Bangladesh Climate Resilient Infrastructure Investment Roadmap

Technical report

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GLOBAL CENTER ON ADAPTATION

BRAC UNIVERSITY

C3ER Centre for Climate Change and Environmental Research

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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.

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1. ABBREVIATIONS

Acronyms	Definitions
ADB	Asian Development Bank
AIIB	Asian Infrastructure Investment Bank
ADP	Annual Development Programme
BBS	Bangladesh Bureau of Statistics
BIWTA	Bangladesh Inland Water Transport Authority
BPDB	Bangladesh Power Development Board
CEGIS	Center for Environmental and Geographic Information Systems
CSR	Corporate Social Responsibility
DPE	Directorate of Primary Education
DPHE	Department of Public Health Engineering
DoE	Department of Environment
EPC	Engineering, Procurement, and Construction
FGD(s)	Focus Group Discussion(s)
GCA	Global Center on Adaptation
GCF	Green Climate Fund
GEF	Global Environment Facility
GDP	Gross Domestic Product
GIS	Geographic Information System
GTCL	Gas Transmission Company Limited
HCF(s)	Health Care Facility(ies)
HH	Household
KII(s)	Key Informant Interview(s)
LDCF	Least Developed Countries Fund
LGD	Local Government Division

LGED	Local Government Engineering Department
LKP	Local Key Person
MDBs	Multilateral Development Banks
MoEFCC	Ministry of Environment, Forest and Climate Change
MoDMR	Ministry of Disaster Management and Relief
MoHFW	Ministry of Health and Family Welfare
MoLGRDC	Ministry of Local Government, Rural Development and Co-operatives
M&E	Monitoring and Evaluation
NbS	Nature-based Solutions
NAP	National Adaptation Plan
PIO	Project Implementation Office
PPP	Public–Private Partnership
PROVATi3	Promoting Resilience of Vulnerable through Access to Infrastructure
PURE	Productive Use of Renewable Energy
RCC	Reinforced Cement Concrete
RCP	Representative Concentration Pathway
RHD	Roads and Highways Department
RPCL	Rural Power Company Limited
RP25	25-year return period
RP100	100-year return period
SDG	Sustainable Development Goal
SMART	Sustainable Management of Agricultural Research and Technology
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UNOPS	United Nations Office for Project Services
DWASA	Dhaka Water Supply and Sewerage Authority

WARPO	Water Resources Planning Organisation
WASH	Water, Sanitation and Hygiene
WB	World Bank
WTP	Water Treatment Plant

2. PREAMBLE

Bangladesh is ranked among the most climate-vulnerable nations globally. It faces critical challenges such as escalating risks of flooding, cyclones, sea-level rise, and extreme weather events that threaten the country's infrastructure, economic stability, and the well-being of people. These hazards have far-reaching implications, including not just the damage to physical assets but also disruption of essential services and livelihoods, and exacerbation of existing vulnerabilities, which place Bangladesh at a critical juncture in its development.

Over the past decade, Bangladesh has demonstrated a significant commitment to climate change adaptation. This dedication is also evident in key policy documents, such as the National Adaptation Plan, the Bangladesh Climate Prosperity Plan, and the Delta Plan 2100. Despite these comprehensive national frameworks, challenges remain, particularly in embedding climate resilience into the nation's critical infrastructure network. Insufficient institutional and technical capacity, coupled with a substantial infrastructure investment gap projected to reach $192 billion by 2040, underscores the urgency of this challenge. This insufficiency often stems from a lack of specialized training for engineers and urban planners, fragmented data collection methods that hinder comprehensive risk assessment, and limited inter-agency coordination, making it difficult to implement holistic resilience strategies.

Also, a notable disconnect is often visible in integrating climate risk knowledge and resilience insights into public-private infrastructure projects, primarily due to the perception that resilience offers benefits mainly to the public rather than providing tangible advantages to private entities. To recognize these challenges and bridge the gap, the Ministry of Environment, Forest, and Climate Change, in collaboration with the Global Center on Adaptation (GCA), conducted a comprehensive assessment titled "Climate Resilient Infrastructure and Stress Test" to evaluate the vulnerability of Bangladesh's infrastructure systems to climate-related hazards, quantify their impact on service provision, and inform the realization of national development goals under various climate scenarios.

Through this comprehensive assessment, key climate risks are identified in the following sectors: transport, energy, water, and social infrastructure. Based on the robust findings of the assessment, a roadmap is proposed that prioritizes adaptation-focused investments to build systemic resilience. The roadmap is designed to guide national policy, align with strategic development goals, and catalyze financing and partnerships for climate-resilient infrastructure, ensuring a transformative and enduring shift towards climate-proof infrastructure development across Bangladesh's most exposed regions.

This report will also serve as a call to action for public and private sector stakeholders, development partners, and local communities. By investing in climate-smart infrastructure solutions that are inclusive, data-driven, and scalable, Bangladesh can not only safeguard its development gains but also position itself as a model for adaptive resilience in the Global South.

3. EXECUTIVE SUMMARY

The Climate Resilient Infrastructure and Stress Test assessment report presents the findings and recommendations from a comprehensive assessment of Bangladesh's infrastructure vulnerability to climate change, outlining a strategic roadmap for resilient investment. As the 7th most climate-vulnerable country globally, Bangladesh faces intensifying threats from rising sea levels, cyclones, erratic rainfall, and temperature increases, which profoundly impact its vital infrastructure across transport, energy, water, and social sectors. These impacts manifest as direct physical damage, disruption of essential services, and significant economic losses.

The assessment was conducted by the Ministry of Environment, Forest, and Climate Change, in collaboration with the Global Center on Adaptation, to stress-test the infrastructure systems against climate hazards to identify, assess, and prioritize the adaptation needs of Bangladesh's infrastructure systems in the face of climate change, revealing significant current and projected economic loss and damages. For example, the transport sector is estimated to face approximately €12.3 billion (2.95% of 2021 GDP) in monetary damages from baseline riverine and coastal flooding, projected to rise to €12.7 billion by 2050. Similarly, the energy sector incurs significant losses, with 67% of power plants and 90% of electricity grids exposed to climate hazards. Water infrastructure, though limited in data, shows growing vulnerability, particularly the Saidabad Water Treatment Plant. Critical social infrastructure, including healthcare facilities, market centers, and educational institutions, also demonstrates alarmingly high exposure (95%, 93%, and 95%, respectively) to at least one significant climate hazard.

To address these vulnerabilities, the assessment report identifies and prioritizes a pipeline of 35 adaptation solutions given below:

Traditional built environment projects: Structural reinforcements, elevation of critical assets, construction of reinforced cyclone shelters, and upgrades to existing drainage systems to manage intensified rainfall and flood events.

Nature-based solutions: Leverage ecosystem services, such as the restoration and planting of mangrove forests along coastal belts to act as natural barriers against storm surges, the preservation and expansion of wetlands for flood retention and water purification, and the implementation of eco-dikes to protect agricultural lands while promoting biodiversity.

Urban resilience projects: Integrate both built and nature-based approaches, focusing on comprehensive urban planning that incorporates resilient zoning codes, develops early warning systems, and promotes resilient housing solutions.

Enabling environment initiatives: Build institutional and technical capacities through specialized training programs for local government officials and engineers, the development and enforcement of climate-informed building codes, and the establishment of robust data collection and sharing platforms to inform decision-making.

The proposed roadmap outlines a strategic investment portfolio, featuring detailed project concepts, cost estimates, co-benefits, and financing options. These projects align with national development priorities, such as the Delta Plan 2100 and the National Adaptation Plan (NAP), as well as the Sustainable Development Goals (SDGs 9, 11, 13), while emphasizing equity, economic resilience, and environmental sustainability. Also, a fundamental commitment to gender equality and inclusivity is present in all proposed projects, ensuring that women, youth, and other vulnerable groups are not only protected but also actively integrated into every stage of infrastructure design, implementation, and emergency access planning.

This holistic roadmap is designed to prevent future damage, enable safe and inclusive development, and promote long-term resilience, serving as an actionable model for climate-proofing national infrastructure through collaborative efforts across government, development partners, and communities to accelerate the transition toward climate-resilient prosperity.

4. INTRODUCTION

Bangladesh ranks as the 7th most vulnerable country globally to the risks posed by climate change. One of the most affected systems is the infrastructure network, which underscores the necessity to embed climate resilience into every aspect of infrastructure projects. This imperative is reflected in several key governmental policy documents, including the National Adaptation Plan, the Bangladesh Climate Prosperity Plan, and the Delta Plan 2100. Over the past decade, the nation has made notable advancements in adaptation planning to address the impacts of climate change that threaten its development progress.

Despite having comprehensive national-level plans and policies, challenges remain due to insufficient institutional and technical capacity, hindering the effective resilience of infrastructure systems. The existing infrastructure gap not only poses significant challenges but also presents a unique opportunity to integrate climate change considerations into future infrastructure planning and investment strategies. Securing financing for resilient infrastructure is essential, with equitable service delivery becoming increasingly critical.

To address the infrastructure investment gap, projected to reach $192 billion by 2040, the government of Bangladesh is increasingly seeking to engage the private sector. However, a notable gap exists in integrating knowledge about how to combine public-private infrastructure projects with insights on climate risks, resilience, and infrastructure development. The discrepancy arises from the perception that resilience and adaptation primarily offer public benefits rather than private ones.

To bridge this gap, an assessment was conducted by the Ministry of Environment, Forest, and Climate Change (MOEFCC) of the Government of Bangladesh in collaboration with the Global Center on Adaptation (GCA). This assessment aimed to stress test the nation's infrastructure systems against climate-related hazards and to measure the impact of such hazards on infrastructure service provision and the realization of development goals under various climate scenarios. The findings from this assessment are intended to guide national policy and planning efforts and inform future investments in climate-resilient infrastructure.

The assessment identified national adaptation needs across key sectors – water, energy, transport, and social infrastructure – highlighting the essential development of a roadmap for resilient investment projects that address critical infrastructure needs. This roadmap takes into account contextual opportunities and constraints, particularly the political and social significance of various assets, as well as their potential contributions to current or forthcoming policy revisions. This tailored approach ensures that the proposed adaptation measures are both relevant and aligned with national development objectives.

The study team has identified and prioritized a pipeline of 35 adaptation solutions aimed at addressing key climate risks and integrating resilience within Bangladesh's infrastructure systems. Informed by data and insights from the Climate Resilient Infrastructure and Stress Test assessment, these solutions represent a vital component of the country’s roadmap for adaptation projects. The identified initiatives are designed to enhance the climate resilience of infrastructure and support the objectives outlined in Bangladesh’s national plans and policies.

The Climate Resilient Infrastructure and Stress Test assessment served as the foundation for identifying adaptation solutions, which include engineered measures, nature-based solutions (NBS), and enabling environmental interventions. Each solution has been developed into a comprehensive project concept that outlines estimated investment costs, anticipated economic and financial benefits, and a preliminary analysis of potential financing mechanisms. A robust evidence base, including detailed feasibility studies, assessments of alignment with adaptation needs, indicative implementation timelines, and an analysis of expected sustainable development co-benefits, underpins the project list.

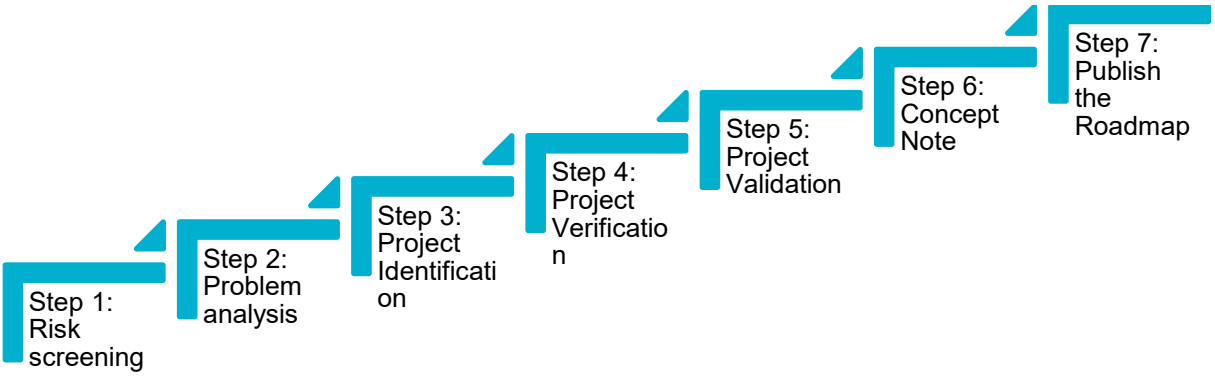


Figure 1Investment Roadmap Steps

5. ASSESSING CLIMATE RISK FOR BANGLADESH'S INFRASTRUCTURE SYSTEM

5.1 Climate Change Scenario in Bangladesh

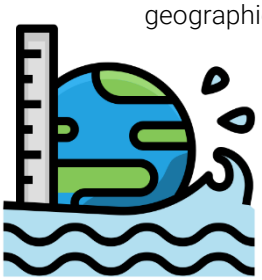
Bangladesh, a densely populated and low-lying country in South Asia, is highly susceptible to the impacts of climate change. Rising sea levels pose a severe threat to its coastal regions, leading to erosion, salinity intrusion, and displacement of communities. The country also faces increased frequency and intensity of cyclones, resulting in widespread damage to infrastructure and lives. Changing rainfall patterns, including erratic precipitation and prolonged droughts, affect agriculture and water availability. Bangladesh experiences a gradual temperature rise, leading to heatwaves, reduced crop yields, and health risks. Vulnerabilities include coastal vulnerability, water scarcity, agricultural risks, and health challenges. The government has implemented initiatives such as climate change strategies, adaptation plans, and the Bangladesh Climate Change Resilience Fund. International collaboration is crucial in addressing climate change impacts. Continuous efforts are needed to enhance resilience and ensure a sustainable future for Bangladesh amidst these challenges.

Climate Change Impacts

Climate change impacts refer to the observed or projected effects of climate change on various aspects of the Earth's systems, ecosystems, societies, and economies. These impacts manifest in a wide range of changes and disruptions caused by alterations in temperature, precipitation patterns, sea-level rise, and extreme weather events. Climate change impacts can have both direct and indirect effects on natural and human systems, with significant consequences for biodiversity, agriculture, water resources, public health, infrastructure, and socio-economic well-being.

(Hatfield & Walthall, 2014)

Bangladesh, being a small country situated between the Bay of Bengal to the south and the Himalayas to the north, faces significant challenges due to its geographical location and dense population. The country relies heavily on its limited natural resources to support its large population. However, the impacts of climate change pose a severe threat to its current state. Given its unique geographic position, Bangladesh is particularly vulnerable to the adverse effects of climate change, which can exacerbate existing challenges and increase the country's susceptibility to environmental risks.



Rising Sea Levels: Bangladesh's low-lying coastal areas are particularly susceptible to rising sea levels. As global temperatures increase, glaciers melt, and ocean waters expand, the coastal regions face the threat of inundation and erosion. This leads to the loss of land, displacement of communities, and salinity intrusion into freshwater sources, affecting agriculture and access to clean drinking water.

Increased Frequency and Intensity of Cyclones: Bangladesh is prone to tropical cyclones, which are expected to become more frequent and intense due to climate change. These cyclones bring strong winds, heavy rainfall, storm surges, and flooding, causing extensive damage to infrastructure, homes, agriculture, and leading to loss of lives.

Changing Rainfall Patterns: Climate change is altering rainfall patterns in Bangladesh. The country experiences increased variability, with more intense rainfall events and prolonged dry periods. Erratic and heavy rainfall can lead to flooding, landslides, and soil erosion, impacting agricultural productivity, water resources, and causing damage to infrastructure.

Temperature Rise and Heatwaves: Bangladesh is experiencing a gradual increase in temperature, resulting in more frequent and prolonged heatwaves. Higher temperatures pose health risks, particularly for vulnerable populations, including heat-related illnesses and heat stress. Increased temperatures also affect agricultural productivity and contribute to the spread of vector-borne diseases.

Impact on Water Resources: Climate change affects Bangladesh's water resources, including rivers, lakes, and groundwater. Changes in rainfall patterns can lead to water scarcity, reduced availability for irrigation, and challenges in maintaining water quality. This has significant implications for agriculture, food security, and the livelihoods of communities dependent on water resources.

Agricultural Impacts: Agriculture is a vital sector for Bangladesh's economy and livelihoods, but climate change poses significant risks. Erratic rainfall patterns, increased temperatures, and extreme weather events affect crop yields, leading to decreased productivity, reduced food security, and increased vulnerability for rural communities.

Ecosystem Disruption: Climate change disrupts natural ecosystems in Bangladesh, affecting biodiversity, wetlands, and coastal habitats. This disruption has implications for ecological balance, wildlife populations, and ecosystem services, such as coastal protection and fishery resources.

It is essential for Bangladesh to address these climate change impacts through adaptation and mitigation strategies. The country has taken initiatives to enhance resilience, promote sustainable development, and seek international collaboration and support to address the challenges posed by climate change.

Vulnerability

Vulnerability refers to the susceptibility or exposure of individuals, communities, or systems to potential harm, damage, or negative impacts. It is a measure of the degree to which someone or something is at risk or prone to adverse effects, often in the context of social, environmental, or economic factors. Vulnerability can arise from various factors such as geographical location, socioeconomic conditions, limited access to resources, lack of infrastructure, and dependence on natural systems. Understanding vulnerability is essential for identifying and addressing risks, developing resilience strategies, and implementing measures to mitigate and adapt to potential threats or stressors.

(Sarwar & Islam, 2013)

This section sets the stage for exploring the vulnerabilities and risks associated with climate change in Bangladesh. Understanding these risks is crucial for implementing effective adaptation and mitigation strategies to protect the population, safeguard livelihoods, and promote sustainable development in the face of a changing climate.

Climate Change Vulnerabilities	
Coastal Vulnerability	Bangladesh's extensive coastline is highly vulnerable to sea-level rise, storm surges, and increased frequency and intensity of cyclones. The low-lying coastal regions are at risk of inundation, erosion, and saltwater intrusion, threatening lives, infrastructure, and livelihoods of coastal communities.

Water Resources	Changes in rainfall patterns and increased temperature affect water resources in Bangladesh. Erratic precipitation leads to droughts and floods, impacting water availability, irrigation, and water quality. This puts pressure on agricultural productivity, water supply for domestic use, and overall water security.
Agriculture and Food Security	The majority of the population relies on agriculture for their livelihoods and food security. Climate change-induced events such as floods, droughts, and changes in temperature and precipitation patterns can result in crop failures, reduced agricultural productivity, and increased vulnerability to food insecurity.
Health Risks	Climate change impacts in Bangladesh pose health risks to its population. Increased temperatures contribute to heatwaves, heat stress, and related illnesses. Changes in rainfall patterns and flooding can lead to waterborne diseases, while changes in ecosystems may influence the prevalence of vector-borne diseases like dengue fever and malaria.
Ecosystem Disruption	Climate change affects Bangladesh's unique ecosystems, including wetlands, forests, and coastal areas. Rising sea levels and increased salinity intrusion impact biodiversity, coastal habitats, and the services they provide, such as coastal protection, fisheries, and tourism.
Socioeconomic Impacts	Climate change exacerbates existing socioeconomic vulnerabilities in Bangladesh. Disasters and extreme weather events can lead to displacement, loss of livelihoods, increased poverty, and social unrest. Vulnerable groups, such as women, children, and marginalized communities, face heightened risks and reduced adaptive capacity.
Infrastructure and Urban Risks	Bangladesh's rapidly growing urban areas are at risk from climate change impacts. Inadequate infrastructure and urban planning make cities vulnerable to flooding, waterlogging, and infrastructure damage, leading to disruptions in services, economic losses, and threats to public safety.

