooking fuel, which might reduce the tree cover and drive temperature higher
	Maximum of maximum temperature is 36°C	may increase by 0.6°	It may also impact water resources and agricultural productivity.	

Climate Hazards	Analysis	Predictions (Near future - SSP245 & SSP370)	Climate Driven Vulnerability	Human Driven Vulnerability and Community impacts
Heatwave	Warm spell duration close to 11 days	May increase to 36 days	Increased mortality rates, particularly among elderly and vulnerable populations	More than 75% of the households in Chalna have metal sheet as roof and 35% have metal sheet as walls, which will worsen the situation
			May strain healthcare systems, reduce productivity, and damage physical assets	Almost 92% of the women spend whole day at home, and 21% of working men is involved in agriculture, who are extremely vulnerable to heatwave
Sea Level Rise	3.6-4.5 mm per year	23 to 50 mm for conservative scenario and 27 to 55 mm for worst case scenario	Saltwater intrusion into the 12 canals and the 3.5 km drainage system, which are used as freshwater source	The dependence on canal water for irrigation might have a long-lasting impact on Agriculture
			Erosion of Chunkuri and Passur riverbanks	
			Flooding of low-lying areas alongside the river	
River Salinity	10 to 15 ppt	May increase to 16-20 ppt	Reduced access to freshwater and agricultural productivity	The pourashava does not have water supply system to household
			Negative impact on freshwater ecosystems	
River Erosion	Significant erosion	Likely to worsen in the future	Damages to physical asset, like roads and buildings	Potential displacement of communities living in erosion-prone areas
Cyclone & Storm Surge	Medium hazard	Likeky to worsen in the future	Significant damages to human life and physical asset	Embankments are poorly maintained or illegally cut for shrimp farming access, causing breaches during cyclones. Widespread shrimp farming has replaced protective mangrove belts, leaving the area directly exposed to tidal surges; as a result.
			long-term economic impacts and population displacement	
			Disruption of essential services	

4.3 Nature-based Solutions for Chalna Pourashava

4.3.1 Addressing the inadequate maintenance of the drainage

One of the key issues is drainage congestion because drains are not well established and connected with the Khals. There are four majors Khals in Chalna – Borokholisha Khal, Chalna khal, Asabbua Khal, and Baroikhali Khal (Figure). All the khals are well operated by the Sluice gate except the Asabbua Khal (22.595996°N, 89.516341°E), which causes waterlogging and drainage congestion in wards no 7 and 8.

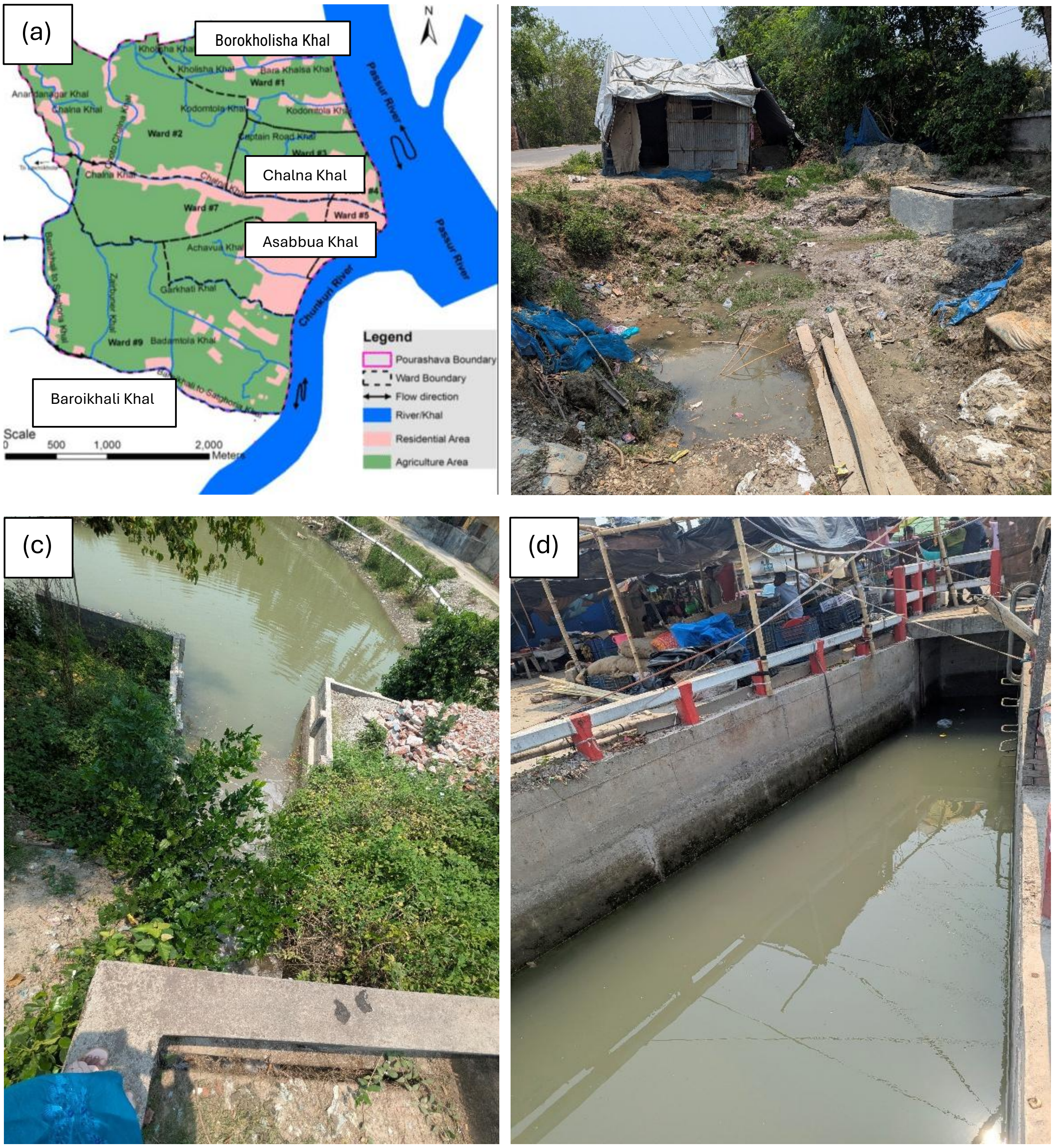

Figure 4.1: (a) Drainage Map of Chalna Pourashava[1], (b) Non-functional sluice gate of Assabbua Khal, (c) Baroikhali Sluice Gate, (d) and Boumar Gachtola Sluice Gate.

[1] Rahman, Atiqur & Saha, Rupayan & Haque, Md Mahmudul & Hossain, Shahadat. (2014). *Storm Water Management for Urban Areas of Bangladesh by Analytical & Modelling Approach: A Case Study of Chalna Municipality*.

Historically, Asabbua Khal was directly connected to the drainage network illustrated in Figure (b), playing a crucial role in the area's stormwater and tidal water management. However, due to the malfunction of the Asabbua Sluice Gate, this entire drainage linkage has been severely disrupted, leading to significant drainage congestion and waterlogging.

Local officials reported that the Boumar Gachtola Sluice Gate also experienced structural failure due to the overflow of water. In response, the gate structure was elevated by one meter to stabilize it. Despite this adjustment, the number and capacity of sluice gate vents remain insufficient to manage the high volume of water, particularly during peak flow events. This mismatch continues to hinder effective drainage and poses a risk of recurrent flooding in the surrounding areas. The drain shown in Figure 4.2 was previously connected to the Chalna River which is now disrupted due to sluice gate failure.

Figure 4.2: Chalna River (left) and the connected drain with Chalna River at Chalna Pourashava (right).