Addressing these vulnerabilities and risks requires comprehensive strategies and actions to enhance resilience, promote sustainable development, and ensure the well-being of the population. Bangladesh has been proactive in implementing adaptation measures, strengthening early warning systems, and seeking international cooperation to address these challenges and build a more resilient future.

5.2 Climate Change Impact on the Physical Assets and Infrastructure Systems

5.2.1 Climate Change Risks to Transport Sector

5.2.1.1 Transport Sector in Bangladesh

Bangladesh's transport sector plays a critical role in linking the country's rapidly growing urban centers with rural communities. It facilitates access to essential services such as healthcare, education, and economic opportunities, and enables the movement of goods and people across domestic and international markets. As the sector continues to expand, through the development of extensive road networks, landmark bridges across major river systems, and the modernization of ports and inland waterways, its importance to national connectivity and socio-economic development becomes ever more pronounced.

The transport system in Bangladesh is deeply interconnected with other sectors. Consequently, disruptions, whether from natural hazards or infrastructure failures, can severely impact access to basic services, economic productivity, and the broader stability of livelihoods. For instance, damage to road or railway infrastructure can hinder access to healthcare and education, while interruptions at ports or

airports may disrupt trade flows, adversely affecting the national economy. As such, strengthening the resilience of transport assets and networks is essential to achieving Bangladesh's long-term development objectives and mitigating the risks associated with climate change and natural hazards.

5.2.1.2 Climate Risk Assessment of Transport Infrastructure

The climate risk assessment conducted for Bangladesh's transport sector covered a comprehensive range of assets, including:

- Roads: 173,809 km
- Railway infrastructure: 519 stations and 3,159 km of railway lines
- Airports: 13
- Ports: 32
- Inland waterways: 6,056 km and 80 inland water terminals

Data on these assets were compiled from key national institutions such as the Local Government Engineering Department (LGED), the Roads and Highways Department (RHD), and the Water Resources Planning Organisation (WARPO).

Transport infrastructure in Bangladesh is highly exposed to a variety of climate-related hazards, including riverine and coastal flooding, cyclones, and erosion. These hazards pose significant threats to the long-term functionality and reliability of the transport system.

Flood risk analyses were conducted using riverine and coastal flood exposure models, incorporating four time horizons: the base year, 2030, 2050, and 2080. For each time frame, flood hazard projections were evaluated for five return periods: 2, 10, 25, 50, and 100 years. These analyses were conducted under two climate scenarios, based on Representative Concentration Pathways (RCPs):

- RCP 4.5: A realistic emissions scenario
- RCP 8.5: A high-emissions, extreme scenario

Flood depth data were derived from the global Aqueduct flood hazard database (Winsemius et al., 2015), offering a spatial resolution of 100m x 100m across Bangladesh. Based on consultations with national stakeholders and partners, the analysis primarily focuses on RCP 4.5, the 50-year return period, and the year 2050—as this combination is considered most relevant for planning purposes.

In contrast to flood risk modeling, the assessment of cyclone and erosion exposure was limited to the base year, due to the lack of reliable future hazard projections for these risks:

- Cyclones: Exposure was assessed using maximum wind gust data (in m/s) across different return periods, derived from the Steptoe (2021) dataset, which resimulates cyclone events using historical and modeled data.
- River and Coastal Erosion: The DeepWaterMap model (Jarriel et al., 2020), a satellite-based tool, was used to detect and analyze long-term changes in river channels and coastlines, providing valuable insights into the erosion dynamics impacting transport assets.

Economic damage estimates were conducted specifically for coastal and riverine flooding, as these hazards are most quantifiable with the available data. These assessments highlight the potential financial impacts of climate-related disruptions to transport infrastructure and help inform strategies for climate adaptation and infrastructure resilience planning. Detailed information on climate risk assessment of transport infrastructure can be found in Gall et al. (2022).

5.2.1.3 Estimated Risks to Transport Infrastructure

Bangladesh's transport sector faces significant and increasing risks from a variety of climate-related hazards. Currently, the sector is highly exposed to coastal and riverine flooding, cyclones, and erosion. Among the assessed hazards, cyclonic wind exposure stands out as the most pervasive, with more than 75% of transport assets across the country falling within high-exposure zones. This includes critical assets such as roads, railways, ports, and airports. When all climate hazards are considered together, the figures are even more alarming: approximately 95% of the road network, 93% of the railway network, and

94% of railway stations (488 out of 519) are exposed to at least one major climate hazard. Furthermore, all 32 ports and all 13 airports in the country are exposed under baseline conditions, indicating near-universal vulnerability across the entire transport system (Figure 2Error! Reference source not found.).

Looking to the future, the exposure of transport assets—especially roads and railways—to coastal and riverine flooding is projected to increase significantly. This trend is driven by both sea-level rise and intensified rainfall patterns under changing climate scenarios. Even under the relatively moderate RCP 4.5 scenario, risks escalate over time, necessitating urgent resilience planning and investment.

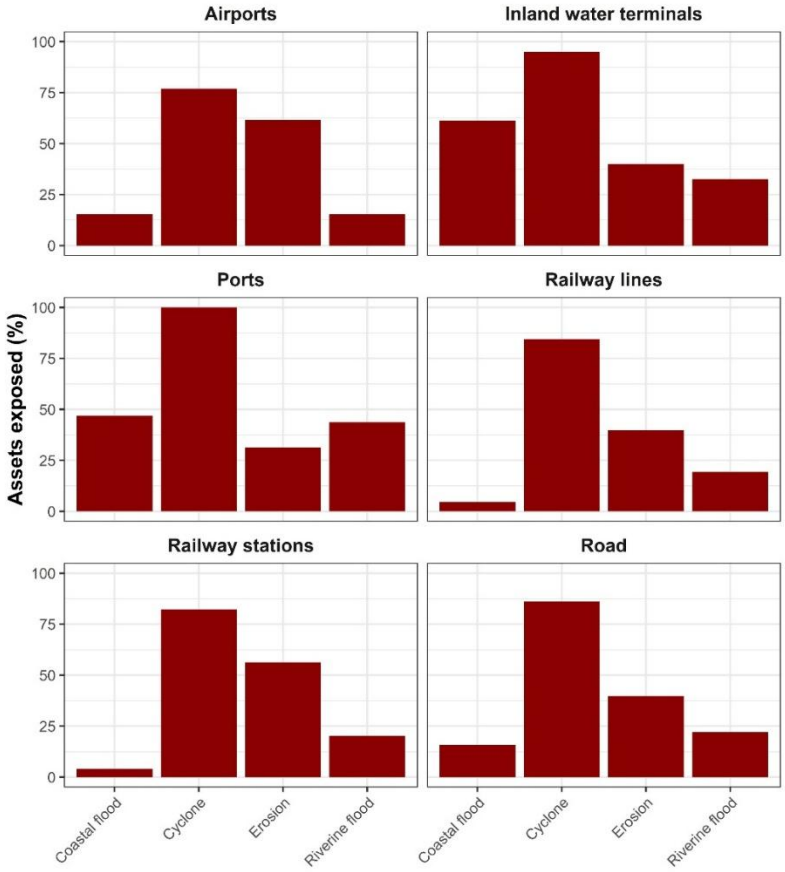


Figure 2: Exposure of transport infrastructure assets — including airports, inland water terminals, ports, railway lines, railway stations, and roads — to climate hazards under baseline conditions. The figure illustrates asset-level exposure to coastal flood, cyclone, erosion, and riverine flood

In terms of economic damage, coastal flooding is the most damaging hazard to the transport sector, despite its relatively lower geographic extent compared to other hazards (e.g., riverine flooding). This suggests that the infrastructure located in coastal zones is not only highly critical but also particularly vulnerable. According to the analysis, economic damages from baseline riverine and coastal flooding are estimated at approximately €12.3 billion, which represents 2.95% of Bangladesh's GDP in 2021. Under the future 2050 scenario for a 1-in-50-year flood event (RCP 4.5), this figure increases to €12.7 billion or 3.05% of 2021 GDP.

The road network bears a large share of the estimated damage, particularly in the 19 coastal districts where flood exposure is most acute (Figure 3). At the Upazila level, the highest damages in the baseline scenario are projected in Shyamnagar Upazila (Satkhira district) with €389.2 million, followed by Patuakhali Sadar Upazila (Patuakhali district) with €355.5 million, and Hatiya Upazila (Noakhali district) with €257.6 million. These values are expected to increase in the future, reaching €389.9 million, €383 million, and €294.7 million, respectively, under the 2050 scenario.

The railway infrastructure is similarly at risk, with the highest estimated damages to railway lines occurring in Gopalganj Sadar Upazila (Gopalganj district), Boalkhali Upazila (Chattogram district), and Bhanga Upazila (Faridpur district). Damage to railway stations is most severe in Boalkhali Upazila and

Bagerhat Sadar Upazila (Bagerhat district). Additional flood scenarios and results are presented in Figure B1-B3 in Appendix A.

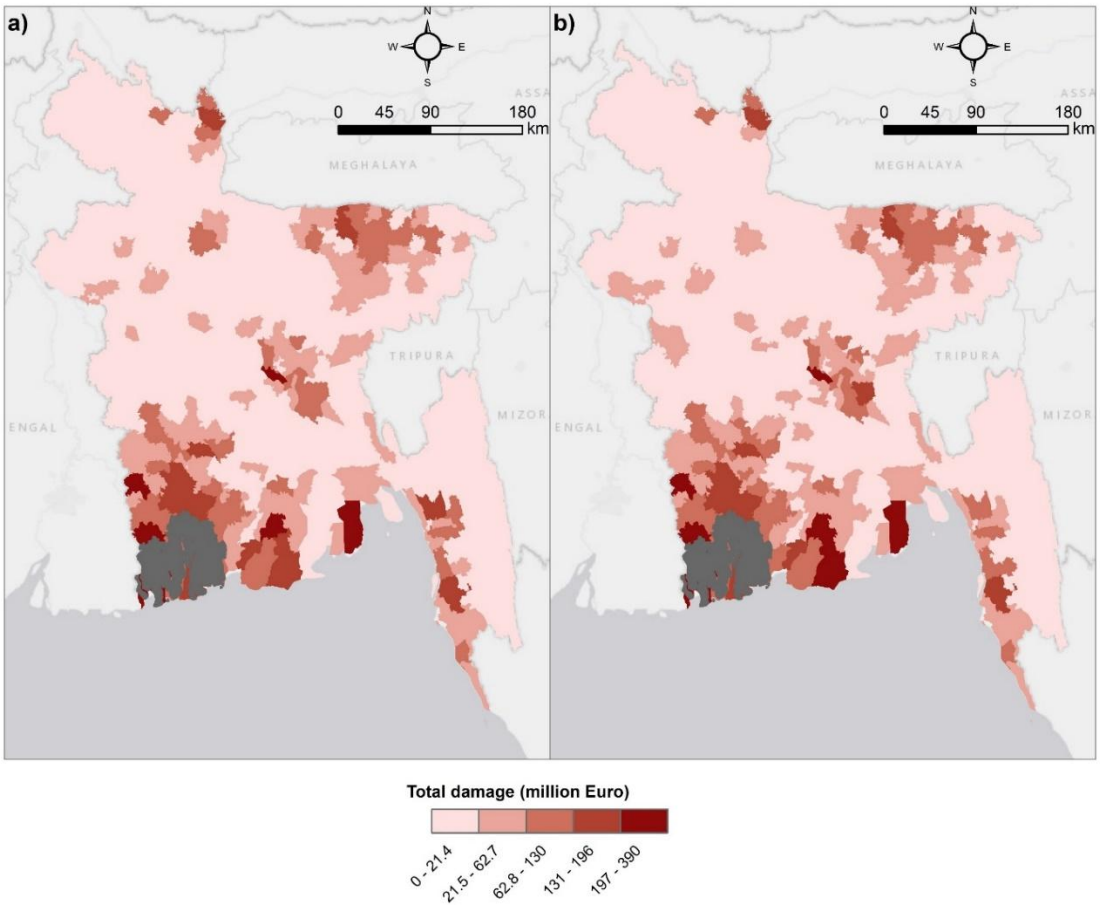


Figure 3: Total estimated damage to the road network due to coastal and riverine flooding for a 1-in-50-year return period event: (a) baseline scenario and (b) future climate change scenario under RCP 4.5 for the year 2050.

With regard to port infrastructure, the most significant damages are anticipated in Sadarpur Upazila (Faridpur district) and Shibchar Upazila (Madaripur district), reflecting the high economic and logistical value of river ports located in flood-prone regions.

These findings underscore the urgent need for adaptive planning, climate-resilient design standards, and investment in protective infrastructure. Without such measures, climate hazards will continue to undermine Bangladesh's transport connectivity and jeopardize national development goals.

5.2.2 Climate Change Risks to Energy Sector

5.2.2.1 Energy sector in Bangladesh

The energy sector in Bangladesh is a critical component of the country's development, yet it continues to face significant challenges in meeting growing demand. Bangladesh primarily relies on a mix of natural gas, coal, oil, and a smaller share of hydropower to meet its energy needs. Despite efforts to expand capacity and improve access, energy resources remain insufficient, with many regions still underpowered or reliant on unstable supply. As of 2015, only about 70% of the population had access to electricity (Uddin et al., 2019), highlighting ongoing disparities in energy distribution and infrastructure development.

The analysis of Bangladesh's energy sector in this context focuses on the physical assets and networks that constitute the national electricity and gas supply systems. These include power generation plants, transmission and distribution lines, gas pipelines, and associated infrastructure. As demand for energy continues to rise in tandem with industrialization and urban growth, ensuring resilience, sustainability, and equitable distribution of energy services has become a national priority.

5.2.2.2 Climate Risk Assessment of Energy Infrastructure

The climate risk assessment of Bangladesh's energy sector evaluates the vulnerability of key infrastructure assets to multiple climate hazards, including coastal and riverine flooding, cyclonic winds, and coastal and riverbank erosion. The assessment covers a comprehensive inventory of assets: 106 power plants, 113 electricity substations, 6,150 km of electricity grid lines, 25 gas fields, and 11,098 km of gas pipelines. These data were compiled from major national entities such as the Bangladesh Power Development Board (BPDB), Gas Transmission Company Limited (GTCL), and Petro Bangla, ensuring a wide-ranging and accurate representation of energy infrastructure across the country.

Following a methodology similar to that of the transport sector, the risk analysis incorporates flood exposure models for both riverine and coastal flooding, considering four time periods—the base year, 2030, 2050, and 2080. For each time frame, flood risk was assessed under five return periods (2, 10, 25, 50, and 100 years), and two climate scenarios based on Representative Concentration Pathways (RCPs): RCP 4.5, representing a realistic emissions trajectory, and RCP 8.5, depicting an extreme high-emissions future. Additional hazard data sources, including those for cyclonic wind speeds and erosion, align with those used in prior assessments and provide consistent analytical depth across sectors.

In terms of impacts, economic damage estimates were calculated for coastal and riverine flooding, as well as cyclones, with flooding risks evaluated under both current and future climate conditions, and cyclone-related risks assessed for the baseline scenario only, due to limitations in future cyclone projections. The results highlight significant exposure and vulnerability within the energy sector, reinforcing the urgency of adaptive planning and infrastructure investment. Further technical details and modeling approaches can be found in Gall et al. (2022).

5.2.2.3 Estimated Risks to Energy Infrastructure

Bangladesh's energy infrastructure is highly vulnerable to a range of climate-related hazards, including coastal and riverine flooding, cyclonic winds, and erosion. In the baseline year, an alarming portion of the sector is already exposed to these hazards. Specifically, 67% of power plants (71 out of 106), 65% of electricity substations (74 out of 113), 90% of electricity grid lines (24,152 km), 52% of gas fields (13 out of 25), and over 4,462 km of gas pipelines are located in areas subject to at least one of the four assessed hazards (Figure 4). These figures reveal the widespread and systemic nature of climate exposure within the energy sector. Moreover, projections indicate that exposure to coastal and riverine flooding will increase in the future, particularly under climate change scenarios that involve sea-level rise and intensified precipitation events.

In terms of economic damage, the energy sector is already incurring significant losses due to climate hazards. For the baseline scenario alone, direct economic damages are estimated at €44.47 million, equivalent to 0.01% of Bangladesh's GDP in 2021. Of the various hazards, cyclonic winds pose the greatest threat, both in terms of physical exposure and potential economic impact. This is particularly concerning given the heavy reliance on electricity across the country—disruptions in the electricity grid, often caused by cyclone damage, affecting large swaths of the population, interrupting essential services and daily livelihoods.

Geographically, the Chattogram district stands out as one of the most at-risk regions (Figure 5). Power plants in Patiya, Raozan, and Shikalbaha Upazilas face the highest combined risks from flooding and cyclones, with estimated damages of €5.73 million, €2 million, and €0.773 million, respectively. Similarly, electricity substations in Patiya and Hathazari Upazilas are projected to experience significant impacts, with damages of €0.041 million and €0.033 million under the baseline scenario.

Further south, Cox's Bazar district, particularly Chakaria and Teknaf Upazilas, is highly exposed to cyclonic wind damage along the electricity grid. Here, the estimated damages are €0.15 million and €0.111 million, respectively, reflecting the high vulnerability of infrastructure in coastal areas prone to severe storms. These localized insights underscore the need for targeted adaptation strategies, especially in regions where critical energy assets are clustered. Additional results are provided in Figure B4 (Appendix A).

Overall, the findings highlight an urgent need for climate-resilient planning across Bangladesh's energy sector. As climate risks increase over time, without proactive investments in adaptation and infrastructure

reinforcement, the reliability of the country's energy systems—and by extension, its broader development trajectory—could be severely compromised.

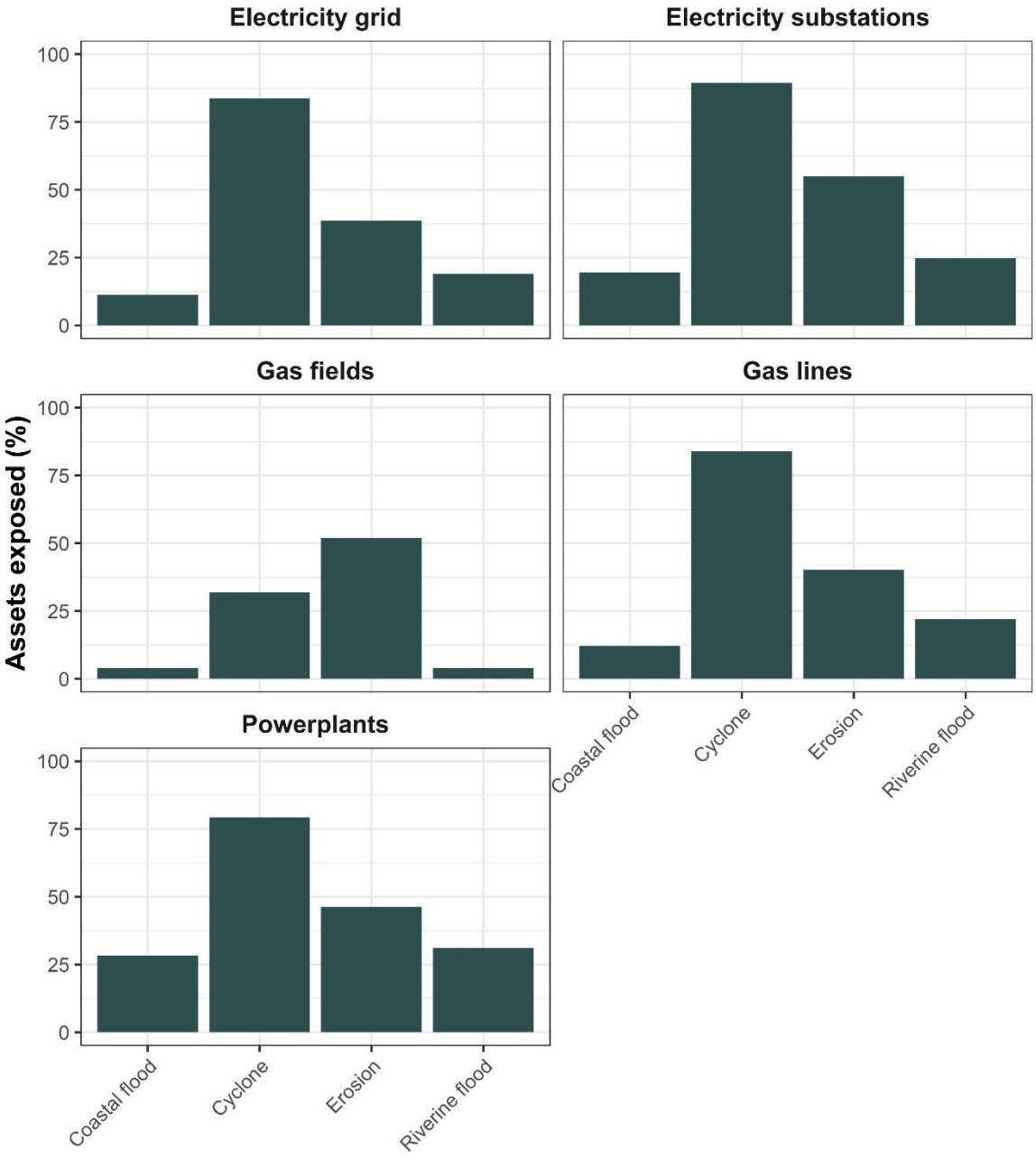


Figure 4: Exposure of energy sector assets—including electricity grids, substations, gas fields, gas pipelines, and powerplants—to coastal and riverine flooding, cyclonic winds, and erosion under present-day (baseline) conditions.

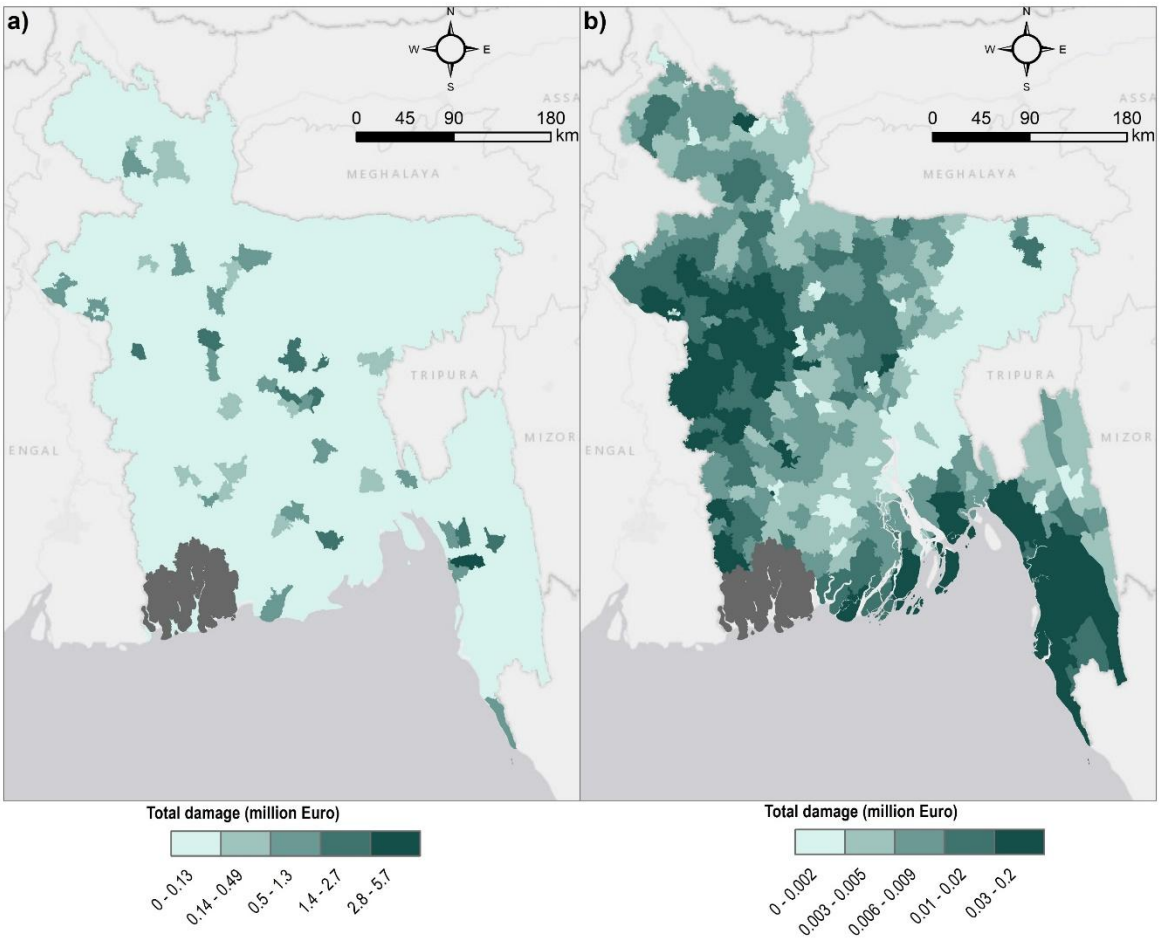


Figure 5: a) Total estimated damage to power plants from coastal flooding, riverine flooding, and cyclonic winds during a 1-in-50-year return period under baseline conditions. b) Estimated damage to electricity grids from cyclonic winds during a 1-in-5

5.2.3 Climate Change Risks to Water Sector

5.2.3.1 Water Sector in Bangladesh

The water sector in Bangladesh is highly susceptible to the impacts of climate change, particularly from hazards such as floods, cyclones, and droughts. These hazards are projected to affect water infrastructure both in the short term—through sudden, extreme events—and in the long term, as climate patterns shift gradually over time. Given that Bangladesh is a deltaic country with a dense network of rivers and low-lying topography, its water systems are especially vulnerable to disruptions from climate variability.

Flooding, particularly during the monsoon season, can overwhelm water supply systems, damage infrastructure such as pumping stations, pipelines, and treatment facilities, and contaminate drinking water sources with sediments, waste, or salinity. Cyclones, often accompanied by storm surges, can lead to physical destruction of water infrastructure, especially in coastal areas, while saline intrusion can degrade the quality of surface and groundwater resources. On the other end of the spectrum, droughts can lead to water shortages, especially during the dry season, reducing availability for household use, agriculture, and industry.

5.2.3.2 Climate Risk Assessment of Water Infrastructure

The climate risk assessment of water infrastructure in Bangladesh is significantly constrained by limited data availability. Unlike other infrastructure sectors, comprehensive national datasets on water supply and treatment systems are largely unavailable. As a result, this assessment focuses on only three water treatment plants (WTPs) for which data could be accessed: Saidabad and Chandni Ghat WTPs in Dhaka, and Kushighat WTP in Sylhet. These facilities are critical for ensuring clean water supply to densely populated urban areas, making their resilience a vital concern.

Other potential water-related datasets—such as Dhaka's underground water supply network and national observation wells—were excluded from this analysis. The underground network, while essential to the water system, is not considered vulnerable to surface-level climate hazards, and the observation wells, though useful for monitoring purposes, do not directly affect public water supply or access if disrupted.

Given the geographic and hydrological context of these WTPs, riverine flooding was identified as the sole relevant climate hazard for assessment. This is because flooding from overflowing rivers poses a direct threat to surface-level water treatment infrastructure by potentially damaging equipment, interrupting operations, and introducing contamination into the water supply. Other climate hazards such as cyclones, droughts, and coastal flooding were not deemed directly impactful to the specific WTPs under review.

While the scope of this assessment is narrow due to data constraints, it highlights the urgent need for expanded and centralized data collection on water infrastructure assets across the country. Doing so would enable more comprehensive climate risk analyses and better-informed adaptation planning for ensuring safe, reliable water access under current and future climate conditions.

5.2.3.3 Estimated Risks to Water Infrastructure

Although data limitations restrict the scope of analysis, the climate risk assessment reveals that Bangladesh's water infrastructure is not entirely immune to future climate threats, particularly from riverine flooding. For the baseline year, none of the three assessed WTPs—Saidabad and Chandni Ghat in Dhaka, and Kushighat in Sylhet—experienced flooding. Moreover, Chandni Ghat and Kushighat WTPs are not located in areas identified as flood-prone under any current or projected flood scenarios, suggesting a relatively low exposure risk for these two facilities.

However, Saidabad WTP, a major component of Dhaka's water supply system, shows growing vulnerability under future flood scenarios. In both 2030 and 2050, the plant is expected to experience inundation during extreme riverine flooding events with a 100-year return period (RP100). By 2080, the risk increases further, with flooding projected even during more moderate events (RP25). Flood depths at Saidabad could range from 0.05 meters to 0.68 meters, posing operational and structural risks. For a 100-year riverine flood in 2050, the estimated direct economic damage to Saidabad WTP is approximately €0.49 million.

Beyond treatment facilities, the water supply network in Dhaka is also exposed to climate hazards. While this underground system is generally less vulnerable to surface flooding, certain components remain at risk. For instance, a historical 50-year riverine flood event could result in damages of around €0.11 million to Dhaka's water supply infrastructure (Error! Reference source not found.). These findings highlight the importance of incorporating flood resilience measures into urban water infrastructure planning, particularly in densely populated and flood-prone cities like Dhaka, where even localized disruptions can affect millions of residents.

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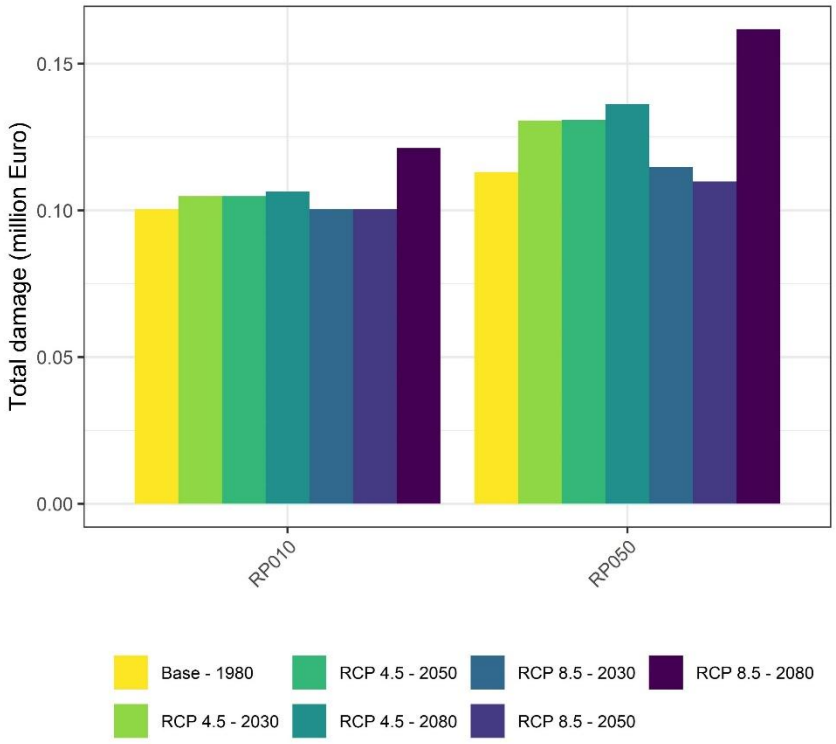

Figure 6: Estimated economic damage to the water supply network in Dhaka city due to riverine flooding under multiple scenarios, including different return periods and future climate projections.

Figure 6: Estimated economic damage to the water supply network in Dhaka city due to riverine flooding under multiple scenarios, including different return periods and future climate projections.

5.2.4 Climate Change Risks to Critical Social Infrastructure

5.2.4.1 Critical Social Infrastructure in Bangladesh

Critical social infrastructure in Bangladesh forms the backbone of the country's socio-economic development, providing essential services that support public well-being and national progress. This infrastructure includes market centers, healthcare facilities, cyclone shelters, and educational institutions such as schools, colleges, and universities. These facilities are vital not only for everyday life but also for long-term sustainable development, particularly through the delivery of healthcare, education, and economic opportunities.

Access to these critical services is often closely tied to the surrounding transport networks, which enable communities, especially in rural and hazard-prone areas, to reach essential services. For example, during natural disasters, the functionality of roads and bridges can determine whether people are able to reach

cyclone shelters or receive urgent medical care. Thus, ensuring the resilience and accessibility of critical infrastructure is central to improving quality of life and reducing vulnerability across Bangladesh.

5.2.4.2 Climate Risk Assessment of Critical Social Infrastructure

The climate risk assessment of critical social infrastructure in Bangladesh evaluates the vulnerability of essential community assets to key climate hazards, including coastal and riverine flooding, cyclonic winds, and coastal and riverbank erosion. The assessment covers a broad range of facilities crucial for social and economic functioning, including 2,062 market centres, 3,086 healthcare facilities, 3,777 cyclone shelters, and 73,814 educational institutions. Data for these assets were obtained from a range of national organizations, including the WARPO, LGED, and the Bangladesh Bureau of Statistics (BBS).

Using consistent methodologies across sectors, the flood risk assessment was conducted through exposure modeling for both riverine and coastal flooding, examining four key time periods: the base year, 2030, 2050, and 2080. Each time period included assessments for five different return periods—2, 10, 25, 50, and 100 years—under two climate scenarios based on Representative Concentration Pathways (RCPs): RCP 4.5 (a realistic emissions scenario) and RCP 8.5 (a high-emissions, extreme scenario). The assessment also included hazard data on flood depth and extent, cyclonic wind speeds, and erosion patterns, in line with previous sectoral evaluations.

In addition to exposure analysis, economic damage estimates were developed specifically for coastal and riverine flooding, both for the baseline year and under future climate change scenarios. These projections offer valuable insights into the potential financial impacts of climate hazards on critical infrastructure that directly supports public health, education, and economic resilience. The findings highlight the pressing need to strengthen the climate resilience of these facilities to ensure uninterrupted access to vital services, particularly in vulnerable and disaster-prone areas. Further technical details and data sources are available in Gall et al. (2022).

5.2.4.3 Estimated Risks to Critical Social Infrastructure

Critical social infrastructure in Bangladesh faces significant and growing exposure to climate hazards, including coastal and riverine flooding, cyclonic winds, and erosion. These facilities are vital for ensuring the wellbeing, safety, and development of communities, particularly in the context of health services, disaster response, education, and economic activity. In the baseline year, exposure is alarmingly high: 95% of healthcare facilities (2,931), 70% of cyclone shelters (2,643), 93% of market centres (1,913), and 95% of educational institutions (70,123) are exposed to at least one or more of these hazards (Figure 7). This high degree of exposure reflects the acute vulnerability of essential services that millions of people rely on daily.

Projections under the 2050 RCP4.5 scenario point to a further escalation in risk, especially from flooding. For a 50-year return period coastal flood, exposure is projected to rise by 3.33% for healthcare facilities, 6.79% for cyclone shelters, 3.06% for market centres, and 2.88% for educational facilities. Similarly, exposure to riverine flooding is expected to increase by 7.32% for healthcare, 5.96% for cyclone shelters, 6.9% for market centres, and 7.49% for education facilities. These trends suggest increasing challenges for maintaining the functionality of public services, particularly in disaster-prone coastal and low-lying areas.

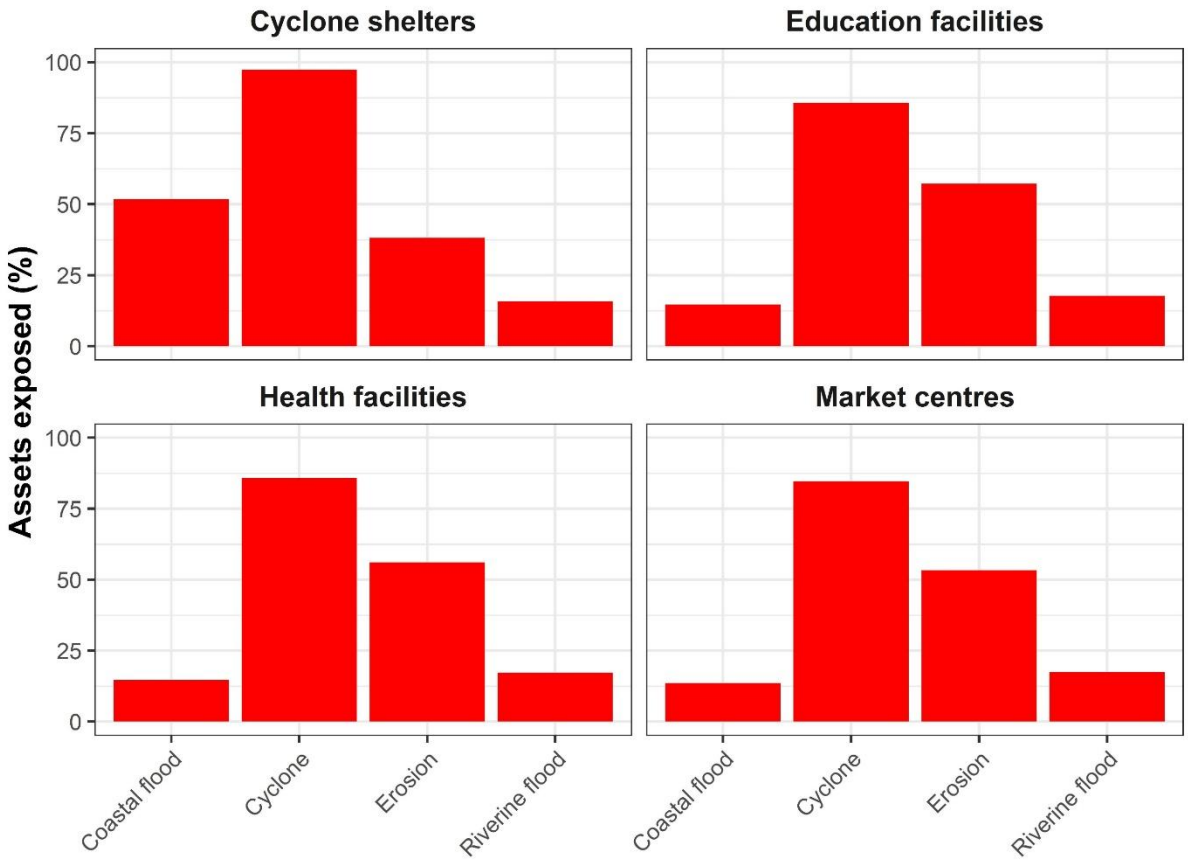

Figure 7: Exposure of critical social infrastructure assets—cyclone shelters, educational facilities, healthcare facilities, and market centres—to coastal and riverine floods, cyclones, and erosions under baseline conditions.