Proposed NbS for Restoration of the Drainage System

- Removal of plastic and polythene waste from drains: Immediate cleaning and removal of plastic and polythene debris from the drainage network is essential to increase drainage capacity and maintain uninterrupted water flow. This should be accompanied by community awareness programs to discourage waste disposal in drains and promote responsible solid waste management.
- Reinforcement with vegetated embankments: Stabilize both sluice gate structures and adjacent embankments using bioengineering methods, such as planting deep-rooted grasses and shrubs. This reduces erosion and strengthens structural integrity.
- Buffer zone plantation around waterways: Plant native vegetation along the banks of Asabbua Khal and near sluice gates to act as a natural buffer, reduce sediment inflow, and provide cooling and biodiversity benefits.
- Restoration of the Asabbua gate: The Asabbua gate should be restored and made fully functional to address the issue of drainage congestion. Reviving this critical water control structure will help regulate water flow and reduce urban flooding during heavy rainfall and tidal events.
- Upgradation of sluice gate vent capacity: Increase the number and size of vents at both Asabbua and Boumar Gachtola sluice gates to allow sufficient water discharge, especially during high-flow periods and storm surges.

4.3.2 **Tackling vulnerable sites for erosion**

Chalna Pourashava is identified as a highly erosion-prone area, with repeated damage to critical infrastructure, shown in Figure (22.595547°N, 89.516691°E). Local residents reported that the bridge has been eroded three to five times over recent years, significantly compromising connectivity and safety. In response, the Roads and Highways Department implemented temporary wooden piling as an emergency measure to protect the adjacent road from further erosion. However, a more sustainable and long-term solution is urgently required to safeguard infrastructure and ensure uninterrupted access.

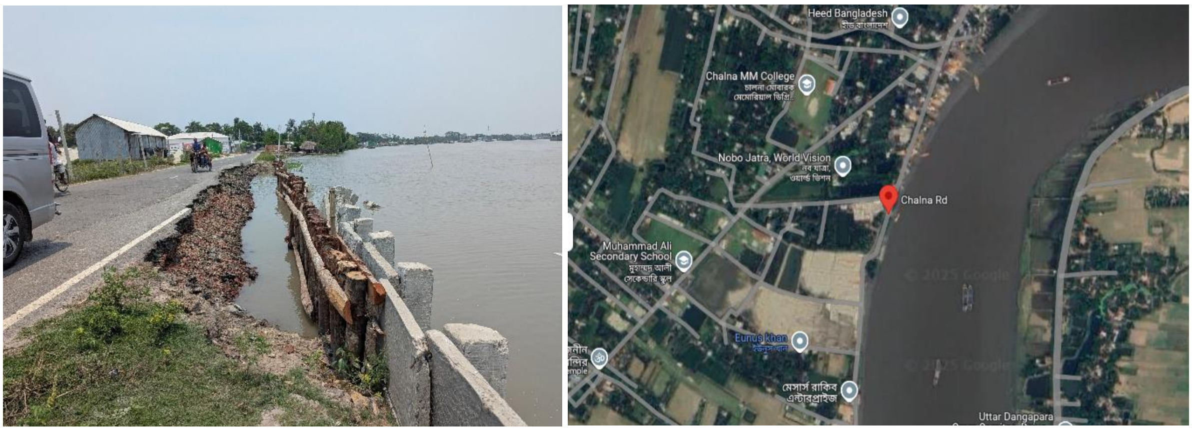

Figure 4.3: The erosion-prone Chalna road (left), and the dropped red pin shows the Google location of the site (right).

Proposed NbS for Erosion

- **Bioengineering with Vetiver grass and bamboo**: Plant vetiver grass, bamboo, and other deep-rooted native vegetation (ex, Mangrove plants) along riverbanks and erosion-prone slopes to stabilize soil and reduce surface runoff. These plants form dense root networks that naturally bind soil and reduce erosion.
- **Construction of vegetated riprap or green gabions**: Replace or reinforce existing wooden piling with vegetated riprap or green gabions (wire mesh baskets filled with stones and vegetated with local plants) to provide both structural protection and ecological benefits along riverbanks and around the bridge.
- **Restoration of riparian buffers**: Re-establish natural riparian buffer zones along the banks by planting native shrubs and trees. These buffers absorb wave energy, slow down runoff, and trap sediments before they reach the water body.
- **Community monitoring and maintenance groups**: Form community-based erosion watch teams to monitor early signs of erosion, assist in the maintenance of green infrastructure, and ensure long-term sustainability of NBS interventions.

4.3.3 Utilizing surface water supply system

Vadra River: The drying up of the Vadra River (22.595234°N, 89.480095°E) is a direct consequence of a series of decisions taken by local authorities, particularly the construction and non-operational status of the sluice gate in Polder 31. Originally, Polder 31 was constructed to prevent salinity intrusion into the surrounding areas and protect agricultural lands and freshwater resources. However, due to the malfunctioning sluice gate, the natural flow from the upstream has been obstructed, preventing water from reaching downstream areas. This disruption has led to the drying of the Vadra River, severely impacting the riverine ecosystem and water availability. Moreover, in the vicinity of the dried riverbed, the government has implemented the Ashrayan Project (Ashrayan Prokolpo) to provide housing for homeless people. While this is a commendable social initiative, the lack of water in the adjacent river raises concerns about water security, sanitation, and long-term sustainability for the relocated community (Figure).

Figure 4.4: Failure of sluice gate at polder 31 (left); Water treatment plant of Chalna Pourashava at Vadra River (right)

Proposed NbS for Restoration of the Vadra River

- **Reactivation and ecological re-design of sluice gates**: Immediately repair and operationalize the existing sluice gates to restore the natural upstream-to-downstream flow. Incorporate an ecological design that allows seasonal freshwater flow while still preventing salinity intrusion.
- **Controlled flow regulation through smart tidal gates**: Introduce smart or semi-permeable tidal gates that allow freshwater passage during low tides and block saline water during high tides. This supports ecological flow while maintaining salinity control objectives.
- **Dredging and channel reconnection**: Carry out selective ecological dredging to remove silt deposits and reconnect the original river course, ensuring continuous flow from upstream to downstream sections of the Vadra River.
- **Reintroduction of native aquatic life and vegetation**: After restoring flow, gradually reintroduce native aquatic plants and fish species to rebuild the river's ecological function and revive local livelihoods dependent on the river.

Existing ponds in Chalna Pourashava: The Pourashava office pond (22.602746°N, 89.522232°E) has one side lined with concrete, which disrupts the natural infiltration and groundwater recharge, limiting the pond's ecological functionality (Figure (a)). Another pond in the Pourashava (22.602188°N, 89.522589°E) is surrounded by vertical retaining walls, posing a structural risk of collapse and reducing slope stability, which may lead to pond bank failure over time (Figure (b). The third pond (22.602509°N, 89.521601°E) is actively used as a retention pond for treated drinking water, where water is pumped from the Vadra River by the water treatment plant and temporarily stored before being distributed to the Pourashava. The quality of this water is critical for public health (Figure (c)).

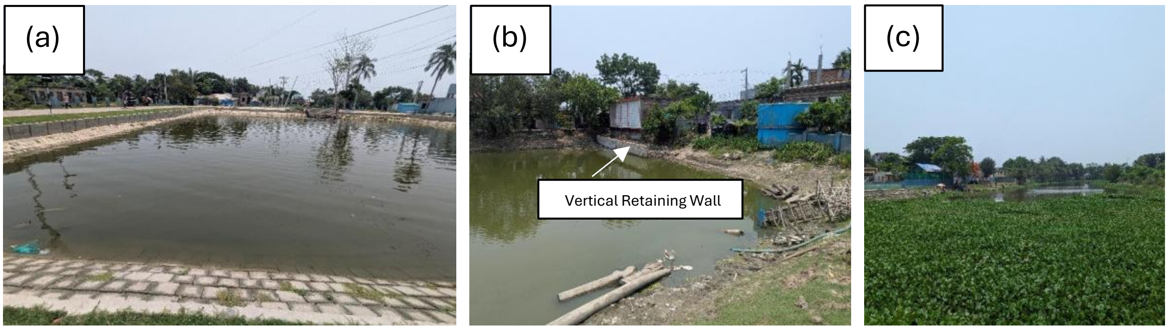

Figure 4.5: (a) Pourashava office pond 1, (b) the Pourashava office pond 2, (c) the Backside Pond of the Pourashava office.