From an economic perspective, coastal flooding emerges as the most impactful hazard for critical social infrastructure. In the baseline year, it is estimated to cause €20.71 million in damage, a figure expected to rise by 24% to €25.72 million by 2050. Educational institutions in Khulna, Chattogram, Bagerhat, Satkhira, Patuakhali, Pirojpur, Sunamganj, Barisal, Barguna, and Gopalganj are especially exposed, with estimated damages of €3.77 million for a historical 50-year coastal and riverine flood event (Figure 8). Likewise, healthcare facilities in Khulna, Chattogram, Patuakhali, Satkhira, Bagerhat, Barisal, Pirojpur, Sunamganj, Barguna, and Kishoreganj are highly vulnerable, with €0.35 million in estimated damages under the same conditions.

Market centres, which are crucial for local economies and livelihoods, also face substantial risks. Key districts such as Khulna, Chattogram, Bagerhat, Satkhira, Patuakhali, Pirojpur, Sunamganj, Barisal, Barguna, and Gopalganj are particularly exposed, with an estimated €14.43 million in damages from a historical 50-year flood. Cyclone shelters, concentrated in all 19 coastal districts, continue to play a vital role in saving lives during extreme weather events. Their high exposure to cyclonic winds and coastal flooding is unsurprising, and damages from a 50-year coastal flood are estimated at €0.67 million. Strengthening these shelters remains a key priority to ensure resilience and safety in cyclone-prone communities.

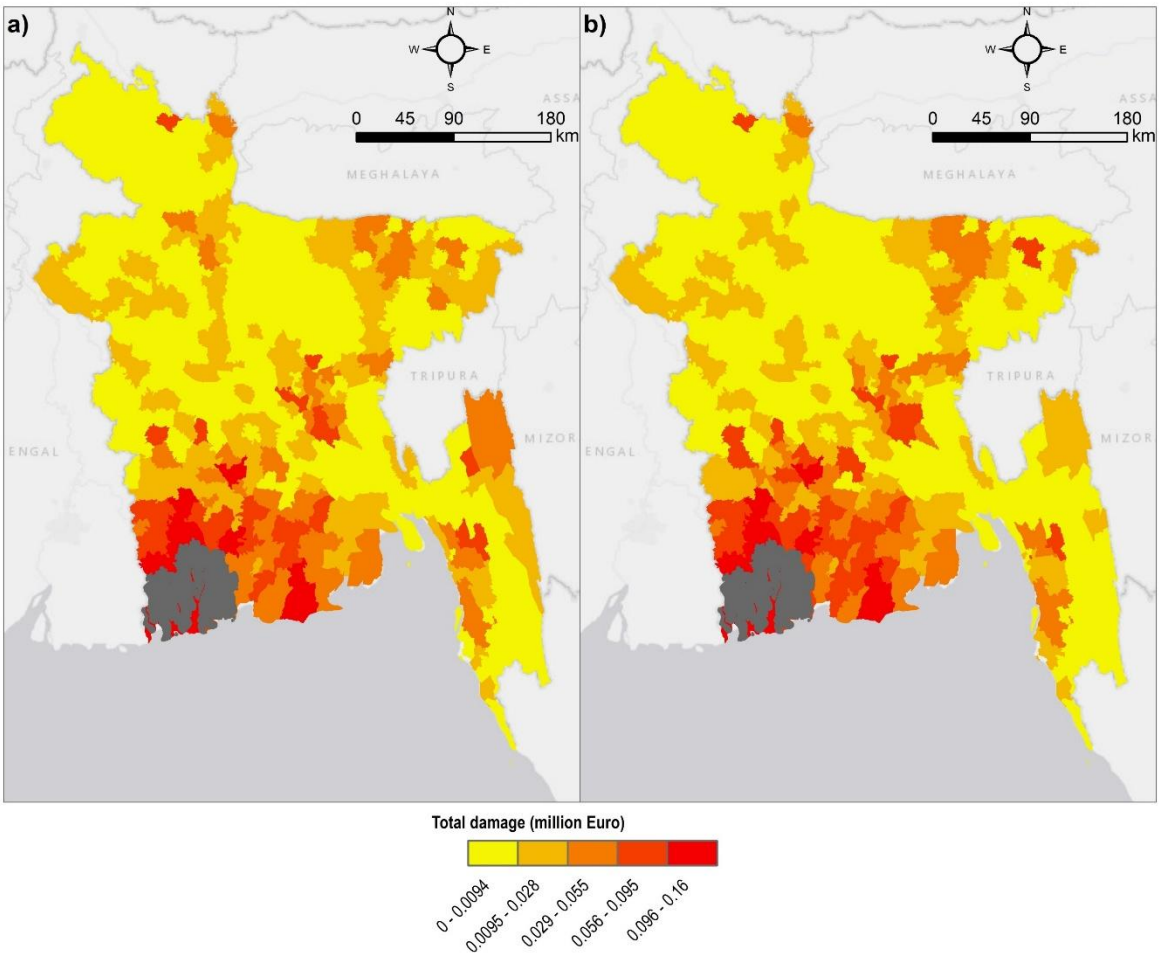

Figure 8: Total estimated economic damage to educational institutions due to coastal and riverine flooding for a 1-in-50-year return period: a) baseline scenario, and b) future climate scenario for RCP 4.5 in 2050.

6. ADDRESSING PRIORITIZED INFRASTRUCTURE ADAPTATION NEEDS THROUGH A RESILIENT INFRASTRUCTURE ROADMAP

6.1 Prioritizing Adaptation Needs

Bangladesh, with its extensive coastal and riverine landscapes, is navigating significant challenges posed by climate change, which renders it particularly vulnerable. This situation creates an opportunity for various sectors to embrace robust adaptation strategies that address the increasing frequency and intensity of climate-related hazards. This report constructively examines the transport, energy, water, and critical social infrastructures, shedding light on the vulnerabilities of ports, roads, airports, railway lines, and power infrastructure across multiple districts. By analyzing historical data on damages caused by severe weather events, such as cyclones and flooding, we aim to foster a deeper understanding of the pressing need for prioritized adaptation measures. Our findings emphasize the importance of resilience planning as a proactive approach to protect essential transportation and energy assets against the evolving climate.

As climate change and its associated hazards increasingly challenge critical infrastructure in vulnerable regions, Bangladesh stands at a crucial juncture. Characterized by its vast coastline and numerous waterways, the country's transport and energy sectors are particularly susceptible to threats from climate-induced events. This assessment identifies the various assets within these sectors, focusing on specific areas that require attention and estimating the economic damages linked to both historical and projected climate occurrences. By highlighting these vulnerabilities and prioritizing adaptation needs, this analysis seeks to empower stakeholders and policymakers to develop effective strategies that enhance resilience and ensure the ongoing functionality of essential services amidst climate threats. Through well-directed interventions, we can create pathways to mitigate the impacts on these vital infrastructures, ultimately safeguarding communities and promoting sustainable development in the region.

Table 1: Description of prioritised adaptation needs

Sector (Sub-sector)	Asset(s) or areas	Justification for prioritized adaptation need
Transport (Port)	Ports located in Bagerhat, Barisal, Chandpur, Chattogram, Faridpur, Jhalokati, Khulna, Madaripur, Manikganj, Munshiganj, Narayanganj, Pabna, Patuakhali, Pirojpur, Rajbari, and Sirajganj districts	**Hazards:** Cyclone **Considerations:** • Ports, both sea and river, located along the coastal areas and major rivers in Bangladesh, are vulnerable to cyclonic winds. • In particular, ports in 24 Upazilas across 16 districts face a high level of exposure. • For a historical 50-year cyclone event, the estimated damage to ports in these 16 districts amounts to 1.66 million euros.
Transport (Roads)	19 coastal districts	**Hazards:** Coastal and riverine flooding **Considerations** • Roads in coastal districts are highly vulnerable to both coastal and riverine flooding. • For historical 50-year riverine and coastal flood events, the estimated damage to roads in 126 Upazilas amounts to 7,022.77 million euros.

		• This damage is projected to increase to 7,447.57 million euros by 2050 for future 50-year flood events, affecting 128 Upazilas across 19 coastal districts.
Transport (Roads)	Shyamnagar Upazila, Satkhira district Patuakhali Sadar Upazila, Patuakhali district Hatiya Upazila, Noakhali district	**Hazards:** Coastal and riverine flooding **Considerations** • Roads in these three Upazilas are most severely impacted by coastal and riverine flooding. • In Shyamnagar Upazila, historical 50-year riverine and coastal flood events caused damages of €389.2 million, projected to increase to €389.9 million by 2050 for similar events. • In Patuakhali Sadar Upazila, historical 50-year riverine and coastal flood events resulted in damages of €355.5 million, expected to rise to €383 million by 2050 for similar events. • In Hatiya Upazila, historical 50-year riverine and coastal flood events caused damages of €257.6 million, likely to increase to €294.7 million by 2050 for similar events.
Transport (Airports)	Cox's Bazar Airport; Khan Jahan Ali Airport, Bagerhat; Osmani International Airport, Sylhet	**Hazards:** Coastal and riverine flooding **Considerations** • Cox's Bazar Airport is vulnerable to both coastal and riverine flooding, with estimated damages from historical 50-year flood events amounting to €0.11 million. • Khan Jahan Ali Airport in Bagerhat is exposed to coastal flooding, with estimated damages from historical 50-year flood events at €0.07 million. • Osmani International Airport in Sylhet is at risk of riverine flooding, with estimated damages from a historical 50-year flood event totalling €0.01 million.
Transport (Railway lines)	Chattogram, Gopalganj, Khulna, Faridpur, Bogra, Feni, Maulvibazar, Tangail, Rajbari, and Gaibandha districts	**Hazards:** Coastal and riverine flooding **Considerations** • Regarding railway lines, these are the top 10 districts most highly exposed to coastal and/or riverine flooding. • For historical 50-year riverine and coastal flood events, the estimated damage to railway lines is €5.68 million.
Transport (Railway stations)	Chattogram, Khulna, Bagerhat, Bogra, Feni, Gaibandha, Gopalganj, Faridpur, Jamalpur, and Chuadanga districts	**Hazards:** Coastal and riverine flooding **Considerations** • In terms of railway stations, these are the top 10 districts most highly exposed to coastal and/or riverine flooding.

		• For historical 50-year riverine and coastal flood events, the estimated damage to railway stations is €0.46 million.
Transport (Inland water transport terminals)	Barisal, Bhola, Chattogram, Cox's Bazar, Khulna, Madaripur, Munshiganj, Noakhali, Patuakhali, and Pirojpur districts	**Hazards:** Coastal and riverine flooding **Considerations** • Regarding inland water transport terminals, these are the top 10 districts most highly exposed to coastal and/or riverine flooding. • For historical 50-year riverine and coastal flood events, the estimated damage to inland water transport terminals is €1.90 million.
Energy (Power plants)	Raozan and Patiya Upazila	**Hazards:** Primary hazard – Cyclone **Other hazards:** riverine flooding and coastal flooding **Considerations** • Raozan and Patiya Upazilas host several power plants that are vulnerable to cyclonic winds, riverine flooding, and coastal flooding. • In particular, the Rural Power Company Limited (RPCL) – Raozan 25 MW Dual Fuel Power Plant and the Shikalbaha 150 MW Peaking Power Plant are highly exposed to multiple hazards. • For historical 50-year cyclone, riverine, and coastal flood events, the estimated damage to power plant infrastructure in these two Upazilas is €7.73 million.
Energy (Electricity substations)	Substations in Chattogram and Cox's Bazar districts	**Hazards:** Primary hazard – Cyclone **Other hazards:** riverine flooding and coastal flooding **Considerations** • Substations located in 10 Upazilas within the Chattogram and Cox's Bazar districts are highly vulnerable to cyclonic winds, riverine flooding, and coastal flooding. • For historical 50-year cyclone, riverine, and coastal flood events, the estimated damage to power plant infrastructure in these two districts is €0.21 million.
Energy (Electricity grids)	Chattogram, Cox's Bazar, and Bhola districts	**Hazards:** Cyclone **Considerations** • Electricity grids located in 29 Upazilas across the Chattogram, Cox's Bazar, and Bhola districts are highly vulnerable to cyclonic winds. • For a historical 50-year cyclone event, the estimated damage to electricity grids in these three districts is €1.40 million.
Energy (Gas field)	Bhola North-1 Gas Field Shahbazpur Gas Field (Bhola district)	**Hazards:** Coastal and riverine flooding **Considerations** • Gas fields in Bhola district are vulnerable to coastal flooding.

	Bibiyana gas field (Habiganj district)	• For a historical 50-year coastal flood event, the estimated damage to gas fields in Bhola district is €0.03 million. • The Bibiyana gas field in Habiganj district is exposed to riverine flooding. • For a historical 50-year riverine flood event, the estimated damage to the Bibiyana gas field is also €0.03 million.
Energy (Gas pipeline)	Satkhira, Khulna, Pirojpur, Patuakhali, Barisal, Madaripur, Gopalganj, Munshiganj, and Brahamanbaria districts.	Hazards: Coastal and riverine flooding Considerations • Gas pipelines in the southwestern, south-central, and central districts of Bangladesh are vulnerable to coastal and riverine flooding. • Specifically, gas pipelines in 49 Upazilas across these nine districts are highly exposed. • For historical 50-year riverine and coastal flood events, the estimated damage to gas pipelines in the selected nine districts is €1.18 million.
Water (Water supply network)	Dhaka city corporation	Hazards: Riverine flooding Considerations • The water supply network in Dhaka is vulnerable to riverine flooding. • For a historical 50-year riverine flood event, the estimated damage to the water supply network in Dhaka is €0.11 million.
Water (Water treatment plant)	Saidabad Water Treatment Plant	Hazards: Riverine flooding Considerations • The Saidabad water treatment plant is vulnerable to potential extreme future riverine flooding. • For a future 100-year riverine flood event in 2050, the estimated damage to this water treatment plant is projected to be €0.49 million.
Critical infrastructure (Healthcare facilities)	Khulna, Chattogram, Gopalganj, Satkhira, Pirojpur, Patuakhali, Bagerhat, Barisal, Jhalokati, and Barguna districts	Hazards: Coastal and riverine flooding Considerations • Regarding healthcare facilities, these are the top 10 districts most highly exposed to coastal and/or riverine flooding. • For historical 50-year riverine and coastal flood events, the estimated damage to healthcare facilities is €0.35 million.
Critical infrastructure (Market centres)	Khulna, Chattogram, Patuakhali, Satkhira. Bagerhat, Barisal, Pirojpur, Sunamganj, Barguna, and	Hazards: Coastal and riverine flooding Considerations • Regarding market centres, these are the top 10 districts most highly exposed to coastal and/or riverine flooding.

	Kishoreganj districts	• For historical 50-year riverine and coastal flood events, the estimated damage to market centres is €14.43 million.
Critical infrastructure (Education institutions)	Khulna, Chattogram, Bagerhat, Satkhira, Patuakhali, Pirojpur, Sunamganj, Barisal, Barguna, and Gopalganj districts	Hazards: Coastal and riverine flooding Considerations • Regarding educational institutions, these are the top 10 districts most highly exposed to coastal and/or riverine flooding. • For historical 50-year riverine and coastal flood events, the estimated damage to educational institutions is €3.77 million.
Critical infrastructure (Cyclone shelters)	19 coastal districts	Hazards: Coastal flooding Considerations • Although cyclone shelters were built to protect people during cyclone events, these structures are vulnerable to damage from coastal flooding. • For a historical 50-year coastal flood event, the estimated economic loss to cyclone shelters is €0.67 million.

6.2 Development of a Roadmap of Investment Projects

In an era marked by escalating climate-related challenges, the development of resilient and adaptable infrastructure is more than just a necessity; it is imperative for ensuring the safety and sustainability of our communities. This document presents a carefully crafted roadmap of projects that aim to bolster resilience and mitigate the risks presented by climate hazards.

The roadmap is structured around a diverse range of adaptation options, each tailored to meet specific needs and circumstances. Traditional built environment projects play a crucial role, focusing on investments in man-made barriers, fortifications, elevation of assets, and relocation of vulnerable facilities. These projects also encompass necessary retrofits and upgrades to existing structures, as well as the construction of new ones designed to withstand environmental pressures.

Complementing these traditional approaches are nature-based solutions, which harness the power of natural ecosystems to provide protection. These initiatives prioritize the restoration and enhancement of natural infrastructure systems—such as coastal mangroves and coral reefs—surrounding critical assets. Additionally, by implementing catchment-level interventions like afforestation and river restoration, these solutions work to reduce climate hazard risks across broader geographical areas, ultimately safeguarding a wider array of infrastructure and natural resources while yielding valuable social and economic co-benefits.

Urban resilience projects form another key component of this roadmap. These initiatives may combine built and nature-based approaches to effectively tackle citywide challenges such as flooding, extreme heat, and other climate-related hazards. By focusing on a variety of urban assets—including roads, buildings, and public spaces—these projects aim to enhance the overall resilience of urban environments.

A vital aspect of achieving success in these efforts lies in building an enabling environment. Initiatives within this category focus on enhancing institutional and technical capacities that are essential for the effective planning and implementation of both built and natural infrastructure projects. This foundational support is crucial for ensuring that projects can have a far-reaching impact across various sectors and regions.

Furthermore, every project within this roadmap is underscored by a commitment to gender equality and inclusivity. Recognizing the unique challenges faced by vulnerable groups, we ensure that considerations of gender and inclusivity are integrated at every stage of the infrastructure lifecycle. By doing so, we aim to foster equitable access and participation, empowering all community members to be part of the solution.

Together, these interconnected elements form a robust vision for strengthening community resilience in the face of an uncertain climate future, ensuring that we not only withstand the challenges ahead but also thrive in a sustainable manner.