Proposed NbS for Restoration of Water Bodies

- Partial removal or modification of concrete lining: In the first pond, replace sections of the concrete boundary with permeable natural materials (e.g., stone pitching, grassed banks) to restore groundwater recharge while maintaining erosion control.
- Stabilization of retaining walls with vegetated slopes: Replace the vertical walls of the second pond with gently sloped, vegetated embankments using bioengineering techniques such as coir logs, vetiver grass, and terracing to ensure long-term bank stability and enhance ecological value.
- Water quality buffering for the drinking water retention pond: For the third pond, establish buffer vegetation zones around the perimeter to filter runoff, reduce sedimentation, and provide a natural barrier against contamination. Introduce floating wetlands to support water quality improvement through phytoremediation.
- Native tree plantation and shade management: Plant native trees around all three ponds to improve the microclimate, reduce evaporation, and support local biodiversity. Species selection should consider root stability to avoid structural issues near pond edges.

4.3.4 Potential Eco Park in Chalna Pourashava

This location (22.618919210164734, 89.5112811547413) is primarily suitable for an Eco Park in Chalna Pourashava. Strategically situated within a semi-urban, ecologically sensitive area, the location offers significant potential to serve as a recreational, educational, and biodiversity-enhancing blue and green space for the local community (Figure).

Figure 4.6: The proposed Eco Park location (left) and the excavated water body in the proposed Eco Park (right).

Proposed NbS for Eco Park Development

- Native tree plantation and microclimate regulation: Plant a diverse mix of native and climate-resilient trees to provide natural shading, regulate temperature, and improve air quality. Select species that support local birds, pollinators, and soil enrichment.
- Rain garden and stormwater management: Develop rain gardens and bioswales within the park to naturally capture and filter rainwater, reducing runoff and recharging groundwater while supporting aesthetic landscaping.
- Permeable walkways and open spaces: Use pervious materials (e.g., brick chips, grass pavers) for pathways and open areas to maintain natural drainage and reduce surface heat buildup.
- Wetland or pond area restoration: If a natural lowland or wet area exists at the site, restore it as a constructed wetland or pond to support aquatic life, act as a water reservoir, and increase biodiversity.
- Waste-free zone with segregated bins: Ensure the Eco Park is maintained as a zero-waste zone by installing segregated waste bins, composting stations, and running awareness campaigns to promote responsible visitor behavior.

- **Butterfly garden and biodiversity zones**: Allocate sections of the park for butterfly gardens, native flower beds, and habitat islands to encourage pollination and conservation of local species.
- **Community garden or learning corner**: Integrate a community-managed garden or nature education corner to engage local schools, youth groups, and visitors in ecological learning and conservation practices.
- **Solar lighting and green infrastructure**: Use solar-powered lighting and low-carbon construction materials for benches, viewing decks, and park shelters to align with sustainability goals.

Figure 4.7: Few examples of eco-friendly parks

5 MORRELGANJ POURASHAVA

5.1 Context

Morrelganj Pourashava faces recurring challenges of flooding, drainage congestion, and water management. Its vulnerability is exacerbated by tidal surges, unplanned urbanization, and weak maintenance of natural and built water systems. Ponds and canals – once vital for flood management and water supply – are under threat from encroachment, pollution, and siltation. Conventional drainage systems, often constructed without holistic design, have proven inadequate. On the other hand, concrete-heavy interventions and a lack of proper maintenance have further reduced the natural conveyance capacity of canals and water bodies. While rapid urbanization and climate change have further compounded these issues, waste dumping into drains, canal encroachments, and inadequate cleaning have worsened the situation. Morrelganj also faces a severe drinking water crisis, relying heavily on untreated pond water and limited rainwater harvesting systems. In this context, an integrated NbS approach is proposed for drainage and flood management for Morrelganj Pourashava.

5.2 Climate Risk Assessment

Morrelganj Pourashava faces high climate-driven and human-induced vulnerabilities, placing its 23,000 residents – equally split by gender – at substantial risk. Increasing rainfall and heat, coupled with inadequate drainage, have made waterlogging a persistent problem across marketplaces and densely populated zones, such as Bashkhali village, Krishi bank road, and Boyra bazar. With monsoon rainfall expected to rise by 10% by 2055, existing infrastructure will be further strained.

The absence of embankments and poorly maintained canals exposes wards 8 and 9 to river erosion, endangering transport networks and housing. Climate projections show heatwaves may extend up to 39 days, while over 72% of homes with metal roofs and 90% of women confined indoors are at heightened risk of heat stress. With 71% of households depending on wood for cooking fuel, the loss of vegetation may intensify urban heat.

Salinity intrusion into surface water used for drinking (33%) and irrigation will increase vulnerability to waterborne diseases and reduce agricultural yields. Cyclone-induced inundation and storm surges further threaten lives, livelihoods, and infrastructure. Together, these impacts underscore the urgency of integrated, gender-responsive, and ecosystem-based climate adaptation in Morrelganj.

Climate Hazards	Analysis	Predictions (Near future - SSP245 & SSP370)	Climate Driven Vulnerability	Human Driven Vulnerability and Community impacts
Rainfall	Annual rainfall is close to 2000 mm	Monsoon rainfall might increase by almost 10%	More frequent flooding, impacting physical assets and communities	Higher risk of waterborne diseases, given only 55% toilet comes with safe disposal with flushing water
Temperature	Average maximum temperature is close to 31°C	may increase by 1.0°	Impact human health especially of vulnerable population	71% of the pourashava use wood as source of cooking fuel, which might reduce the tree cover and drive temperature higher
	Maximum of maximum temperature is 35°C	may increase by 0.5°	It may also impact water resources and agricultural productivity.	

Climate Hazards	Analysis	Predictions (Near future - SSP245 & SSP370)	Climate Driven Vulnerability	Human Driven Vulnerability and Community impacts
Heatwave	Warm spell duration close to 12 days	May increase to 39 days	increased mortality rates, particularly among elderly and vulnerable populations	More than 72% of the households in Morelganj have metal sheet as roof and 38% have metal sheet as walls, which will worsen the situation
			May strain healthcare systems, reduce productivity, and damage physical assets	Almost 90% of the women spend whole day at home, and 15% of working men is involved in agriculture, who are extremely vulnerable to heatwave
Sea Level Rise	3.6-4.5 mm per year	13 to 47 mm for conservative scenario and 22 to 49 mm for worst case scenario	Saltwater intrusion into the 12 canals and the 3.5 km drainage system, which are used for drinking water	The dependence on canal water for irrigation might have a long-lasting impact on Agriculture
			Erosion of Chunkuri and Pasur riverbanks	
			Flooding of low-lying areas alongside the river	
River Salinity	2.1 to 4 ppt	May increase to 5.1-21 ppt	Reduced access to freshwater and agricultural productivity	Surface water accounts for 33% of drinking water source, making the people susceptible to salinity related diseases
			Negative impact on freshwater ecosystems	
River Erosion	Significant erosion	Likely to worsen in the future	Damages to physical asset, like roads and buildings	Lack of protective embankments and according to some, unchecked sand extraction accelerate erosion
Cyclone & Storm Surge	High hazard	Likely to worsen in the future	Significant damages to human life and physical asset	inundate key infrastructure—including the main hospital, markets, and schools—forcing thousands into shelters, disrupting healthcare and education for days, and leaving many families facing acute food insecurity and loss of income
			long-term economic impacts and population displacement	
			Disruption of essential services	

5.3 Nature-based Solutions for Morrelganj Pourashava

5.3.1 **Reviving the surface water system**

Recognizing that rivers and canals form the lifeblood of any administrative region, a key objective of the project was to assess the current condition of the primary khals (canals) within Morrelganj Pourashava. These water bodies play a crucial role in drainage, flood management, and support the local ecosystem. Numerous khals and ponds exist in Morrelganj Pourashava, including, Malbahi khal, Kalachad Majar khal, Bashgari khal, Fokirbari khal, Vaijora khal, Kamarpotti khal, KG School pond, Kuthibari pond, and Pourashava office pond.

Malbahi Khal: One of the most critical examples of drainage mismanagement was observed at a specific canal site (22.4530°N, 89.8565°E) in this Pourashava. The area was marked by an unpleasant odor, and the canal was heavily clogged with solid and plastic waste. This blockage has severely impaired the canal's drainage capacity (Figure).