Table 1: Description of adaptation options proposed within the roadmap

Project type	Description
Traditional built environment projects	These include investments in man-made barriers, fortification, elevation, or relocation of assets, facility retrofits and upgrades, new structures, or the like.
Nature-based solutions	These focus on protecting, restoring, or enhancing natural infrastructure systems, such as coastal mangroves or reefs, around a particular asset. They also include catchment-level interventions (e.g. afforestation and river restoration) that reduce climate hazard risk more broadly around a watershed or geographical area, resulting in protection of a wider range of assets (i.e. an infrastructure system), including the natural infrastructure assets themselves. Nature-based solutions may have a wide range of social or economic co-benefits, which are described qualitatively throughout the project concepts.
Urban resilience projects	These are built, nature-based, or a combination of both, and target citywide resilience to flooding, heat, or other climate hazards, with impacts across a range of urban assets including roads and buildings
Enabling environment	These aim to build institutional and technical capacity that can support the successful planning and implementation of built and natural infrastructure projects, and may have broader impacts across all sectors.
Gender and inclusivity projects	All projects in this roadmap have considerations around gender and inclusivity of other vulnerable groups, which should be mainstreamed at all stages of the infrastructure lifecycle.

SOURCE: (ADSHEAD ET AL., 2022)[1]

[1] Adshead, D., Thacker, S., Fuldauer, L.I., Gall, S.S., Chow, N., Pant, R., Russell, T., Bajpai, A., Morgan, G., Bhikhoo, N., Boroto, D., Palmer, R., Cançado, D., Jain, N., Klöttschen, V., Lawal, H., Dery, P., Twum, E., Mohammed, G., Hall, J.W., and Agbesi, L. 2022. Ghana: Roadmap for resilient infrastructure in a changing climate. Ministry of Environment, Science, Technology & Innovation, Accra, Ghana.

6.3 Prioritized Portfolio of Investment Projects for the Resilient Infrastructure Roadmap

As the effects of climate change and rapid urbanization become increasingly pronounced, the urgency for establishing resilient infrastructure cannot be overstated. Communities across the globe are faced with unprecedented challenges, ranging from rising sea levels and extreme weather events to the pressures of accommodating expanding populations and urban sprawl. In light of these escalating threats, the need for infrastructure systems that can withstand and adapt to such changes is more critical than ever.

This section outlines a comprehensive, prioritized portfolio of investment projects designed to enhance the resilience of infrastructure across various sectors. The focus is placed on formulating adaptive strategies that not only address existing vulnerabilities but also proactively anticipate future risks, ensuring that these systems remain functional and effective under adverse conditions.

The roadmap presented herein spans several key sectors, including transport, energy, water, and critical social infrastructure. Each sector has been methodically assessed to identify its specific challenges and opportunities for adaptation. The proposed adaptation options encompass a diverse range of strategies, including traditional built environments—such as reinforced structures and upgraded facilities—, innovative nature-based solutions that leverage natural processes for mitigation and adaptation, and enabling environments that create the necessary policy, regulatory, and financial frameworks to support these initiatives.

In the transport sector, for instance, projects include enhancing port infrastructure, upgrading roads, and improving railway systems to ensure they can endure climate impacts while also facilitating urban resilience. Similarly, in the energy sector, adaptation measures focus on integrating nature-based solutions into power generation and transmission systems to increase their robustness and reliability.

Furthermore, this initiative prioritizes the enhancement of critical social infrastructure, such as healthcare facilities and educational institutions, recognizing their vital role in community stability and well-being. By investing in adaptable and resilient public services, the framework aims to safeguard communities during extreme weather events, thereby ensuring public safety and continuity of essential services.

Added to these sector-specific projects, the plan also emphasizes cross-sectoral collaboration, fostering integrated planning that encourages synergies between various domains. This approach not only enhances the resilience of individual sectors but also reinforces overall urban resilience, creating a more cohesive and fortified infrastructure system that can better withstand and recover from unforeseen challenges.

Ultimately, by strategically investing in these proposed projects, communities can build a more resilient future—one that is equipped to handle the uncertainties of a changing climate while simultaneously supporting economic vitality and promoting sustainable development practices. Through these efforts, we can create infrastructure that not only survives threats but thrives in the face of adversity, securing a safer and more prosperous future for all.

Table 2: Summary of sector-wise adaptation options

Sector	Sub-sector	Project codes	Adaptation option types
Transport	Port	1.1	Traditional built environment and Enabling environment
	Roads	1.2	Urban resilience projects
		1.3	Traditional built environment projects
		1.4	Nature-Based Solutions
	Airports	1.5	Traditional built environment and Enabling environment
	Railway lines	1.6	Traditional built environment
	Railway stations	1.7	Traditional built environment; nature-based solutions

	Inland water transport terminals	1.8	Traditional built environment
Energy	Power plants	2.1	Nature-based solutions
	Electricity substations	2.2	Traditional built environment
	Electricity grids	2.3	Traditional built environment
	Gas field	2.4	Traditional built environment; enabling environment
	Gas pipeline	2.5	Traditional built environment; enabling environment
Water	Water supply network	3.1	Traditional built environment
	Water treatment plant	3.2	Traditional built environment
	Water supply	3.3	Traditional built environment; nature-based solutions
	Water supply	3.4	Enabling environment
Critical social infrastructure	Healthcare facilities	4.1	Enabling environment
		4.2	Traditional built environment; enabling environment
	Market centres	4.3	Traditional built environment; nature-based solutions
		4.4	Nature-based solutions
	Education institutions	4.5	Urban resilience projects
		4.6	Enabling environment
	Cyclone shelters	4.7	Traditional built environment
		4.8	Enabling environment
Cross-sectoral projects	All sub-sectors	5.1	Urban resilience projects
	Roads and all sub-sectors of critical infrastructure	5.2	Traditional built environment
	Roads and all sub-sectors of critical infrastructure	5.3	Traditional built environment
	All sub-sectors	5.4	Traditional built environment
	Roads and water sources	5.5	Nature-based solutions
	All sub-sectors	5.6	Urban resilience projects
	All sub-sectors	5.7	Enabling environment
	All sub-sectors	5.8	Enabling environment
	All sub-sectors	5.9	Enabling environment
	All sub-sectors	5.10	Traditional built environment; nature-based solutions

6.3.1 Transport Sector

6.3.1.1 IMPROVING PORT RESILIENCE TO CYCLONE WIND EFFECTS

Sectors:	Transport
Subsectors:	Ports
Locations:	Chattogram; Khulna; Barisal; Narayanganj; Patuakhali; Sirajganj
Adaptation option type:	Traditional built environment and Enabling environment
Objective	• Enhance the structural resilience of ports to withstand cyclone wind effects. • Minimize economic and operational disruptions caused by extreme weather events. • Improve emergency preparedness and response capabilities at ports. • Integrate nature-based solutions (NbS) to enhance long-term resilience. • Ensure inclusive and gender-responsive resilience measures. • Align the project outcomes with Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).
Expected outputs and impacts	• Reduction in cyclone-induced disruptions • Lower infrastructure maintenance costs • Increased trade and economic stability • Improved emergency preparedness • Enhanced ecological benefits from NbS
Gender considerations	• Actively involve women and marginalized groups in planning and decision-making processes related to port resilience. • Develop evacuation and sheltering plans that address the specific needs of women, children, the elderly, and persons with disabilities. • Promote local workforce capacity-building programs to enhance community participation in resilience planning. • Implement gender-sensitive emergency response measures to ensure equitable access to relief and recovery resources.
Potential SDG targets influenced	9, 11, 13
Linkage to NAP projects	Protection and management of potentially vulnerable areas due to tropical cyclone, sea-level rise, extreme storm surges and flooding

CONCEPT NOTES ON ENERGY SECTOR INFRASTRUCTURE DEVELOPMENT

6.3.1.2 BUILDING URBAN TRANSPORT RESILIENCE IN COASTAL DISTRICTS THROUGH CLIMATE-RESPONSIVE INFRASTRUCTURE DESIGN AND INTEGRATED PLANNING

Sectors:	Transport
Subsectors:	Road
Locations:	Chattogram, Khulna, Barisal; Satkhira, Bagerhat, Patuakhali; Noakhali, Bhola, Barguna; Cox's Bazar, Laxmipur, Feni; Patuakhali
Adaptation option type:	Urban resilience projects
Objective	• Implement climate-resilient infrastructure design in urban transport systems vulnerable to flooding and climate shocks. • Reduce economic losses and disruptions through strengthened transport functionality and reliability. • Promote integrated land-use and transport planning responsive to climate scenarios. • Ensure inclusive, gender-equitable, and locally relevant transport infrastructure development. • Align project outcomes with SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).
Expected outputs and impacts	• Improved resilience of urban roads • Decreased maintenance and repair costs • Economic revitalization • Reduced transport disruptions • Climate-adapted planning practices
Gender considerations	• Inclusive Planning: Actively involving women, youth, the elderly, and persons with disabilities in transport planning and feedback mechanisms. • Employment Opportunities: Promoting gender-equitable hiring practices in road construction, maintenance, and drainage system management. • Safety and Accessibility: Designing sidewalks, intersections, and public transport stops that are safe and accessible for all user groups, including lighting and signage improvements. • Community-Led Maintenance: Creating local maintenance teams, particularly involving women, to oversee neighborhood-level upkeep and drainage clearing.
Potential SDG targets influenced	9, 11, 13

Linkage to NAP projects	CDM12 - Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.1.3 Strengthening road infrastructure through traditional engineering solutions in the most vulnerable coastal upazilas

Sectors: Transport

Subsectors: Road

Locations: Shyamnagar (Satkhira); Patuakhali Sadar; Kalapara (Patuakhali); Hatiya (Noakhali)

Adaptation option type: Traditional built environment projects

Objective

- Enhance the structural resilience of critical road infrastructure to withstand cyclones, tidal surges, and floods.
- Minimize economic and operational disruptions caused by road damage and closures in extreme weather conditions.
- Improve emergency evacuation and response capacity by maintaining all-weather, safe road access routes.
- Ensure community-focused, inclusive, and gender-responsive resilience measures for road users and residents.
- Align the project's outcomes with Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).

Expected outputs and impacts

- Reduction in road disruptions and flooding
- Lower infrastructure maintenance costs
- Increased economic and social stability
- Improved evacuation and disaster response
- Enhanced safety and resilience of roads

Gender considerations

- Actively involving women's groups and vulnerable households in community consultations and resilience planning.
- Creating targeted employment and skill-building opportunities for women in road maintenance, construction, and awareness programs.
- Designing roads with gender-sensitive features, such as safe waiting areas, lighting, and easy access to emergency shelters.
- Developing evacuation and emergency service plans that consider the specific needs of women, children, elderly, and persons with disabilities.

Potential SDG targets influenced: 5, 9, 11, 13

Linkage to NAP projects	CDM12 - Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.1.4 Flood-Proofing Coastal Road Infrastructure Using Nature-Based Solutions

Sectors:	Transport
Subsectors:	Road
Locations:	Shyamnagar (Satkhira), Kalapara (Patuakhali), Hatiya (Noakhali), Faridpur, Koyra (Khulna)
Adaptation option type:	Nature-Based Solutions
Objective	• Reduce road flooding through natural water retention, drainage, and barrier systems. • Restore and conserve coastal ecosystems that mitigate flood intensity and protect roads. • Enhance long-term climate resilience using cost-effective, low-carbon solutions. • Promote community stewardship and gender-inclusive participation in ecosystem-based road maintenance. • Align with SDG 9 (Infrastructure), SDG 13 (Climate Action), and SDG 15 (Life on Land).
Expected outputs and impacts	• Reduced flood damage to road assets • Enhanced biodiversity and green cover • Lower maintenance and repair costs • Community resilience and awareness • Contribution to NDC and SDG targets
Gender considerations	• Community Planting Programs: Women's groups and youth clubs will be engaged in roadside greening and mangrove reforestation. • Eco-guard Training for Vulnerable Groups: Skill-building in ecosystem monitoring, nursery management, and eco-tourism services. • Gender-Sensitive Access Design: Roads will include safe waiting spaces, shade, and gender-aware signage for cyclone response. • Participatory Planning Platforms: Inclusive decision-making through union-level committees representing women and marginalized groups.
Potential SDG targets influenced	5, 9, 11, 13, 14
Linkage to NAP projects	WRM7 - Construction and rehabilitation of flood and drainage management measures with eco-engineering solutions

6.3.1.5 Enhancing flood resilience for airport infrastructure

Sectors:	Transport
Subsectors:	Airport
Locations:	Cox's Bazar Airport, Khan Jahan Ali Airport (Bagerhat), Osmani International Airport (Sylhet)
Adaptation option type:	Traditional built environment and Enabling environment
Objective	• Strengthen the physical and operational resilience of airports to extreme rainfall and flood events. • Ensure continuity of critical airport functions during and after floods. • Minimize economic losses and disruptions to aviation services. • Enhance safety for passengers, staff, and surrounding communities. • Incorporate inclusive and gender-responsive resilience strategies. • Align project outcomes with SDG 9 (Infrastructure), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action)
Expected outputs and impacts	• Improved airport functionality during floods • Reduced economic losses from disruptions • Increased safety for all users
Gender considerations	• Ensure evacuation plans address the needs of women, children, the elderly, and persons with disabilities. • Promote gender-inclusive employment in the design, implementation, and monitoring of flood resilience activities. • Engage local communities, especially women's groups, in awareness and preparedness training.
Potential SDG targets influenced	9, 11, 13
Linkage to NAP projects	Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.1.6 Flood-proofing railway infrastructure in flood-prone areas

Sectors:	Transport
Subsectors:	Railway lines
Locations:	Gaibandha, Khulna, Chattogram, Faridpur, Tangail, Bogur, Jamalpur, Feni, Maulvibazar, Gopalganj, Rajbari
Adaptation option type:	Traditional built environment
Objective	• Enhance the structural integrity of railway infrastructure to withstand severe flood events. • Reduce service disruptions and accidents caused by water damage and inundation. • Improve drainage and flood management systems in railway corridors. • Integrate climate-resilient design and materials in railway construction and maintenance. • Align with national climate adaptation priorities and Sustainable Development Goals (SDGs) 9 (Industry, Innovation, and Infrastructure), 11 (Sustainable Cities and Communities), and 13 (Climate Action).
Expected outputs and impacts	• Reduced Economic Losses • Enhanced Infrastructure Resilience • Improved Passenger Safety • Strengthened Connectivity and Equity • Support for Climate Adaptation Goals
Gender considerations	• Reliable and safe railway services during and after flood events are essential for women, as they support mobility, access to essential services, and economic empowerment. • Ensuring continued railway functionality during floods will reduce disruption to women's livelihoods, particularly for those engaged in informal work, caregiving, and market access • The project will actively involve women in the planning, construction, management, and maintenance phases, with targeted skills training and employment opportunities
Potential SDG targets influenced	9, 11, 13
Linkage to NAP projects	Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.1.7 Enhancing railway station resilience to flooding using integrated adaptation approaches

Sectors:	Transport
Subsectors:	Railway stations
Locations:	Chattogram, Khulna, Bagerhat, Bogra, Feni, Gaibandha, Gopalganj, Faridpur, Jamalpur, and Chuadanga
Adaptation option type:	Traditional built environment; nature-based solutions
Objective	• Elevate critical railway station infrastructure above flood levels to prevent disruption. • Integrate structural and ecological flood management solutions. • Minimize operational losses and physical damage from flood events. • Improve passenger and worker safety during flooding. • Promote green infrastructure for flood mitigation and environmental benefits. • Align interventions with SDGs 9 (Industry, Innovation and Infrastructure), 11 (Sustainable Cities and Communities), and 13 (Climate Action).
Expected outputs and impacts	• Use of corrosion-resistant materials • Enhanced station operability during floods • Reduced infrastructure repair costs • Improved ecosystem health • Increased passenger safety
Gender considerations	• Reliable and safe railway services during and after flood events are essential for women, supporting mobility, caregiving, and economic activities. • The project will actively involve women in planning, construction, management, and maintenance phases, offering targeted skills training and employment. • Ensuring consistent station access during floods will help mitigate the disproportionate impact on women and marginalized groups. • Evacuation and emergency procedures will include gender-sensitive provisions such as safe spaces and targeted communication.
Potential SDG targets influenced	9, 11, 13
Linkage to NAP projects	Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.1.8 Flood-proofing inland water transport terminals using traditional engineering solutions

Sectors:	Transport
Subsectors:	Inland water transport terminals
Locations:	Chattogram, Khulna, Barishal, Patuakhali, Bagerhat, Bogra, Feni, Gaibandha, Gopalganj, Faridpur, Jamalpur, Chuadanga
Adaptation option type:	Traditional built environment
Objective	• Enhance the structural resilience of inland water transport terminals to withstand floods, storm surges, and rising water levels. • Minimize operational disruptions and ensure continuous functionality of terminals during extreme weather events. • Improve safety and accessibility for passengers, particularly women, children, and vulnerable groups, during flood events. • Reduce economic losses caused by infrastructure damage, transport delays, and cargo losses. • Align project outcomes with Sustainable Development Goals (SDGs) 5 (Gender Equality), 9 (Industry, Innovation, and Infrastructure), 11 (Sustainable Cities and Communities), and 13 (Climate Action).
Expected outputs and impacts	• Reduced terminal disruptions • Lower infrastructure maintenance costs • Increased safety for vulnerable groups • Improved economic stability • Enhanced climate resilience
Gender considerations	• Engage women's groups in planning and implementation to ensure their needs are met. • Create employment opportunities for women in terminal maintenance and awareness programs. • Design terminals with gender-sensitive features, such as safe waiting areas and lighting. • Develop emergency plans that consider the needs of women, children, elderly, and persons with disabilities.
Potential SDG targets influenced	5, 9, 11, 13
Linkage to NAP projects	Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.2 Energy Sector

6.3.2.1 ENHANCING ENERGY SECTOR RESILIENCE THROUGH THE PROMOTION OF RENEWABLE ENERGY SOURCES

Sectors:	Energy
Subsectors:	Powerplants
Locations:	Raozan; Patiya
Adaptation option type:	Nature-based solutions
Objective	• Promote energy diversification through decentralized renewable energy systems such as solar, wind, and mini-hydro. • Reduce reliance on centralized power generation and mitigate the risks associated with grid failure during disasters. • Enhance the climate resilience of essential services (healthcare, communications, water, and sanitation) through stable power supply. • Generate local employment and entrepreneurship opportunities in renewable energy deployment and maintenance. • Align with SDGs, specifically SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), and SDG 13 (Climate Action).
Expected outputs and impacts	• Reduced grid dependency and energy loss • Continuous operation of critical facilities • Decreased emissions and fossil fuel dependency • Enhanced community resilience and autonomy • Economic growth and rural electrification
Gender considerations	• Community-Based Planning: Actively involve women in energy access planning, site selection, and oversight committees. • Job Creation and Training: Provide technical and non-technical training to women and youth on renewable energy installation, repair, and management. • Improved Access for Women: Ensure power supply to public toilets, maternal health services, and night-time lighting in public spaces for enhanced safety and dignity. • Ownership and Benefit-Sharing: Design local solar cooperatives or user associations where women can participate in governance and benefit-sharing models.
Potential SDG targets influenced	7, 9, 13
Linkage to NAP projects	Productive use of renewable energy (PURE) phase I