Figure 5.1: The Malbahi Canal is clogged with polythene and plastic materials (left). This khal is connected with Pangunchi River at its outlet. The dropped red pin shows the google location of the Malbahi Khal (right)

Pourashava Office Pond: This pond is located adjacent to the Morrelganj Pourashava (22.4515°N, 89.8588°E) and it plays a vital role in supporting the daily needs of approximately 200 households. It serves as a key water source for cooking, sanitation, and dishwashing. The pond is periodically replenished with water collected from the nearby Dumuri River, ensuring its continued usability for domestic purposes (Figure).

Figure 5.2: More than 200 household pipes that are connected to this pond (left) and the dropped red pin shows the Google location of the Khal (right)

Kg School Pond: This is another freshwater pond in Morrelganj (22.4514°N, 89.8574°E). It is used for daily activities such as bathing, drinking, and washing (Figure).

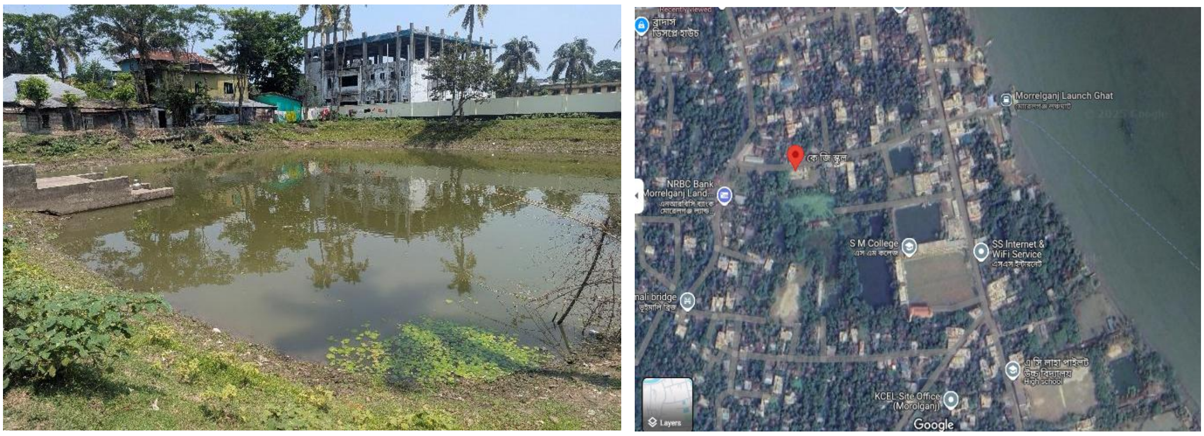

Figure 5.3: Kg school pond location(left); the dropped red pin shows the Google location of the Kg school pond (right)

Proposed NbS for Restoration of Canals and Ponds

- **Excavation and capacity enhancement:** Excavation of approximately 1-1.5 meters depth is proposed to increase the ponds' water-holding capacity and improve its longevity as a reliable water source.
- **Cleaning and rehabilitation of ponds:** As a preliminary step, the associated ponds must be thoroughly cleaned to restore their water retention capacity and ensure proper hydraulic connectivity with the canal network.
- **Community awareness and behavior change:** Sustained community engagement is essential to maintain water quality. Awareness campaigns should be introduced to educate local residents on the impact of waste dumping and the importance of protecting water resources.
- **Planting native aquatic vegetation:** Vegetation helps filter pollutants, stabilizes pond banks, and supports aquatic ecosystems and specific plants (e.g., cattails, reeds) within and around the pond and canal. It will absorb heavy metals and toxins from water.
- **Decentralized wastewater pre-treatment units:** Small pre-treatment tanks upstream to reduce organic waste entering the pond. Minimizes nutrient overload and water contamination.
- **Pond bank protection and slope stabilization:** Proper protection measures must be implemented along the pond banks, with naturally reinforced slopes to prevent erosion and ensure structural stability over time.

5.3.2 Potential Eco Park Location in Morrelganj Pourashava

The historic Robert Henry Morrell Kuthi Bari (22.4475°N, 89.8622°E) has been identified as a potential site for the development of an Eco Park within Morrelganj Pourashava (Figure). This site offers both historical value and ecological significance, making it an ideal location to promote environmental sustainability, public engagement, and heritage preservation. The Kuthi Bari area currently contains four active ponds, which are regularly used by local residents for daily purposes, such as, washing, cooking, and sanitation. Two additional ponds existed in this area which were encroached upon, reducing the site's water retention and ecological capacity. The site is adjacent to the vulnerable riverbank of the Panguchi River. Over time, the river has gradually widened, exerting increasing pressure on the riverbank, thereby raising concerns about erosion and land stability.

 

Figure 5.4: Morrelganj Kuthi bari pond (left) and Robert Henry Morrell Kuthi Bari site (right)

Proposed NbS for Eco Park Development

- Eco Park development with pond preservation: The establishment of an Eco Park is proposed to promote biodiversity, create recreational opportunities, and preserve the existing pond as a central ecological feature. This initiative will enhance environmental awareness and provide a green space for the community while ensuring the conservation of the pond.
- Vertical green walls: Grow plants on walls of buildings, fences, or rest shelters. Improves air quality and aesthetics while reducing heat.
- Eco-art installations: Artistic structures made from natural or recycled materials raises environmental awareness and cultural value.
- Pollinator gardens: Dedicated flower zones with native nectar-rich plants attracts bees, butterflies, and improves biodiversity.

5.3.3 Tackling safe drinking water challenges

Nobboi Roshi Khal: Nobboi Roshi Khal is one of the largest water bodies in the area, currently serving multiple purposes for the local community (Figure). However, its ecological integrity has been compromised due to several anthropogenic interventions. The lake has been divided into segments by six earthen interventions, constructed to facilitate pedestrian movement across the water body. Additionally, parts of the lake are obstructed by informal fish cultivation barriers, and several informal settlements (slums) have developed directly over the water. These settlements, present for many years, lack proper sanitation systems, potable water, and other basic facilities.

Figure 5.5: Intervention in the lake for pedestrians (left) and a local slum constructed over the khals (right)

Rainwater harvesting system: In Morrelganj, a few households have already adopted rainwater harvesting systems to address the persistent scarcity of safe drinking water. Traditionally, residents begin collecting rainwater after the first few hours of rainfall and store it for use throughout the year. To ensure long-term drinking water security, it is recommended that these systems be scaled up and introduced more widely across the area.

Figure 5.6: Existing rainwater harvesting system in Morrelganj

Proposed NbS for Ensuring Safe Drinking Water

- **Development of Nobboi Roshi khal as a drinking water hub**: Given the acute shortage of potable water in the area, Nobboi Roshi khal can be transformed into a community drinking water hub. Since the khal is just next to a busy road, appropriate treatment and conservation measures need to be placed.
- **Removal of earthen interventions**: The earthen barriers that currently divide the lake should be removed to restore hydrological connectivity, enhance water circulation, and improve the ecological balance of the water body.
- **Relocation of slum settlements**: the informal settlements built over the lake should be relocated to suitable and safer locations to prevent ongoing water pollution and allow for proper restoration of the lake's ecosystem.

- Elimination of illegal fish Ghers: Unauthorized fish enclosures that hinder the natural flow and usage of the lake should be dismantled to ensure equitable and sustainable use of the water resource.
- Upgrading and promoting rainwater harvesting systems: Upgrading and promoting rainwater harvesting systems can significantly enhance water security, especially in drought-prone areas. By capturing and storing rainwater, communities can reduce dependence on groundwater and ensure sustainable water availability.

5.3.4 Addressing riverbank erosion

Riverbank erosion is a significant and persistent issue in Morrelganj Pourashava. Located in the south-western coastal region of the country, Morrelganj is crisscrossed by several rivers such as the Panguchi, Baleshwar, Ghasiakhali, and Bhola. These rivers are vital to the region's livelihood, but also contribute to serious environmental challenges, especially riverbank erosion (Figure).