6.3.2.2 SAFEGUARDING VULNERABLE SUBSTATIONS FROM CYCLONE AND MULTIPLE TYPES OF FLOODING

Sectors:	Energy
Subsectors:	Electricity substations
Locations:	Chattogram; Cox's Bazar; Sylhet
Adaptation option type:	Traditional built environment
Objective	• Strengthen structural and operational resilience of substations to cyclonic wind and flood impacts. • Reduce risk of service disruptions and safeguard personnel during extreme weather events. • Minimize damage to critical energy infrastructure through physical protection and smart planning. • Contribute to SDGs 7 (Clean Energy), 9 (Infrastructure), 10 (Reduced Inequalities), 11 (Sustainable Cities), and 13 (Climate Action).
Expected outputs and impacts	• Reliability of Power Supply • Safety for Workers and Equipment • Economic Efficiency
Gender considerations	• Inclusive Planning: Conduct gender-sensitive stakeholder engagement and community consultations to integrate diverse perspectives. • Employment Equity: Promote equal access for men and women in substation upgrade, maintenance, and monitoring programs. • Community Outreach: Develop education campaigns that address the specific safety needs of different genders during electrical emergencies and disasters. • Gender-Specific Monitoring: Implement evaluation tools that track how resilience interventions impact women, men, and marginalized groups differently.
Potential SDG targets influenced	7, 9, 10, 11, 13
Linkage to NAP projects	Protection and management of potentially vulnerable areas due to tropical cyclone, sea-level rise, extreme storm surges and flooding

6.3.2.3 STRENGTHENING ELECTRIC GRIDS AGAINST CYCLONIC WIND IMPACTS

Sectors:	Energy
Subsectors:	Electricity grids
Locations:	Chattogram; Cox's Bazar; Bhola; Feni; Noakhali; Lakshmipur
Adaptation option type:	Traditional built environment
Objective	• Enhance the physical and operational resilience of electric grid infrastructure to cyclonic wind events. • Reduce the frequency, duration, and impact of power outages caused by storm-related infrastructure failure. • Minimize risks to public safety by preventing electrical hazards during and after cyclones. • Support uninterrupted delivery of essential services such as healthcare and emergency response. • Contribute to the achievement of SDGs 7, 9, 11, and 13 by improving infrastructure, energy access, and climate resilience.
Expected outputs and impacts	• Grid Resilience • Public Safety • Economic Stability • Essential Services Continuity
Gender considerations	• Inclusive Engagement: Ensure participation of women and marginalized groups in consultations and planning of grid improvements. • Job Creation: Promote equitable employment in the construction, maintenance, and monitoring of resilient electric grids. • Community Awareness: Design public safety campaigns tailored to gender and age-specific needs on cyclone preparedness and electrical safety.
Potential SDG targets influenced	7, 9, 11, 13
Linkage to NAP projects	Extension of resilient and eco-friendly materials engaging private sectors through incentives and tax rebates for climate-resilient infrastructures development in urban areas

6.3.2.4 INCREASING FLOOD RESILIENCE OF GAS FIELDS

Sectors:	Energy
Subsectors:	Gas fields
Locations:	Bhola North-1 & Shahbazpur (Bhola district); Bibiyana (Habiganj district)
Adaptation option type:	Traditional built environment; enabling environment
Objective	• Strengthen critical gas field infrastructure to withstand and recover from flood events. • Minimize interruptions to gas production and processing, safeguarding energy reliability and economic resilience. • Enhance the safety of workers and surrounding communities by mitigating flood-related hazards. • Integrate early warning systems and flood-proof engineering in national energy planning. • Clearly identify and benefit public utilities, dependent industries, and surrounding communities, enabling transparent cost-benefit analysis. • Ensure alignment with SDGs 9, 11, and 13, and explore framing the project under critical infrastructure adaptation rather than energy expansion.
Expected outputs and impacts	• Infrastructure Resilience • Operational Continuity • Workplace and Community Safety • Energy Security
Gender considerations	• Inclusive Planning: Engage women and marginalized groups in the design and implementation of gas field resilience projects. • Community Representation: Ensure affected communities are consulted through participatory workshops and focus groups. • Safety Education: Promote awareness campaigns targeting all genders on safe practices during flood-triggered gas emergencies.
Potential SDG targets influenced	7, 9, 11, 13
Linkage to NAP projects	Protection and management of potentially vulnerable areas due to tropical cyclone, sea-level rise, extreme storm surges and flooding

6.3.2.5 PROTECTING GAS PIPELINES FROM COASTAL AND RIVERINE FLOODING

Sectors:	Energy
Subsectors:	Gas lines
Locations:	Satkhira, Khulna Patuakhali, Barisal Madaripur, Gopalganj Munshiganj, Brahmanbaria Feni
Adaptation option type:	Traditional built environment; enabling environment
Objective	• Improve structural protection of gas pipelines through climate-resilient design and engineering upgrades. • Minimize the risk of gas leaks and system failures during coastal and riverine floods. • Protect ecosystems and public health by reducing the risk of environmental contamination from damaged pipelines. • Ensure continuous transmission and distribution of gas during and after flooding events. • Align interventions with national adaptation priorities and contribute to relevant SDG targets (SDG 7, 9, 11, and 13). • Integrate pipeline protection planning into the national energy transition roadmap, supporting resilience while enabling future shifts toward cleaner energy sources such as distributed solar systems and low-carbon technologies.
Expected outputs and impacts	• Resilience of Gas Pipelines • Environmental and Public Health • Economic Stability • Disaster Response
Gender considerations	• Inclusive Participation: Ensure meaningful involvement of women and vulnerable community members in planning and consultations related to pipeline safety and emergency planning. • Employment Equality: Promote gender-balanced job opportunities in inspection, construction, and maintenance roles tied to pipeline resilience upgrades. • Public Awareness: Engage both men and women in awareness programs on pipeline safety during floods, with tailored messaging to meet diverse needs.
Potential SDG targets influenced	7, 9, 11, 13
Linkage to NAP projects	Protection and management of potentially vulnerable areas due to tropical cyclone, sea-level rise, extreme storm surges and flooding

6.3.3 Water Sector

6.3.3.1 FLOOD RESILIENCE FOR WATER SUPPLY NETWORKS: PROTECTING CRITICAL INFRASTRUCTURE FROM FLOOD EVENTS

Sectors:	Water
Subsectors:	Water supply network
Locations:	Dhaka City Corporation
Adaptation option type:	Traditional Built Environment Projects
Objective	• Reinforce water supply infrastructure to prevent floodwater intrusion, physical damage, and contamination. • Ensure uninterrupted access to safe drinking water during and after flood events. • Minimize repair and maintenance costs and avoid service downtime through proactive flood-proofing measures. • Improve real-time disaster response capabilities using digital monitoring tools for early flood alerts. • Contribute to Bangladesh's National Adaptation Plan and global SDGs (particularly SDG 6, 9, 11, and 13).
Expected outputs and impacts	• Uninterrupted Water Access • Public Health Protection • Cost Savings • Community Resilience
Gender considerations	• Health and Time Burden Reduction: Ensuring consistent water supply reduces time women spend searching for safe water during floods, improving family health. • Protection for Vulnerable Groups: Women, children, and the elderly are disproportionately affected by contaminated water; flood-resilient infrastructure protects their well-being. • Inclusive Participation: Women's involvement will be encouraged in planning, monitoring, and awareness campaigns related to resilient water infrastructure
Potential SDG targets influenced	6, 9, 11, 13
Linkage to NAP projects	Management of freshwater resources and monitoring of salinity for reducing vulnerabilities in existing and potential salinity-prone areas

6.3.3.2 ENHANCING RESILIENCE OF WATER TREATMENT PLANTS TO FLOODING

Sectors:	Water
Subsectors:	Water treatment plant
Locations:	Saidabad Water Treatment Plant
Adaptation option type:	Traditional Built Environment Projects
Objective	• Strengthen the physical resilience of the Saidabad Water Treatment Plant to withstand extreme flood events. • Minimize operational disruptions and safeguard continuous access to clean and safe drinking water. • Reduce public health risks by ensuring uninterrupted water treatment and supply during and after floods. • Improve early warning, response capacity, and decision-making through real-time data and monitoring systems. • Align the intervention with national adaptation planning and key SDG targets including SDG 6 (Water), SDG 9 (Infrastructure), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action).
Expected outputs and impacts	• Operational Continuity • Health and Hygiene • Economic Stability • Infrastructure Longevity
Gender considerations	• Involving diverse community groups, especially women, in consultations regarding water supply and safety priorities. • Designing inclusive emergency communication systems and contingency plans. • Considering women's roles as primary water managers in households to reflect their specific needs and vulnerabilities.
Potential SDG targets influenced	6, 9, 11, 13
Linkage to NAP projects	Management of freshwater resources and monitoring of salinity for reducing vulnerabilities in existing and potential salinity-prone areas

6.3.3.3 ENSURING DRINKING WATER SECURITY AGAINST COASTAL FLOODING IN BANGLADESH

Sectors:	Water
Subsectors:	Water supply
Locations:	Satkhira, Khulna, Bagerhat Bhola, Barguna, Patuakhali Chattogram, Cox's Bazar, Barisal Noakhali, Feni, Laxmipur
Adaptation option type:	Traditional Built Environment Projects and Nature-Based Solutions
Objective	• Safeguard public health and livelihoods by ensuring continuous access to safe drinking water before, during, and after coastal flooding. • Strengthen institutional and community-based systems for managing climate-resilient drinking water infrastructure. • Promote inclusive, affordable, and gender-responsive drinking water solutions across flood-prone districts. • Integrate water security into national adaptation frameworks and disaster preparedness plans. • Contribute to SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action).
Expected outputs and impacts	• Safe drinking water accessible year-round • Strengthened local water governance • Reduced disruption during floods and disasters • Increased use of rainwater and alternative sources • Elevated and flood-safe water systems • Empowered community water management
Gender considerations	• Promote the active participation of women, especially those from marginalized and low-income households, in water management committees and emergency planning groups. • Design water collection systems with a focus on safety, accessibility, and dignity, especially for female-headed households. • Introduce skills-building and employment pathways for women in maintenance of drinking water facilities and hygiene education.
Potential SDG targets influenced	5, 6, 11, 13
Linkage to NAP projects	Management of freshwater resources and monitoring of salinity for reducing vulnerabilities in existing and potential salinity-prone areas

6.3.3.4 ENHANCING WATER SECURITY IN COASTAL REGIONS: BUILDING AN ENABLING ENVIRONMENT FOR CLIMATE-RESILIENT WATER RESOURCES MANAGEMENT

Sectors:	Water
Subsectors:	Water supply
Locations:	Satkhira, Khulna, Bagerhat Bhola, Barguna, Patuakhali Noakhali, Laxmipur, Feni Chattogram, Barisal, Cox's Bazar
Adaptation option type:	Enabling environment
Objective	• Strengthen institutional and regulatory frameworks to integrate water security into national and local adaptation strategies. • Improve community resilience to water scarcity caused by saline intrusion, drought, and extreme weather. • Promote inclusive and participatory water governance involving women and marginalized communities. • Enhance cross-sectoral coordination between water, agriculture, fisheries, and planning authorities. • Support the achievement of relevant SDGs, especially SDGs 5 (Gender Equality), 6 (Clean Water), 11 (Sustainable Cities), and 13 (Climate Action).
Expected outputs and impacts	• Coastal populations gain reliable access to safe drinking water during both regular and extreme conditions. • Strengthened institutional capacity and integration of water planning in development processes. • Improved community health, food security, and disaster resilience through stable water access. • Reduced water-related conflict and stronger collaboration between sectors. • More inclusive, transparent, and gender-sensitive water governance. • Reduced vulnerability to saline intrusion and drought
Gender considerations	• Actively involving women's groups in task forces and local water user committees. • Building leadership capacity among women for water system maintenance and emergency response. • Ensuring water facilities are safe, accessible, and inclusive for all users. • Addressing specific health and hygiene concerns for women in water access planning.
Potential SDG targets influenced	5, 6, 11, 13

Linkage to NAP projects	Management of freshwater resources and monitoring of salinity for reducing vulnerabilities in existing and potential salinity-prone areas

6.3.4 Critical social infrastructure

6.3.4.1 DEVELOPMENT OF CLIMATE-RESILIENT HEALTH CARE FACILITIES IN COASTAL DISTRICTS OF BANGLADESH

Sectors:	Critical social infrastructure
Subsectors:	Health
Locations:	Khulna, Satkhira, Bagerhat Chattogram Patuakhali, Barguna, Pirojpur Gopalganj, Barisal, Jhalokati Cumilla Noakhali Feni
Adaptation option type:	Enabling environment
Objective	• Enhance structural and operational resilience of health care facilities to withstand flooding, storms, and cyclones. • Ensure inclusive design of HCFs to accommodate the needs of women, children, the elderly, and persons with disabilities. • Improve emergency readiness of health care facilities during climate-induced disasters. • Build institutional capacity for climate-responsive health infrastructure planning and management. • Align project outcomes with national and international goals, including SDG 3 (Health), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).
Expected outputs and impacts	• Enhanced resilience of health services • Improved health outcomes • Inclusive and equitable care • Strengthened institutional capacity
Gender considerations	• Inclusive Participation: Engage women, youth, and persons with disabilities in planning and decision-making. • Design Adaptations: Include ramps, railings, gender-segregated WASH facilities, and private maternity care spaces. • Responsive Evacuation Planning: Ensure facilities and shelters are accessible to all, especially during emergencies. • SRHR Inclusion: Climate-resilient HCFs will provide dedicated SRHR service spaces and trained staff to deliver safe, inclusive, and confidential care—especially during emergencies when women's health risks increase significantly.

Potential SDG targets influenced	3, 11, 13
Linkage to NAP projects	CRC11 - Establishment of climate-resilient health care facilities in urban areas

6.3.4.2 MAKING HEALTHCARE FACILITIES RESILIENT TO CYCLONES AND COASTAL FLOODING

Sectors:	Critical social infrastructure
Subsectors:	Health
Locations:	Bagerhat, Khulna, Satkhira Barisal, Bhola, Patuakhali Pirojpur, Gopalganj
Adaptation option type:	Traditional built environment projects and enabling environment
Objective	• Ensure operational continuity of healthcare services during cyclones and floods. • Build and retrofit facilities to withstand high wind speeds and flood levels. • Protect critical utilities (electricity, water, medical gas) from damage. • Improve drainage and incorporate nature-based stormwater management. • Enhance emergency preparedness and response among health personnel. • Promote gender-sensitive, inclusive healthcare design.
Expected outputs and impacts	• Strengthened design and elevation of new and existing healthcare facilities • Backup power, water, and gas systems integrated with facility operations • Drainage improvements and green infrastructure surrounding hospitals • Emergency preparedness plans and staff trained in cyclone/flood protocols • Gender-sensitive infrastructure designed for universal access
Gender considerations	• Gender-Sensitive Facility Design: Ensure access to healthcare for women, children, elderly, and persons with disabilities through dedicated amenities and safe spaces. • Inclusive Participation: Engage women's groups and marginalized voices in facility planning and design consultations. • Universal Accessibility: Ensure ramps, private recovery zones, and safe waiting areas for vulnerable groups. • Community Engagement: Promote training of female health workers in emergency preparedness and patient support. • Ensure healthcare infrastructure and emergency response plans account for the mobility, sensory, and communication needs of persons with disabilities, including accessible restrooms, signage, and examination areas.
Potential SDG targets influenced	3, 9, 11, 13
Linkage to NAP projects	CRC11 - Establishment of climate-resilient health care facilities in urban areas

6.3.4.3 REDUCING DAMAGE TO MARKET CENTRES AGAINST COASTAL AND RIVERINE FLOODING

Sectors:	Critical social infrastructure
Subsectors:	Market Centre
Locations:	Khulna, Satkhira, Bagerhat, Barisal Chattogram, Patuakhali, Pirojpur Sunamganj, Barguna, Kishoreganj
Adaptation option type:	Traditional built environment projects and nature-based solutions
Objective	• Enhance flood resilience of market infrastructure in flood-prone districts. • Protect livelihoods and business continuity for vendors and traders during disasters. • Integrate green infrastructure and permeable surfaces to manage stormwater. • Establish emergency response and contingency systems tailored for markets. • Promote inclusive planning and insurance access for vulnerable market actors.
Expected outputs and impacts	• Elevated, flood-proof market structures • Structural upgrades and effective drainage installed • Weather forecasting systems and emergency response plans in place • Vendor-focused insurance and relocation mechanisms developed
Gender considerations	• Provide targeted support for female market vendors to access resources and post-flood recovery aid. • Engage women and marginalized groups in market infrastructure planning and emergency response design. • Ensure diverse representation in consultation and planning workshops. • Incorporate gender-sensitive infrastructure (lighting, secure stalls, toilets) into upgraded market centres.
Potential SDG targets influenced	1, 8, 9, 11, 13
Linkage to NAP projects	▪ CRC2 - Expansion and conservation of green and blue infrastructures for improvement of the urban environment and drainage system ▪ Drainage management of economic/industrial zones and critical infrastructure, and reinforced climate resilience through risk assessment

6.3.4.4 ENHANCING WETLAND CONSERVATION EFFORTS IN URBAN ENVIRONMENTS

Sectors:	Critical social infrastructure
Subsectors:	
Locations:	Dhaka Chattogram Khulna Rajshahi Sylhet
Adaptation option type:	Urban resilience projects
Objective	• Strengthen urban flood resilience by conserving natural drainage systems and wetlands. • Promote biodiversity and ecosystem services through wetland restoration. • Improve public awareness and community involvement in wetland conservation. • Integrate wetland protection into urban development policies and planning. • Enhance recreational and eco-tourism potential in urban settings.
Expected outputs and impacts	• Demarcation and zoning of protected urban wetlands • Restoration of degraded wetlands • Creation of walkways and green recreational zones • Awareness and education programs across communities
Gender considerations	• Inclusive Access: Ensure wetlands and adjacent recreational areas are accessible to women, children, elderly, and persons with disabilities. • Community Participation: Actively involve women and marginalized communities in wetland co-management and planning. • Livelihood Enhancement: Explore employment and entrepreneurship in wetland-based eco-tourism, waste management, and nursery development for women and youth.
Potential SDG targets influenced	6, 13, 15
Linkage to NAP projects	▪ CRC2 - Expansion and conservation of green and blue infrastructures for improvement of the urban environment and drainage system ▪ Drainage management of economic/industrial zones and critical infrastructure, and reinforced climate resilience through risk assessment