Figure 5.7: Erosion site at Pangunchi river near Morrelganj Kuthi bari (left) and erosion of Baleshwar River (right)

Proposed NbS for Erosion Management at Morrelganj

- Riverbank stabilization with native mangroves: To ensure long-term stability and erosion control of the riverbank, it is recommended that vegetative protection be implemented using locally available mangrove species. This approach will create a naturally resilient buffer against erosion, promote sediment retention, and improve ecological connectivity.
- Riparian vegetation planting: Plant native trees, grasses, and shrubs along riverbanks to strengthen soil, reduce erosion, and improve biodiversity.
- Bioengineering (e.g., bamboo/brush layering): Use biodegradable materials like bamboo, jute, and coir to stabilize riverbanks in an eco-friendly, low-cost manner.
- Community-based bank management programs: Involve local communities in monitoring and managing riverbank health to ensure sustainability and reduce displacement risks.

6 KUAKATA POURASHAVA

6.1 Context

Kuakata Pourashava, a rapidly growing urban center and a renowned coastal tourist destination, faces mounting challenges in drainage and flood management. The town's natural drainage systems, including ponds and interconnected canals such as Khajuria Khal and Alipur Khal, historically played a vital role in managing stormwater runoff. However, unchecked urbanization, land encroachment, and infrastructure bottlenecks have severely compromised these systems. The drainage infrastructure, including sluice gates, drains, and culverts, is inadequate in design, poorly maintained, and lacks sufficient capacity. For example, runoff from Cyclone Remal took days to drain, underscoring the system's vulnerabilities. The fragmentation of natural canals due to narrow culverts and roads without proper openings has disrupted hydraulic connectivity, worsening localized flooding. The problem is compounded by the indiscriminate dumping of solid waste into drainage channels, which further diminishes flow capacity. The absence of a comprehensive drainage master plan means that improvements to the system are fragmented and reactive, lacking a holistic understanding of the town's hydrology. Given Kuakata's vulnerability to climate change impacts, such as sea-level rise, storm surges, and extreme rainfall, there is an urgent need for a NbS centric approach to restore natural drainage functions, reduce flood risk, and create a resilient and livable urban environment.

6.2 Climate Risk Assessment

Located on the exposed southern coast, Kuakata Pourashava in Kalapara is highly vulnerable to climate change, facing compounding threats from sea level rise, coastal erosion, salinity intrusion, heatwaves, and flooding. With 13,000 residents – 46% of them women – the community's resilience is critically challenged by both climate-driven and human-induced vulnerabilities.

Monsoon rainfall is expected to rise by 10%, worsening already inadequate drainage systems and causing recurrent waterlogging, particularly in low-lying areas like Bashkhali village and Main Kuakata Bazar. Coastal and riverbank erosion, especially in wards 8 and 9 and near ferry ghats, threatens roads and markets, impacting livelihoods and local businesses.

Heatwaves are projected to extend from 10 to 32 days, disproportionately affecting vulnerable populations. More than 97% of women stay at home, many in structures made with metal sheet roofs and walls (89% and 78%), increasing exposure to extreme heat. Surface water salinity, which may reach up to 15 ppt, is jeopardizing freshwater access for both drinking and irrigation.

With 87% of households relying on wood fuel, deforestation may worsen urban heat and reduce adaptive capacity. Without urgent adaptation, Kuakata faces escalating risks to health, livelihoods, and infrastructure – especially among women and low-income communities.

Climate Hazards	Analysis	Predictions (Near future - SSP245 & SSP370)	Climate Driven Vulnerability	Human Driven Vulnerability
Rainfall	Annual rainfall is close to 2850 mm	Monsoon rainfall might increase by almost 10%	More frequent flooding, impacting physical assets and communities.	Higher risk of waterborne diseases, given only 51% toilet comes with safe disposal with flushing water.
Temperature	Average maximum temperature is close to 31°C	may increase by 0.3°	Impact human health especially of vulnerable population .	87% of the pourashava use wood as source of cooking fuel, which might reduce the tree cover and drive temperature higher.

Climate Hazards	Analysis	Predictions (Near future - SSP245 & SSP370)	Climate Driven Vulnerability	Human Driven Vulnerability
	Maximum of maximum temperature is 36.8°C	may increase by 0.9°	It may also impact water resources and agricultural productivity	
Heatwave	Warm spell duration close to 10 days	May increase to 32 days	Increased mortality rates, particularly among elderly and vulnerable populations.	More than 89% of the households in Kuakata have metal sheet as roof and 78% have metal sheet as walls, which will worsen the situation.
			May strain healthcare systems, reduce productivity, and damage physical assets.	Almost 97% of the women spend whole day at home, and 28% working men is involved in agriculture, who are extremely vulnerable to heatwave.
Sea Level Rise	3.6-4.5 mm per year	22 to 49 mm for conservative scenario and 27 to 55 mm for worst case scenario	Saltwater intrusion into the surface water, which are used as fresh water source.	The dependence on surface water for irrigation might have a long-lasting impact on Agriculture.
			Flooding of low-lying areas alongside the river.	
			Kuakata is on the coast, which increases its vulnerability to SLR.	
Surface water Salinity	5.1 to 10 ppt	May increase to 11-15 ppt	Reduced access to freshwater and agricultural productivity	
			Negative impact on freshwater ecosystems	
Coastal Erosion	Significant erosion	Likely to worsen in the future	Damages to physical asset, like roads and buildings.	Potential displacement of communities living in erosion-prone areas.
Cyclone & Storm Surge	High hazard zone	Likely to worsen in the future	Significant damages to human life and physical asset.	
			long-term economic impacts and population displacement.	
			Disruption of essential services.	

6.3 Nature-based Solutions for Kuakata Pourashava

6.3.1 Addressing the inadequate maintenance of the drainage

Kuakata Pourashava currently lacks an adequate drainage system, with only about 1 to 1.5 kilometers of drainage infrastructure, located primarily along Rakhain Mohila Market road and the roads in Ward No. 03. Expansion of the drainage network has been severely constrained due to encroachment by private property owners. The Pourashava has been engaged in ongoing efforts to negotiate with local stakeholders to resolve this issue. Additionally, the existing drains suffer from poor maintenance and are not cleaned regularly, further diminishing their functionality. The Pourashava personnel informed that the Pourashava has a plan to construct 3.3 km drainage works from Panjupara to Mussalliabad, where the drainage water will be poured into the natural Kajupara khal. This khal is ultimately linked with the Andharmanik River through the sluice gate at Alipur.

Figure 6.1: (a) Rakhain Mohila Road drainage and (b) Khajur Para khal starting point, and (c) drainage lines encroached on my privately owned property

The drainage sluice (21.825102°N, 90.120113°E) at Kuakata is a three-vent structure, each vent measuring 1.5 meters by 1.8 meters, constructed across the Khapravanga River. This sluice plays a crucial role in regulating local water flow and managing drainage, particularly during monsoons and tidal surges. According to local accounts, the average depth of the river at this location is approximately 2.5 meters, allowing for effective water discharge and flood mitigation. The sluice gate opening is too small compared to the width of the river, which obstructs the natural flow coming through the river (Figure 6.2 (left)). On the other hand, the Khajuria Khal and Alipur Khal have been detached due to the construction of a road with a narrow opening for drainage (Figure 6.2 (right)).

Figure 6.2: Three-vent sluice gate over the Khaprabhanga River (left), and the Khajuria Khal and Alipur Khal have been detached due to the construction of a road with a narrow opening (right)

Proposed NbS for Drainage System at Kuakata

- Restoration of Kajupara Khal: Rehabilitate the natural khal by removing silt, regrading banks, and planting native vegetation. This will improve its drainage capacity, prevent erosion, and support water quality before it reaches the Andharmanik River.

- Upgrade of existing sluice gates: Assess the current condition and performance of existing sluice gates, including one-vent and three-vent structures. Based on the findings, upgrade these gates to improve their capacity for controlling water during heavy rainfall and tidal events, ensuring efficient drainage and reduced flood risk.
- Integration with nature-based and climate-resilient systems: Ensure that upgraded water control structures are integrated with nature-based drainage networks such as canals, wetlands, and vegetated swales. Design all infrastructure to be climate-resilient, capable of withstanding future challenges like sea-level rise, increased storm intensity, and changing hydrological patterns.
- Rain gardens and infiltration basins: Establish rain gardens in public spaces, schools, and roadside zones to capture and infiltrate runoff. These landscaped areas reduce surface water load and offer aesthetic and ecological benefits.
- Constructed wetlands at outfall: Develop constructed wetlands near the Alipur sluice gate to naturally treat and store drainage water. This solution mimics wetland functions and enhances biodiversity while improving water management.
- Community engagement in maintenance: Launch community-led initiatives for regular cleaning and upkeep of green drainage infrastructure. This builds local ownership, ensures functionality, and enhances resilience to flooding.

6.3.2 Restoring water bodies

The ghat of the Latachapali pond (Figure (left), located near the Pourashava office, is in a severely deteriorated condition due to a lack of maintenance. With proper reconstruction and infrastructure improvements, the pond has the potential to serve as a viable drinking water source for the Pourashava, subject to adequate water treatment measures. Figure (right) shows a highly polluted and stagnant water body located adjacent to a row of semi-permanent tin-shed houses situated near the Pourashava office. The pond is visibly choked with solid waste, including plastic, organic debris, and algae, indicating prolonged neglect and lack of maintenance. A makeshift structure with bamboo poles and nets suggests an attempt to manage waste or flow, but the overall condition reflects poor sanitation practices. The surrounding area also shows signs of encroachment and unplanned development.

Figure 6.3: Latachapali pond near Latachapali Primary School (left) and Khal opposite to the Pourashava office filled with solid waste (right)

Proposed NbS for Restoration of Wetlands at Kuakata

- Rehabilitation with native vegetation: The pond banks can be stabilized and restored by planting native aquatic and riparian vegetation, such as vetiver grass and reeds. This will help reduce erosion, filter surface runoff, and improve biodiversity around the pond. Creating vegetative buffer zones will also prevent direct waste dumping and protect the pond from further pollution.

- Natural barriers for waste control: Bamboo fencing and vegetative screens around the pond perimeter can act as natural barriers to trap solid waste and discourage illegal dumping. These structures are cost-effective, environmentally friendly, and easy to maintain with community participation.
- Community-based restoration and stewardship: Local community members, particularly youth and school groups, can be engaged in regular pond cleaning, planting drives, and awareness campaigns. Establishing community stewardship groups will help ensure long-term maintenance and foster a sense of ownership.
- Ecological rebalancing with native species: Once the pond's water quality improves, reintroducing native fish and aquatic life can help control mosquito populations and restore ecological balance, contributing to a healthier aquatic environment.
- Encroachment control through eco-zoning: To prevent further encroachment, the pond surroundings can be converted into eco-buffer zones with fruit trees or medicinal plants. This approach provides economic incentives for nearby residents while protecting the pond ecosystem.

6.3.3 **Tackling vulnerable sites for erosion**

The scenic Kuakata Sea Beach is gradually eroding, diminishing its natural beauty due to the absence of effective beach management practices. Residents reported that Kuakata beach has experienced severe erosion over the past several decades, with nearly one kilometer of shoreline lost to the advancing sea. The primary causes identified include changes in river flow regimes, reduced sediment deposition along the coast, wave-induced land erosion, and long-term sea level rise linked to climate change. One notable phenomenon is the formation of new offshore islands, such as Char Bijoy, in remote coastal areas. These emerging landforms suggest that upstream sediments are being deposited further away from the original coastline. As a result, the natural replenishment of beach sediments at Kuakata is being disrupted, accelerating shoreline retreat and contributing to the current state of coastal degradation (Figure).

Figure 6.4: (a) Lembur Bon (Lemon forest), (b) Ganga Matir Char, and (c) Kuakata main sea beach

Proposed NbS to Tackle Coastal Erosion in Kuakata

- Mangrove afforestation and restoration: Expand and maintain mangrove plantations along erosion-prone zones, especially from Lembur Bon (Lemon forest) to Gangamati Beach. It'll serve as natural windbreaks and wave buffers, absorbing the energy of storm surges and reducing shoreline erosion.
- Sand dune creation and stabilization: Promote sand dune nourishment using locally available sand and vegetation like beach grass or Ipomoea pes-caprae (beach morning glory) to stabilize dunes naturally. These dunes act as buffers against high tides and storm surges.
- Restoration of Char Bijoy as a buffer island: Conserve and possibly expand Char Bijoy through sediment trapping vegetation (e.g., salt-tolerant grasses) to reinforce its role as a natural offshore barrier, reducing wave impact on the Kuakata shoreline.
- Living shorelines: Establish living shoreline systems that combine native vegetation, oyster beds (where feasible), and biodegradable materials to stabilize the coast while maintaining the habitat.
- Natural wetland buffer zones: Conserve existing low-lying wetlands and convert degraded lands near the beach into wetland buffer zones. These act as sponges, absorbing excess tidal flows and reducing inland flooding and erosion. Char Bijoy is already working as a buffer zone for Kuakata Pourashava.

7 SCALING UP NBS ACROSS THE COASTAL REGION AND BEYOND

7.1 The Promise of NbS in Coastal Bangladesh

Bangladesh's coastal towns, including the 22 studied in this report, face escalating threats from river erosion, cyclones, storm surges, salinity intrusion, and urban heat. Traditional "hard" infrastructure alone – embankments, drainage, and concrete barriers – has proven insufficient and sometimes even counterproductive. On the other hand, nature-based solutions (NbS) offer a transformative, sustainable pathway to enhance resilience, restore ecosystems, and protect vulnerable communities.

Bangladesh has a rich history of implementing nature-based approaches, though not always under the formal NbS framework. The country's experience with coastal afforestation dates back to 1965, when the Forest Department began establishing mangrove plantations that now (1965–2013) cover over 209,140 hectares of coastal area[2]. These plantations have demonstrated measurable success in preventing coastal erosion, reducing storm surge impacts, and protecting communities during major cyclones.

Recent evidence reinforces the effectiveness of NbS interventions. Following major restoration efforts supported by UNEP and other partners, an estimated 50,000-60,000 hectares of mangroves have been replanted or rehabilitated in Bangladesh since 2010. During Cyclone Amphan in 2020, areas with rehabilitated mangroves experienced significantly reduced flooding and erosion compared to degraded zones, providing tangible proof of NbS effectiveness.

The success rate of NbS projects in Bangladesh is remarkably high, with 91% of reported outcomes being positive, demonstrating robust evidence of benefits for reducing vulnerability to cyclones, storm surges, floods, and salinization. These interventions have helped communities adapt to sea-level rise, water shortages, and extreme temperatures while contributing to nearly all Sustainable Development Goals.

7.1.1 Policy Integration and Institutional Mainstreaming

The scaling of NbS requires systematic integration into Bangladesh's policy landscape. Bangladesh National Adaptation Plan and The Bangladesh Delta Plan (BDP) 2100 provide a crucial framework for this integration. The Delta plan explicitly emphasizes "Living with Nature," "Nature-based Solutions," and "Ecosystem-based Approaches" as core principles, allocating 2.5% of GDP for delta-related interventions.

The BDP 2100 identifies six hotspot areas, including the Coastal Zone covering 27,738 square kilometers, where NbS interventions are particularly critical. The plan's coastal zone strategy specifically emphasizes mangrove afforestation, creation of green belts, and ecosystem restoration as primary measures for combating storm surge and salinity intrusion.

However, policy analysis reveals gaps in implementation mechanisms. While 19 of 20 major national policies include strategies that fall under the NbS umbrella, most lack specific implementation guidelines, robust financial support, and institutional mechanisms for monitoring and evaluation. Addressing these gaps requires:

- Embedding NbS terminology and frameworks directly into policy documents rather than relying on indirect references.
- Establishing clear institutional mandates for NbS implementation across relevant ministries and agencies.
- Developing standardized NbS guidelines for project design, implementation, and monitoring.
- Creating inter-agency coordination mechanisms to prevent fragmented approaches.