6.3.4.5 FLOOD-RESILIENT SCHOOLS: BUILDING A SAFER FUTURE FOR EDUCATION

Sectors:	Critical social infrastructure
Subsectors:	Educational institutions
Locations:	Khulna, Satkhira, Bagerhat Chattogram, Sunamganj Patuakhali, Barguna, Barisal Pirojpur, Gopalganj
Adaptation option type:	Urban resilience projects
Objective	• Improve structural resilience of schools in flood-prone areas • Ensure continuous access to safe and inclusive education during and after flood events • Establish emergency protocols and shelter functionality in school infrastructure • Integrate flood-resilient school development into national and local adaptation plans
Expected outputs and impacts	• Flood-resilient school infrastructure constructed or retrofitted • Safe sanitation facilities and raised pathways developed • Multi-use school-cum-shelter models designed and piloted • Drainage and water discharge systems installed around school premises • Solar-powered lighting and rainwater harvesting introduced in schools • Community-based school disaster preparedness committees activated • School facilities include primary healthcare rooms and supplies • Technical guidelines developed for resilient school design and retrofitting
Gender considerations	• Prioritize girls' safety through gender-segregated toilets and safe waiting zones • Ensure inclusive access for children with disabilities through ramps and raised paths • Involve mothers and women-led committees in school design and shelter protocols • Address safety and sanitation as part of resilience infrastructure investments • Promote girl-friendly shelters to reduce absenteeism during crisis events • Ensure that primary health services are accessible within school shelters, particularly for pregnant women, children, and people with chronic conditions, during flood-induced displacement.
Potential SDG targets influenced	4, 11, 9, 13

Linkage to NAP projects	Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.4.6 FLOOD-RESILIENT EDUCATIONAL INSTITUTIONS THROUGH STRENGTHENING THE ENABLING ENVIRONMENT

Sectors:	Critical social infrastructure
Subsectors:	Educational institutions
Locations:	Khulna, Satkhira, Bagerhat, Patuakhali, Barguna, Barisal Sunamganj, Gopalganj, Pirojpur Chattogram
Adaptation option type:	Enabling environment
Objective	• Develop and enforce institutional frameworks that integrate flood resilience into school planning and construction regulations. • Build the capacity of education authorities, facility managers, and school staff on flood preparedness, infrastructure maintenance, and risk response. • Promote inter-ministerial collaboration to enable integrated education and disaster resilience planning. • Strengthen school-community partnerships through local consultation and inclusive disaster response mechanisms. • Incorporate climate education and flood awareness into school curricula to promote a culture of preparedness.
Expected outputs and impacts	• Institutional frameworks for flood-resilient education planning • Trained education officials, school managers, and teachers • School-specific emergency protocols and drills • Revised curriculam incorporating flood and climate risks
Gender considerations	• Ensure women's representation in education planning committees, school management, and disaster response teams. • Address the safety and privacy needs of girls and women in flood shelters and school premises. • Engage female students, teachers, and parents in curriculum development and awareness campaigns. • Build leadership among women in the education sector to lead emergency preparedness efforts. • Promote inclusive consultations with children, minorities, and differently abled individuals to address diverse vulnerabilities.
Potential SDG targets influenced	4, 9, 11, 13
Linkage to NAP projects	Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.4.7 IMPROVING RESILIENCE TO CYCLONE SHELTERS

Sectors:	Critical social infrastructure
Subsectors:	Cyclone shelters
Locations:	Barguna, Patuakhali, Bhola Satkhira, Khulna, Bagerhat Chattogram, Cox's Bazar
Adaptation option type:	Traditional built environment projects
Objective	• Upgrade structural integrity of existing cyclone shelters to withstand high winds and storm surges. • Ensure continuous access to shelters through flood-resilient roads and walkways. • Improve utility services inside shelters, including water, sanitation, power, and lighting. • Promote inclusive shelter management practices that consider gender, age, and disability needs. • Strengthen local capacities for shelter maintenance, emergency operations, and coordination.
Expected outputs and impacts	• Structurally resilient cyclone shelters capable of withstanding high-intensity storms and tidal surges. • Flood-free access routes ensuring timely and safe evacuation for all residents. • Functional shelters with uninterrupted utility services during and after disasters. • Community-based shelter management and maintenance protocols established. • Reduced casualties and enhanced dignity and protection of women, children, and vulnerable groups during emergencies.
Gender considerations	• Ensure separate and secure spaces for women and girls within shelters. • Design and maintain women-friendly WASH facilities with menstrual hygiene support. • Train women as part of shelter management and emergency response teams. • Engage marginalized groups including persons with disabilities and elderly in shelter design consultations. • Promote leadership of local women's groups in disaster awareness and shelter coordination.
Potential SDG targets influenced	5, 11, 13
Linkage to NAP projects	Integrated management of coastal polders, sea dikes and cyclone shelters against tropical cyclone, sea-level rise and storm surges

6.3.4.8 STRENGTHENING THE ENABLING ENVIRONMENT FOR CYCLONE SHELTER RESILIENCE IN COASTAL DISTRICTS

Sectors:	Critical social infrastructure
Subsectors:	Cyclone shelters
Locations:	Satkhira, Khulna, Bagerhat, Barguna Patuakhali, Bhola, Noakhali Chattogram, Cox's Bazar
Adaptation option type:	Enabling environment
Objective	• Develop and implement standardized operational and maintenance protocols for cyclone shelters across coastal districts. • Strengthen the institutional capacity of local governments and shelter management committees. • Integrate shelter planning and resilience into land use policy, zoning regulations, and urban planning. • Promote community participation, especially of women and marginalized groups, in shelter governance. • Establish long-term systems for monitoring, evaluation, and accountability in cyclone shelter operations.
Expected outputs and impacts	• A harmonized framework for cyclone shelter operations across high-risk districts. • Increased local ownership and community oversight through functional shelter committees. • More responsive and accessible cyclone shelters due to improved planning and service delivery. • Significant reduction in disaster fatalities, injuries, and service disruptions. • Long-term resilience of cyclone shelters integrated into disaster risk management systems.
Gender considerations	• Establish gender-balanced shelter committees and prioritize leadership roles for women. • Incorporate gender-sensitive design and privacy considerations in shelter use guidelines. • Include women, elderly, and persons with disabilities in planning, feedback, and response exercises. • Promote awareness campaigns that address safety, security, and dignity during emergency sheltering. • Ensure that facilities like separate sanitation areas and maternal care spaces are part of shelter standards.
Potential SDG targets influenced	5, 11, 13

Linkage to NAP projects	Integrated management of coastal polders, sea dikes and cyclone shelters against tropical cyclone, sea-level rise and storm surges

6.3.5 Cross Sectoral Projects

6.3.5.1 MANAGING FLASH FLOODS IN NORTHEASTERN AND SOUTHEASTERN BANGLADESH

Sectors:	Cross Sectoral Projects
Subsectors:	all sub-sectors
Locations:	Sylhet Haor Region Chattogram Cox's Bazar
Adaptation option type:	Enabling environment
Objective	• Enhance structural and ecosystem-based flood resilience in flash flood-prone regions. • Reduce flood-induced economic losses and livelihood disruption. • Improve disaster preparedness and response capacity through inclusive early warning and planning systems. • Promote nature-based flood management and ecological restoration. • Align the project with SDGs, especially SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).
Expected outputs and impacts	• Improved flood resilience of infrastructure • Enhanced drainage and water recession capacity • Restored ecosystem buffers • Aligned interventions with related flood projects • Community empowerment and inclusion
Gender considerations	• Inclusion of women in local flood committees and planning bodies. • Leadership and capacity-building programs tailored for women. • Gender-sensitive early warning dissemination and infrastructure design (e.g., lighting, access to shelters). • Targeted consultations with marginalized and vulnerable populations.
Potential SDG targets influenced	5, 6, 9, 10, 11, 13, and 15
Linkage to NAP projects	WRM10 - Protection against flash floods, wave action, erosion and sedimentation

6.3.5.2 REHABILITATING AND MANAGING COASTAL EMBANKMENTS

Sectors:	Cross Sectoral Projects
Subsectors:	Roads and all sub-sectors of critical infrastructure
Locations:	Satkhira District Patuakhali District Hatiya Upazila (Noakhali)
Adaptation option type:	Traditional built environment
Objective	• Rehabilitate and modernize coastal embankments to withstand sea-level rise and extreme storm surges. • Improve drainage and sluice systems to minimize waterlogging within polders. • Enhance the structural durability of embankments using advanced materials and modular designs. • Promote community involvement, particularly women, in embankment monitoring and maintenance. • Align the project with SDGs 5, 9, 11, and 13.
Expected outputs and impacts	• Rehabilitated embankments and polders • Improved sluice and drainage systems • Community-based maintenance units • Gender-responsive infrastructure • Green buffers and modular designs piloted • Detailed cost-benefit estimate completed • Environmental screening and EIA conducted
Gender considerations	• Active involvement of women in consultations and local repair committees • Safety features prioritized for women and elderly (lighting, raised paths) • Gender-segregated FGDs ensured diverse perspectives • Training programs for women in embankment inspection and emergency response
Potential SDG targets influenced	5, 9, 11, 13
Linkage to NAP projects	Integrated management of coastal polders, sea dikes and cyclone shelters against tropical cyclone, sea-level rise and storm surges

6.3.5.3 REHABILITATING DRAINAGE CHANNELS WITHIN THE POLDERS

Sectors:	Cross Sectoral Projects
Subsectors:	Roads and all sub-sectors of critical infrastructure
Locations:	Satkhira District Patuakhali District Hatiya Upazila
Adaptation option type:	Traditional built environment
Objective	• Rehabilitate internal drainage systems through excavation of silted canals and repair of sluice gates. • Alleviate chronic waterlogging in polder communities by improving drainage efficiency. • Enhance agricultural productivity and protect road and utility infrastructure from flood damage. • Empower local communities, especially women and vulnerable groups, to participate in drainage monitoring and maintenance. • Contribute to SDG 9 (Infrastructure), SDG 11 (Sustainable Communities), and SDG 13 (Climate Action).
Expected outputs and impacts	• Rehabilitated drainage channels • Operational sluice gates • Reduced waterlogging inside polders • Local community involvement in upkeep
Gender considerations	• Women from vulnerable households participated in community consultations. • FGDs revealed that women face mobility and health challenges due to standing water around homes, clinics, and markets. • Drainage interventions will prioritize safe pathways, latrine access, and female employment in maintenance. • Community training will include women-led households and local youth to monitor khals and gate conditions.
Potential SDG targets influenced	9, 11, 13
Linkage to NAP projects	WRM1 - Integrated management of coastal polders, sea dikes and cyclone shelters against tropical cyclone, sea-level rise and storm surges WRM8 - Drainage management of economic/industrial zones and critical infrastructure, and reinforced climate resilience through risk assessment

6.3.5.4 DREDGING MAJOR AND MEDIUM RIVERS IN SOUTHERN BANGLADESH

Sectors:	Cross Sectoral Projects
Subsectors:	All sub-sectors
Locations:	Southwest Polders South-Central Polders
Adaptation option type:	Traditional built environment
Objective	• Conduct scientific assessments to guide strategic river dredging in southwest and south-central polders. • Reduce flood-induced waterlogging in polder systems by restoring river flow and discharge capacity. • Enhance river navigation and connect economic zones, facilitating transport and market access. • Build institutional capacity for sustainable dredging operations with community participation. • Align the initiative with Bangladesh's National Adaptation Plan (NAP) and SDGs 5, 9, 11, and 13.
Expected outputs and impacts	• Dredging of priority river segments • Revived navigation channels • Reduced water retention near polder systems • Improved cross-agency coordination
Gender considerations	• Include women, fishers, and river-dependent communities in planning, identifying impact zones, and deciding dredging schedules. • Conduct FGDs to understand gender-specific risks, especially for women living along unstable or flood-prone riverbanks. • Prioritize gender-responsive relocation support where dredging might disrupt riverbank households. • Promote women's involvement in river monitoring committees and sediment reuse planning.
Potential SDG targets influenced	8, 9, 11, 13
Linkage to NAP projects	▪ WRM6 - Dredging of all major and medium rivers for accommodating the smooth drainage of excess floods during climate-induced extreme events ▪ WRM8 - Drainage management of economic/industrial zones and critical infrastructure, and reinforced climate resilience through risk assessment

6.3.5.5 IMPLEMENTING TIDAL RIVER MANAGEMENT IN LOW-LYING EMBANKED AREAS

Sectors:	Cross Sectoral Projects
Subsectors:	Roads and water sources
Locations:	Satkhira District Khulna District South-Central Polders
Adaptation option type:	Nature-based solutions
Objective	• Enhance flood resilience and reduce prolonged waterlogging in polders. • Improve water quality, siltation management, and agricultural productivity. • Support economic growth through restored livelihoods and transport infrastructure. • Foster inclusive and gender-sensitive planning and implementation of TRM. • Align with SDG targets and Bangladesh's National Adaptation Plan (NAP).
Expected outputs and impacts	• Flood and Water Management • Water Quality and Agriculture • Transport and Infrastructure Resilience • Economic Growth • Social and Environmental Benefits
Gender considerations	• Organize dedicated FGDs for women and marginalized communities. • Develop gender-sensitive indicators for TRM outcomes (mobility, health, income). • Ensure women's roles in beel monitoring, committee leadership, and benefit-sharing. • Regularly assess impacts of TRM on access to water, sanitation, and livelihoods for vulnerable groups.
Potential SDG targets influenced	1, 5, 6, 13
Linkage to NAP projects	Integrated management of coastal polders, sea dikes and cyclone shelters against tropical cyclone, sea-level rise and storm surges

6.3.5.6 UTILIZING ECO-ENGINEERING SOLUTIONS FOR FLOOD AND DRAINAGE SYSTEM MANAGEMENT

Sectors:	Cross Sectoral Projects
Subsectors:	All sub-sectors
Locations:	Chattogram Sylhet Rajshahi
Adaptation option type:	Urban resilience projects
Objective	• Mitigate urban pluvial flooding through green infrastructure and eco-engineering interventions. • Improve water quality, stormwater retention, and urban biodiversity. • Enhance urban liveability and climate resilience using nature-based solutions. • Promote inclusive planning with gender and community-sensitive designs. • Align the intervention with SDGs 6, 11, 13, and 15 and the National Adaptation Plan (NAP).
Expected outputs and impacts	• Reduced surface runoff • Improved stormwater management • Enhanced water quality • Urban green space development • Infrastructure cost savings • Real-time flood and drainage monitoring system established • Shifted project focus to high-vulnerability rural/riverine zones
Gender considerations	• Ensure women, youth, and marginalized groups participate in stakeholder consultations, design workshops, and benefit-sharing mechanisms. • Conduct gender-sensitive assessments on access to flood-prone zones, sanitation facilities, and green spaces. • Design safe, accessible green infrastructure (e.g., well-lit rain gardens or wetlands) with community feedback. • Track gender-specific outcomes in the project's Monitoring and Evaluation (M&E) framework.
Potential SDG targets influenced	6, 11, 13, 15
Linkage to NAP projects	WRM7 - Construction and rehabilitation of flood and drainage management measures with eco-engineering solutions

6.3.5.7 WATER MANAGEMENT IN POLDERS

Sectors:	Cross Sectoral Projects
Subsectors:	All sub-sectors
Locations:	Southwest Polders (e.g., Satkhira, Khulna) South-Central Polders (e.g., Barisal, Patuakhali)
Adaptation option type:	Enabling environment
Objective	• Strengthen and institutionalize WMCs for sustainable operation and maintenance (O&M) of water control structures. • Foster inclusive decision-making by ensuring gender-balanced representation in WMCs. • Improve water resource use efficiency to support agriculture, aquaculture, and transport infrastructure. • Reduce flood risk and waterlogging through improved drainage planning and community monitoring. • Align with SDG targets (5, 6, 11, 13) and Bangladesh's National Adaptation Plan (NAP).
Expected outputs and impacts	• Functional and gender-balanced WMCs • Reduced waterlogging and drainage delays • Strengthened infrastructure operation • Integrated community-farmer coordination
Gender considerations	• Mandate gender quotas for WMC formation to promote inclusive leadership and representation. • Organize separate training and consultation sessions for women, especially in socially conservative areas. • Integrate gender-sensitive indicators in M&E: e.g., women-led decision outcomes, satisfaction scores, accessibility feedback. • Document and promote best practices of women-led WMCs to scale nationally.
Potential SDG targets influenced	5, 6, 11, 13
Linkage to NAP projects	Integrated management of coastal polders, sea dikes and cyclone shelters against tropical cyclone, sea-level rise and storm surges

6.3.5.8 STRATEGIC ASSESSMENT OF CLIMATE RISKS AND DEVELOPMENT PLANNING INFORMED BY CLIMATE RISKS

Sectors:	Cross Sectoral Projects
Subsectors:	All sub-sectors
Locations:	Coastal Districts (e.g., Satkhira, Khulna, Patuakhali, Barguna) Urbanizing Coastal Centers
Adaptation option type:	Enabling environment
Objective	• Conduct comprehensive climate risk assessments to identify vulnerabilities across sectors, geographies, and populations. • Develop and mainstream climate risk-informed planning frameworks at national and subnational levels. • Improve adaptive capacity of infrastructure, services, and local economies through risk-responsive policies. • Strengthen institutional mechanisms to integrate climate data into planning, monitoring, and evaluation systems. • Contribute to achieving SDG 5 (Gender Equality), SDG 6 (Water), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action).
Expected outputs and impacts	• Improved resilience of communities, infrastructure, and economies • Development planning processes informed by climate risk assessments • Strengthened institutional capacity for climate risk integration • Availability of climate risk data and decision-support tools (e.g., maps, models) • Inclusion of marginalized groups in risk-informed planning
Gender considerations	• Ensure inclusive participation of women, youth, persons with disabilities, and marginalized groups in climate risk consultations and scenario planning. • Conduct gender-sensitive vulnerability assessments to identify differentiated impacts. • Incorporate social protection and gender equity indicators into risk frameworks. • Facilitate women's leadership roles in planning, monitoring, and implementation of resilience strategies.
Potential SDG targets influenced	5, 11, 13
Linkage to NAP projects	WRM3 - Protection and management of potentially vulnerable areas due to tropical cyclone, sea-level rise, extreme storm surges and flooding

6.3.5.9 MAINSTREAMING SPATIAL HAZARD ANALYSIS INTO POLICY

Sectors:	Cross Sectoral Projects
Subsectors:	All sub-sectors
Locations:	Coastal Districts (e.g., Satkhira, Khulna, Patuakhali, Barguna) Urbanizing Secondary Coastal Towns
Adaptation option type:	Enabling environment
Objective	• Promote data-driven, spatially informed decision-making at local and national levels. • Integrate spatial hazard mapping into key planning documents and sectoral policies. • Strengthen institutional capacities to utilize high-resolution geospatial and climate data. • Ensure inclusive participation and gender equity in spatial data collection and use. • Enhance climate risk governance through mainstreamed spatial analysis.
Expected outputs and impacts	• Enhanced local and national planning using spatial data • Risk-informed infrastructure and service investments • Strengthened community and infrastructure resilience
Gender considerations	• Ensure spatial data collection processes are inclusive, capturing needs of women, elderly, and marginalized populations. • Conduct gender-sensitive analysis to understand how spatial vulnerabilities differ across groups. • Promote women's participation in data collection, mapping exercises, and decision-making committees. • Track gender-disaggregated outcomes of spatial hazard-informed policies to improve future planning.
Potential SDG targets influenced	5, 11, 13
Linkage to NAP projects	WRM3 - Protection and management of potentially vulnerable areas due to tropical cyclone, sea-level rise, extreme storm surges and flooding