[2] Mahmood, R., Zhang, L. & Li, G. Assessing effectiveness of nature-based solution with big earth data: 60 years mangrove plantation program in Bangladesh coast. *Ecol Process* 12, 11 (2023). https://doi.org/10.1186/s13717-023-00419-y

7.1.2 **Innovative Financing Mechanisms**

Scaling NbS requires mobilizing diverse financing sources beyond traditional government budgets. Bangladesh has established several innovative mechanisms, including the Bangladesh Climate Change Trust Fund (BCCTF), which has allocated approximately $490 million since 2009-10 and financed over 856 projects. However, the NbS funding gap remains substantial, requiring strategic approaches to leverage private sector investment and international climate finance.

Key financing strategies include:

- Blended Finance Approaches: Development finance institutions like the Asian Development Bank and World Bank are already demonstrating how concessional finance can leverage private investment. The recently launched Bangladesh Climate and Development Platform (BCDP) represents a groundbreaking collaborative approach involving multiple international financial institutions to leverage adaptation and mitigation investments.
- Payment for Ecosystem Services (PES): The Ministry of Environment, Forest and Climate Change is working with the World Bank on innovative instruments including debt-for-nature swaps and payment for ecosystem services mechanisms. These approaches can monetize the flood protection, carbon sequestration, and biodiversity benefits that NbS provide.
- Green Bonds and Climate Finance: The analysis of global nature funds suggests that scaling financing for NbS in Bangladesh requires both investing in supportive enabling environments while structuring investment projects that leverage specialized nature funds and attract concessional finance.

7.1.3 **Technical Capacity Building and Knowledge Systems**

The successful scaling of NbS depends on building robust technical capacity across multiple levels – from national agencies to local communities. The Global Center on Adaptation (GCA) is already building capacity for the 22 coastal towns, with a special focus on Bagerhat, Chalna, Morrelganj, and Kuakata. In addition to that, critical capacity-building elements include:

- Professional Training Programs: The Nature-Based Solutions Capacity Building Series offered by institutions like the World Bank provides technical deep dives and specialized training through immersive study tours and hands-on learning opportunities. Similar programs need to be adapted for Bangladesh's specific coastal context.
- University Partnerships: The collaboration between GCA and the Institute of Water and Flood Management (IWFM), BUET demonstrates the importance of academic partnerships in building local technical expertise. Expanding these partnerships can create sustainable knowledge generation and training pipelines.
- Community-Level Capacity: The success of community-based mangrove restoration projects, such as those implemented through Village Conservation Forums, demonstrates the critical importance of community engagement and local ownership.

Training programs must include community leaders, women's groups, and youths in NbS design and implementation.

7.1.4 **Community Engagement and Social Inclusion**

Experience from Bangladesh's successful NbS projects consistently highlights the importance of participatory approaches. The Community Based Adaptation to Climate Change through Coastal Afforestation (CBACC-CF) program successfully established 9,650 hectares of new mangrove plantations by involving community members in nursery bed preparation, seedling raising, planting, and maintenance.

The integration of People's Adaptation Plans into the CTCRP represents an innovative approach to ensuring community voice in infrastructure planning. GCA is supporting residents of informal settlements in Patuakhali, Kuakata, and Borhanuddin to develop these plans, which will directly inform project investments. Key principles for community engagement can include:

- Gender-Responsive Design: Ensuring women's leadership and meaningful participation in NbS planning and implementation, recognizing their unique vulnerabilities and knowledge systems.
- Indigenous and Traditional Knowledge Integration: Incorporating local and traditional knowledge systems that have historically sustained coastal communities.
- Equitable Benefit Distribution: Ensuring that NbS benefits reach the most vulnerable populations and that any short-term trade-offs are fairly managed.

7.1.5 Monitoring, Evaluation, and Adaptive Management

Robust monitoring and evaluation systems are essential for demonstrating NbS effectiveness and enabling adaptive management. The current evidence base, while strong, shows gaps in systematic monitoring of biodiversity outcomes and inadequate reporting of participatory engagement arrangements. Bangladesh needs to establish:

- Standardized M&E Frameworks: Developing consistent indicators and methodologies for assessing NbS performance across climate adaptation, biodiversity conservation, and socio-economic outcomes.
- Digital Monitoring Systems: Leveraging satellite imagery, remote sensing, and citizen science approaches to track NbS implementation and outcomes over time.
- Knowledge Sharing Platforms: Creating mechanisms for sharing lessons learned across the 22 towns and beyond, including the development of a national NbS knowledge hub.

7.1.6 Innovation and Technology Integration

The scaling of NbS in Bangladesh increasingly requires integration with technological innovations. The urban NbS compendium recently launched by GCA and IUCN Bangladesh highlights 20 scalable, context-specific interventions that combine natural systems with smart technologies[3]. These include:

- Blue-Green Infrastructure: Urban planning approaches that combine blue (water), green (vegetation), and grey (traditional infrastructure) elements to provide multifunctional urban forms. Research from Dhaka demonstrates how such integrated approaches can address flooding while providing environmental, social, and economic benefits.
- Climate-Smart Agriculture: Integrating NbS with agricultural innovations, including salt-tolerant crop varieties, floating agriculture, and aquaculture-based interventions that have shown highly promising results in coastal areas.
- Early Warning Systems: Combining ecosystem-based approaches with digital early warning systems to enhance community preparedness and response capabilities.

7.2 Regional and Global Collaboration

Bangladesh's experience with NbS scaling can serve as a model for other deltaic regions globally. The country's partnerships with international organizations, including the Global Center on Adaptation, World Bank, Asian Development Bank, and various UN agencies, create opportunities for knowledge exchange and replication of successful approaches.

The recently launched Nature for Climate Adaptation Initiative (NCAI) by the International Institute for Sustainable Development provides additional resources and expert guidance for scaling nature-based climate solutions in vulnerable regions. Such international collaborations can accelerate learning and investment mobilization.

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[3] IUCN Bangladesh and GCA 2025. *Compendium on Nature-based solutions for Urban Resilience in Bangladesh. pp. xviii + 222.* https://gca.org/reports/compendium-on-nature-based-solutions-for-urban-resilience-in-bangladesh/

7.3 Implementation Roadmap

To ensure the effective and sustainable deployment of Nature-based Solutions (NbS) in Bangladesh's coastal towns, a phased implementation roadmap is proposed. This roadmap aligns short-term actions with long-term resilience goals, emphasizing institutional readiness, scalability, and regional leadership.

7.3.1 Phase 1: Foundation Building (2025-2027)

- Complete NbS interventions in the three pilot towns (Bagerhat, Chalna, and Morrelganj) and in one additional town the study is already carried out (Kuakata).
- Establish monitoring and evaluation systems across all interventions.
- Develop standardized NbS guidelines and training curricula.
- Create institutional coordination mechanisms at national and local levels.

7.3.2 Phase 2: Expansion and Scaling (2027-2030)

- Scale up successful NbS interventions to the remaining 18 towns under the CTCRP project.
- Establish sustainable financing instruments, including Payment for Ecosystem Services (PES) schemes, climate resilience bonds, and blended finance models.
- Create regional NbS networks for knowledge sharing.
- Integrate NbS into municipal master plans and development strategies.
- The study has found several suitable NbS options for each of the 22 coastal Pourashavas through field visits, research analysis, expert and community consultations, which are summarized in the following table.

No.	NBS Strategy	Problem Addressed	Relevant Towns among 22 Towns
1	Pond Conservation (Protected Ponds) and Restoration	Urban flooding, Drinking water scarcity	All pourashavas (general)
2	Drainage Canal Rehabilitation and Expansion	Urban flooding	Bagerhat Sadar, Chalna, Morrelganj, Patuakhali Sadar, Mehendiganj, Kuakata
3	Rainwater Harvesting and managed aquifer Recharge (MAR) and Aquifer Storage, Transfer, and Recovery (ASTR) system	Drinking water scarcity, groundwater recharge	Kalapara, Char Fasson, Lalmohan, Burhanuddin, Morrelganj, Chalna, Bagerhat
4	Green Urban Infrastructure (Rain Gardens, Bioswales)	Urban heat mitigation, stormwater infiltration	Bagerhat Sadar, Patuakhali Sadar, Nalchity
5	Eco-Friendly Embankment Upgradation	Address future Storm surges under SLR.	Chalna, Patharghata
6	Vegetative Slope Protection (Vetiver Grass Plantation)	Riverbank erosion, embankment failure	Patharghata, Chalna, Morrelganj, Paikgachha
7	Riverbank Protection using Geo-bags, Riparian Vegetation, and Wooden Piling	River erosion, embankment protection	Morrelganj, Patharghata, Chalna, Mehendiganj
8	Floodplain Restoration and Protection	Flood risk reduction, natural storage	Muladi, Mehendiganj, Morrelganj
9	Solid waste management through waste segregation and composting, community clean-ups, the establishment of native vegetation	Drainage blockage, urban flooding	Bagerhat Sadar, Morrelganj, Patuakhali Sadar, Char Fasson

	buffers, and the restoration of natural waterways		
10	Coastal Ecosystem Rehabilitation and Marine Habitat Restoration	Surge water absorption, ecosystem restoration	Chalna, Bagerhat Sadar
11	Dune Restoration and Conservation	Coastal erosion prevention, storm surge protection	Kuakata, Char Fasson, Kalaroa
12	Oyster Reef for Wave Protection	Erosion resistance, surge protection	Chalna, Patharghata, Char Fasson
13	Bandal-like Structures (V-shaped for Tidal Rivers)	River erosion reduction, channel maintenance	Morrelganj, Paikgachha
14	Preservation and expansion of existing mangroves, wetlands, vegetated riverbanks, beaver dams, sandbars, natural levees, and riparian buffers as a Sediment Trap	Surge buffering, biodiversity conservation, Land accretion, erosion control, and pollution reduction	Chalna, Patharghata, Char Fasson, Paikgachha, Kalapara, Kuakata
15	Restoration of aquatic connectivity by removing or modifying in-stream barriers	Flood mitigation, sediment dispersal	Morrelganj, Bagerhat Sadar
16	Biogas Generation from Solid Waste	Renewable energy, methane reduction	Bagerhat Sadar, Morrelganj, Char Fasson
17	Solar-Powered Aquifer Storage and Recovery System and Water Pumping System	Groundwater salinity mitigation, drinking water supply	Chalna, Bagerhat Sadar, Muladi, Morrelganj

7.3.3 Phase 3: Mainstreaming and Replication (2030-2035)

- Mainstream NbS across all coastal development planning.
- Establish Bangladesh as a global center of excellence for coastal NbS.
- Support replication in other South Asian coastal regions.
- Achieve financial sustainability through diversified funding mechanisms.

7.4 Overcoming Implementation Challenges

The scaling of NbS faces several persistent challenges that require strategic responses:

- Land Use Conflicts: Competition between conservation needs and economic development, particularly pressure to convert ecosystems to aquaculture or agriculture, requires careful management through participatory governance and equitable benefit distribution.
- Maintenance and Longevity: Unlike grey infrastructure, NbS require ongoing ecosystem management and community stewardship. Building sustainable financing for long-term maintenance is crucial.
- Technical Standards: The relative novelty of NbS approaches means that technical standards and best practices are still evolving. Investment in research and development is essential for improving effectiveness.
- Political Economy: Ensuring political commitment across election cycles and institutional changes requires embedding NbS approaches in permanent institutional structures and legal frameworks.

7.5 A Vision for 2035: Bangladesh as a Global NbS Leader

By 2035, Bangladesh can emerge as a global leader in coastal NbS implementation, with all 22 target towns demonstrating resilient, nature-based approaches to climate adaptation. This vision encompasses:

- Ecosystem Restoration at Scale: Tens of thousands of additional hectares of mangroves, wetlands, and coastal forests providing natural protection while supporting sustainable livelihoods.
- Resilient Communities: Coastal populations with significantly reduced vulnerability to climate hazards, supported by diversified, ecosystem-based livelihoods and strong social capital.
- Innovation Hub: Bangladesh serving as a center of excellence for tropical coastal NbS, attracting international research collaboration and investment.
- Policy Model: Bangladesh's NbS integration framework being replicated across South Asia and other deltaic regions globally.
- Financial Sustainability: Mature financing mechanisms ensuring long-term sustainability of NbS investments through diversified funding sources including private sector engagement.

8 CONCLUSION: TRANSFORMING RISK INTO RESILIENCE

By 2050, coastal flooding in Bangladesh is projected to cause €7.4 billion in direct economic losses to the road network[4]. Scaling up Nature-based Solutions (NbS) across the country's 22 coastal towns and wider coastal belt is not just an environmental necessity – it is an opportunity to turn vulnerability into resilience, risk into opportunity, and degraded ecosystems into thriving landscapes that sustain both the people and the economy.

Bangladesh's remarkable transformation – from one of the world's most disaster-prone nations to a global leader in climate adaptation – illustrates the power of long-term investment in resilience. The next frontier lies in mainstreaming NbS at scale, requiring the same level of commitment, innovation, and collaboration that has driven the country's disaster risk reduction success. Bangladesh also holds immense potential to expand biodiversity-centered NbS, unlocking co-benefits for nature and communities (Figure 8.1).

The evidence is clear: NbS deliver tangible results in Bangladesh's context – reducing flood and heat risks, restoring ecosystems, and strengthening livelihoods. The institutional frameworks, financing mechanisms, and technical expertise are already in place in emerging form and can be rapidly scaled through targeted investment and strategic partnerships.

The 22 coastal towns can serve as living laboratories for innovation, showing how NbS can be embedded within urban planning, infrastructure design, and local adaptation strategies. Their success will provide replicable models for coastal resilience across South Asia and beyond.

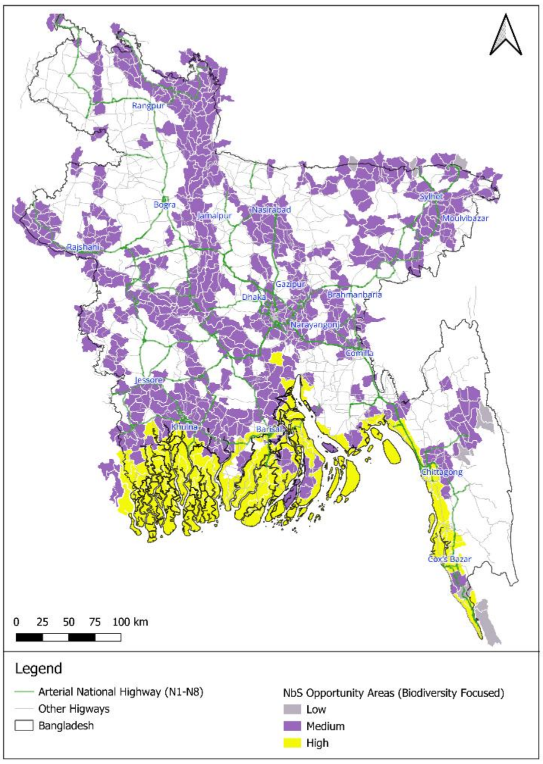

Figure 8.1. Potential NbS locations in Bangladesh[5]

Achieving this vision demands sustained collaboration among government, communities, development partners, and the private sector. It calls for integrated action across sectors and scales – from household-level water management to landscape-scale ecosystem restoration. Most importantly, it requires acknowledging that the future of Bangladesh's coastal communities depends not on resisting nature, but on working with it – to build adaptive, regenerative systems capable of evolving with a changing climate.

The path forward is clear, the tools are ready, and the urgency is real. Bangladesh now stands poised to lead the world in demonstrating how Nature-based Solutions can safeguard millions of vulnerable people while restoring the natural systems that sustain life itself.

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[4] University of Oxford & Global Center on Adaptation (2025): *Scaling up investment in Nature-based Solutions for Climate Resilient Infrastructure Bangladesh*. https://gca.org/scaling-investments-in-nbs-for-climate-resilient-infra/

[5] University of Oxford & Global Center on Adaptation (2025): *Scaling up investment in Nature-based Solutions for Climate Resilient Infrastructure Bangladesh*. https://gca.org/scaling-investments-in-nbs-for-climate-resilient-infra/; Global Tools for NbS (2025): https://global.infrastructureresilience.org/

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