6.3.5.10 RISK-BASED URBAN AND REGIONAL PLANNING FOR RESILIENT COASTAL INFRASTRUCTURE

Sectors:	Cross Sectoral Projects
Subsectors:	All sub-sectors
Locations:	Chattogram, Khulna, Barisal Satkhira, Bagerhat, Patuakhali Noakhali, Bhola, Barguna Cox's Bazar, Laxmipur, Feni Patuakhali
Adaptation option type:	Traditional built environment; nature-based solutions
Objective	• Integrate updated climate, flood, and hazard data into urban and regional planning systems. • Establish multi-sectoral data systems to track risk exposure of energy, water, transport, and social infrastructure. • Promote both nature-based and engineered solutions to reduce climate vulnerability. • Develop and implement planning standards and policies aligned with climate risk. • Enhance institutional and technical capacities at national and sub-national levels. • Improve gender-inclusive infrastructure planning and ensure equitable service access during extreme events.
Expected outputs and impacts	• Development and application of a climate risk index • Resilient energy, water, and transport infrastructure • Nature-based and engineered defenses integrated • Risk-informed urban and regional planning guidelines • Elevated transport and evacuation routes
Gender considerations	• Ensure gender-balanced decision-making through inclusive planning committees. • Conduct community consultations with women, children, the elderly, and people with disabilities. • Design infrastructure for universal accessibility, including transport and evacuation systems. • Support training and employment opportunities for women in climate-resilient construction, maintenance, and disaster preparedness. • Use gender-disaggregated data to inform resilience investments that serve the most vulnerable.
Potential SDG targets influenced	5, 7, 9, 11, 13, 15

Linkage to NAP projects	WRM3 - Protection and management of potentially vulnerable areas due to tropical cyclone, sea-level rise, extreme storm surges and flooding

6.3.5.11 BUILDING URBAN TRANSPORT RESILIENCE IN COASTAL DISTRICTS THROUGH CLIMATE-RESPONSIVE INFRASTRUCTURE DESIGN AND INTEGRATED PLANNING

Sectors:	Transport
Subsectors:	Road
Locations:	Chattogram, Khulna, Barisal; Satkhira, Bagerhat, Patuakhali; Noakhali, Bhola, Barguna; Cox's Bazar, Laxmipur, Feni; Patuakhali
Adaptation option type:	Urban resilience projects
Objective	• Implement climate-resilient infrastructure design in urban transport systems vulnerable to flooding and climate shocks. • Reduce economic losses and disruptions through strengthened transport functionality and reliability. • Promote integrated land-use and transport planning responsive to climate scenarios. • Ensure inclusive, gender-equitable, and locally relevant transport infrastructure development. • Align project outcomes with SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).
Expected outputs and impacts	• Improved resilience of urban roads • Decreased maintenance and repair costs • Economic revitalization • Reduced transport disruptions • Climate-adapted planning practices
Gender considerations	• Inclusive Planning: Actively involving women, youth, the elderly, and persons with disabilities in transport planning and feedback mechanisms. • Employment Opportunities: Promoting gender-equitable hiring practices in road construction, maintenance, and drainage system management. • Safety and Accessibility: Designing sidewalks, intersections, and public transport stops that are safe and accessible for all user groups, including lighting and signage improvements. • Community-Led Maintenance: Creating local maintenance teams, particularly involving women, to oversee neighborhood-level upkeep and drainage clearing.
Potential SDG targets influenced	9, 11, 13
Linkage to NAP projects	CDM12 - Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.5.12 Strengthening road infrastructure through traditional engineering solutions in the most vulnerable coastal upazilas

Sectors:	Transport
Subsectors:	Road
Locations:	Shyamnagar (Satkhira); Patuakhali Sadar; Kalapara (Patuakhali); Hatiya (Noakhali)
Adaptation option type:	Traditional built environment projects
Objective	• Enhance the structural resilience of critical road infrastructure to withstand cyclones, tidal surges, and floods. • Minimize economic and operational disruptions caused by road damage and closures in extreme weather conditions. • Improve emergency evacuation and response capacity by maintaining all-weather, safe road access routes. • Ensure community-focused, inclusive, and gender-responsive resilience measures for road users and residents. • Align the project's outcomes with Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).
Expected outputs and impacts	• Reduction in road disruptions and flooding • Lower infrastructure maintenance costs • Increased economic and social stability • Improved evacuation and disaster response • Enhanced safety and resilience of roads
Gender considerations	• Actively involving women's groups and vulnerable households in community consultations and resilience planning. • Creating targeted employment and skill-building opportunities for women in road maintenance, construction, and awareness programs. • Designing roads with gender-sensitive features, such as safe waiting areas, lighting, and easy access to emergency shelters. • Developing evacuation and emergency service plans that consider the specific needs of women, children, elderly, and persons with disabilities.
Potential SDG targets influenced	5, 9, 11, 13
Linkage to NAP projects	CDM12 - Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.5.13 Flood-Proofing Coastal Road Infrastructure Using Nature-Based Solutions

Sectors:	Transport
Subsectors:	Road
Locations:	Shyamnagar (Satkhira), Kalapara (Patuakhali), Hatiya (Noakhali), Faridpur, Koyra (Khulna)
Adaptation option type:	Nature-Based Solutions
Objective	• Reduce road flooding through natural water retention, drainage, and barrier systems. • Restore and conserve coastal ecosystems that mitigate flood intensity and protect roads. • Enhance long-term climate resilience using cost-effective, low-carbon solutions. • Promote community stewardship and gender-inclusive participation in ecosystem-based road maintenance. • Align with SDG 9 (Infrastructure), SDG 13 (Climate Action), and SDG 15 (Life on Land).
Expected outputs and impacts	• Reduced flood damage to road assets • Enhanced biodiversity and green cover • Lower maintenance and repair costs • Community resilience and awareness • Contribution to NDC and SDG targets
Gender considerations	• Community Planting Programs: Women's groups and youth clubs will be engaged in roadside greening and mangrove reforestation. • Eco-guard Training for Vulnerable Groups: Skill-building in ecosystem monitoring, nursery management, and eco-tourism services. • Gender-Sensitive Access Design: Roads will include safe waiting spaces, shade, and gender-aware signage for cyclone response. • Participatory Planning Platforms: Inclusive decision-making through union-level committees representing women and marginalized groups.
Potential SDG targets influenced	5, 9, 11, 13, 14
Linkage to NAP projects	WRM7 - Construction and rehabilitation of flood and drainage management measures with eco-engineering solutions

6.3.5.14 Enhancing flood resilience for airport infrastructure

Sectors:	Transport
Subsectors:	Airport
Locations:	Cox's Bazar Airport, Khan Jahan Ali Airport (Bagerhat), Osmani International Airport (Sylhet)
Adaptation option type:	Traditional built environment and Enabling environment
Objective	• Strengthen the physical and operational resilience of airports to extreme rainfall and flood events. • Ensure continuity of critical airport functions during and after floods. • Minimize economic losses and disruptions to aviation services. • Enhance safety for passengers, staff, and surrounding communities. • Incorporate inclusive and gender-responsive resilience strategies. • Align project outcomes with SDG 9 (Infrastructure), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action)
Expected outputs and impacts	• Improved airport functionality during floods • Reduced economic losses from disruptions • Increased safety for all users
Gender considerations	• Ensure evacuation plans address the needs of women, children, the elderly, and persons with disabilities. • Promote gender-inclusive employment in the design, implementation, and monitoring of flood resilience activities. • Engage local communities, especially women's groups, in awareness and preparedness training.
Potential SDG targets influenced	9, 11, 13
Linkage to NAP projects	Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.5.15 Flood-proofing railway infrastructure in flood-prone areas

Sectors:	Transport
Subsectors:	Railway lines
Locations:	Gaibandha, Khulna, Chattogram, Faridpur, Tangail, Bogur, Jamalpur, Feni, Maulvibazar, Gopalganj, Rajbari
Adaptation option type:	Traditional built environment
Objective	• Enhance the structural integrity of railway infrastructure to withstand severe flood events. • Reduce service disruptions and accidents caused by water damage and inundation. • Improve drainage and flood management systems in railway corridors. • Integrate climate-resilient design and materials in railway construction and maintenance. • Align with national climate adaptation priorities and Sustainable Development Goals (SDGs) 9 (Industry, Innovation, and Infrastructure), 11 (Sustainable Cities and Communities), and 13 (Climate Action).
Expected outputs and impacts	• Reduced Economic Losses • Enhanced Infrastructure Resilience • Improved Passenger Safety • Strengthened Connectivity and Equity • Support for Climate Adaptation Goals
Gender considerations	• Reliable and safe railway services during and after flood events are essential for women, as they support mobility, access to essential services, and economic empowerment. • Ensuring continued railway functionality during floods will reduce disruption to women's livelihoods, particularly for those engaged in informal work, caregiving, and market access • The project will actively involve women in the planning, construction, management, and maintenance phases, with targeted skills training and employment opportunities
Potential SDG targets influenced	9, 11, 13
Linkage to NAP projects	Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.5.16 Enhancing railway station resilience to flooding using integrated adaptation approaches

Sectors:	Transport
Subsectors:	Railway stations
Locations:	Chattogram, Khulna, Bagerhat, Bogra, Feni, Gaibandha, Gopalganj, Faridpur, Jamalpur, and Chuadanga
Adaptation option type:	Traditional built environment; nature-based solutions
Objective	• Elevate critical railway station infrastructure above flood levels to prevent disruption. • Integrate structural and ecological flood management solutions. • Minimize operational losses and physical damage from flood events. • Improve passenger and worker safety during flooding. • Promote green infrastructure for flood mitigation and environmental benefits. • Align interventions with SDGs 9 (Industry, Innovation and Infrastructure), 11 (Sustainable Cities and Communities), and 13 (Climate Action).
Expected outputs and impacts	• Use of corrosion-resistant materials • Enhanced station operability during floods • Reduced infrastructure repair costs • Improved ecosystem health • Increased passenger safety
Gender considerations	• Reliable and safe railway services during and after flood events are essential for women, supporting mobility, caregiving, and economic activities. • The project will actively involve women in planning, construction, management, and maintenance phases, offering targeted skills training and employment. • Ensuring consistent station access during floods will help mitigate the disproportionate impact on women and marginalized groups. • Evacuation and emergency procedures will include gender-sensitive provisions such as safe spaces and targeted communication.
Potential SDG targets influenced	9, 11, 13
Linkage to NAP projects	Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

6.3.5.17 Flood-proofing inland water transport terminals using traditional engineering solutions

Sectors:	Transport
Subsectors:	Inland water transport terminals
Locations:	Chattogram, Khulna, Barishal, Patuakhali, Bagerhat, Bogra, Feni, Gaibandha, Gopalganj, Faridpur, Jamalpur, Chuadanga
Adaptation option type:	Traditional built environment
Objective	• Enhance the structural resilience of inland water transport terminals to withstand floods, storm surges, and rising water levels. • Minimize operational disruptions and ensure continuous functionality of terminals during extreme weather events. • Improve safety and accessibility for passengers, particularly women, children, and vulnerable groups, during flood events. • Reduce economic losses caused by infrastructure damage, transport delays, and cargo losses. • Align project outcomes with Sustainable Development Goals (SDGs) 5 (Gender Equality), 9 (Industry, Innovation, and Infrastructure), 11 (Sustainable Cities and Communities), and 13 (Climate Action).
Expected outputs and impacts	• Reduced terminal disruptions • Lower infrastructure maintenance costs • Increased safety for vulnerable groups • Improved economic stability • Enhanced climate resilience
Gender considerations	• Engage women's groups in planning and implementation to ensure their needs are met. • Create employment opportunities for women in terminal maintenance and awareness programs. • Design terminals with gender-sensitive features, such as safe waiting areas and lighting. • Develop emergency plans that consider the needs of women, children, elderly, and persons with disabilities.
Potential SDG targets influenced	5, 9, 11, 13
Linkage to NAP projects	Building climate-resilient houses, education & communication infrastructure in areas with high climate risk

7. ACTIONS TO IMPLEMENT THE ROADMAP AND SCALE UP ADAPTATION ACTION

This section outlines how the prepared roadmap can be integrated into the national planning process of the Government of Bangladesh. This roadmap includes a set of comprehensive concept notes detailing prioritized adaptation options.

These concept notes were developed following in-depth feasibility studies conducted by the field research team from the Centre for Climate Change and Environmental Research (C3ER) at BRAC University. The drafts were subsequently reviewed and validated by the Ministry of Environment, Forest and Climate Change (MoEFCC), alongside other relevant ministries, departments, and bilateral and multilateral stakeholders.

To support implementation, the roadmap recommends three key strategic actions:

- Mainstreaming the Roadmap to National Plans and Policies
- Identifying Financing of Development Programme and linkage to Operational Budget
- Strengthening Institutional Capacity of Framework and Planning Process

Strategical planning and securing financing for project implementation will ensure a resilient infrastructure system. The following subsections of the report provide detailed information to support the process.

7.1 Mainstreaming the Roadmap to National Plans and Policies

Mainstreaming the roadmap for climate adaptation into national plans and policies is vital for ensuring that these strategies are effectively integrated into Bangladesh's broader development agenda. This necessitates a systematic approach that aligns the roadmap's objectives with existing national priorities and frameworks, fostering a coordinated response to climate change.

Engaging key stakeholders from diverse sectors—such as government ministries, local authorities, civil society, and the private sector—is essential for this integration. Collaborative workshops and consultations can enhance understanding of the roadmap's goals and underscore the importance of adaptation strategies in advancing sustainable development.

The initial step in mainstreaming involves aligning the roadmap's adaptation options with national development initiatives, including the 8th Five Year Plan and the Bangladesh Climate Change Strategy and Action Plan (BCCSAP). By demonstrating how prioritized adaptation options support the aims of these documents, the government can create synergies that boost both climate resilience and socio-economic development.

Additionally, integrating the roadmap into policy frameworks requires embedding climate considerations into long-term policy making and planning. This can be achieved by developing specific policy instruments and regulatory frameworks that reflect adaptation priorities outlined in the roadmap. Establishing mechanisms such as guidelines, action plans, and sector-specific strategies is crucial to ensure that adaptation measures are systematically integrated into relevant policies.

Monitoring and evaluation are also key components of mainstreaming. Establishing indicators to track the progress of adaptation strategies within national policies will help identify any gaps and challenges. Ongoing assessments will allow the government to adapt its approach as needed, ensuring that the roadmap remains responsive to emerging climate issues.

In conclusion, successfully mainstreaming the roadmap into national plans and policies requires a collaborative approach, alignment with existing frameworks, and strong monitoring mechanisms. By prioritizing adaptation options and integrating them into comprehensive development strategies, Bangladesh can create a resilient future that not only addresses the impacts of climate change but also fosters sustainable growth.

7.2 Identifying Financing of Development Programme and linkage to Operational Budget

Identifying financing for development programs and establishing a clear linkage to the operational budget is a crucial component of ensuring the successful implementation of the roadmap outlined in the report. This process involves a multifaceted approach aimed at creating sustainable financial frameworks that support prioritized adaptation options in line with the national planning process of Bangladesh.

Understanding the Financial Landscape: The first step in identifying financing sources is to conduct a thorough assessment of the existing financial landscape. This includes evaluating public funding sources, such as national and local government budgets, as well as potential international funding avenues from bilateral and multilateral organizations. Engaging with stakeholders, including financial institutions, non-governmental organizations, and private sector partners, can provide valuable insights into available resources and innovative funding mechanisms.

Aligning with National Development Priorities: It is essential that the identified financing for development programs aligns with the broader national development priorities. This alignment ensures that funding is not only accessible but also utilized effectively toward resilience-building initiatives. The roadmap should be integrated into existing national budgetary frameworks, fostering a collaborative approach between various ministries and departments. By aligning adaptation initiatives with national goals, it enhances the visibility and attractiveness of these projects to potential funders.

Establishing Linkages to the Operational Budget: Creating a strong linkage between development program financing and the operational budget involves streamlining the budgeting process to accommodate adaptation projects. This requires:

- Budget Integration: Development programs should be systematically included in the annual operational budget, reflecting their significance in national planning. This integration helps ensure continuous funding and avoids budgetary silos that can hinder project execution.
- Transparent Processes: transparent budgeting processes allows all stakeholders to understand funding allocations and the rationale behind them. This transparency builds trust among stakeholders and encourages more robust collaboration.
- Monitoring and Evaluation: Establishing clear metrics for monitoring and evaluating the impact of funded development programs is vital. Regular assessments can help justify ongoing funding and adjustments in financial allocations as needed, ensuring adaptive management in response to changing circumstances.

Exploring Diverse Financing Mechanisms: A diversified approach to financing can enhance resilience against potential funding shortfalls. Possible avenues to explore include:

- Public-Private Partnerships (PPPs): Engaging the private sector can leverage additional resources and expertise for resilience-building projects.
- Grants and Concessional Loans: Securing grants from international donors or accessing concessional loans can provide necessary financial support while minimizing repayment burdens.
- Innovative Financing Models: Exploring options like green bonds, climate funds, and other innovative financial instruments can attract investment into adaptation efforts.

Identifying financing for development programs and linking it effectively to the operational budget is critical to translating the roadmap into actionable projects. A comprehensive strategy that encompasses stakeholder engagement, alignment with national priorities, transparent budgeting, and diverse financing mechanisms will enhance the capacity of Bangladesh to implement its climate adaptation initiatives successfully. By doing so, the country can build a more resilient infrastructure system and contribute meaningfully to its long-term development goals.

7.3 Strengthening Institutional Capacity of Framework and Planning Process

Enhancing the institutional capacity of the planning framework is vital for successfully implementing the roadmap and its associated climate adaptation strategies. To achieve this, a comprehensive approach is essential, focusing on building the competencies and resources within relevant governmental ministries and agencies. Key initiatives could include the design of targeted training programs and workshops that elevate personnel expertise in important areas such as climate change adaptation, project management, policy formulation, and stakeholder engagement. By emphasizing practical skills alongside theoretical knowledge, these capacity-building efforts can effectively address the unique challenges faced in Bangladesh.

In addition, establishing structured and transparent communication channels among various stakeholders—such as governmental bodies, non-governmental organizations, community groups, and international partners—will foster enhanced coordination and collaboration. By organizing regular forums and collaborative platforms, we can create opportunities for sharing best practices and valuable insights.

Moreover, investing in modern technological tools for data collection, analysis, and reporting will support an evidence-based approach to decision-making. By cultivating a culture of continuous learning, adaptability, and innovation within the institutional framework, Bangladesh can empower its institutions to respond proactively to climate-related challenges. This strengthened institutional capacity will ultimately serve as a solid foundation for informed planning and effective execution of initiatives aimed at creating a resilient infrastructure equipped to withstand the impacts of climate change.

8. ANNEXES

ANNEX1. ADDITIONAL RESULTS FROM STRESS TESTING

Please find the Bangladesh Climate-Resilient Infrastructure Stress-test report here: https://gca.org/reports/bangladesh-climate-resilient-infrastructure-stress-test/

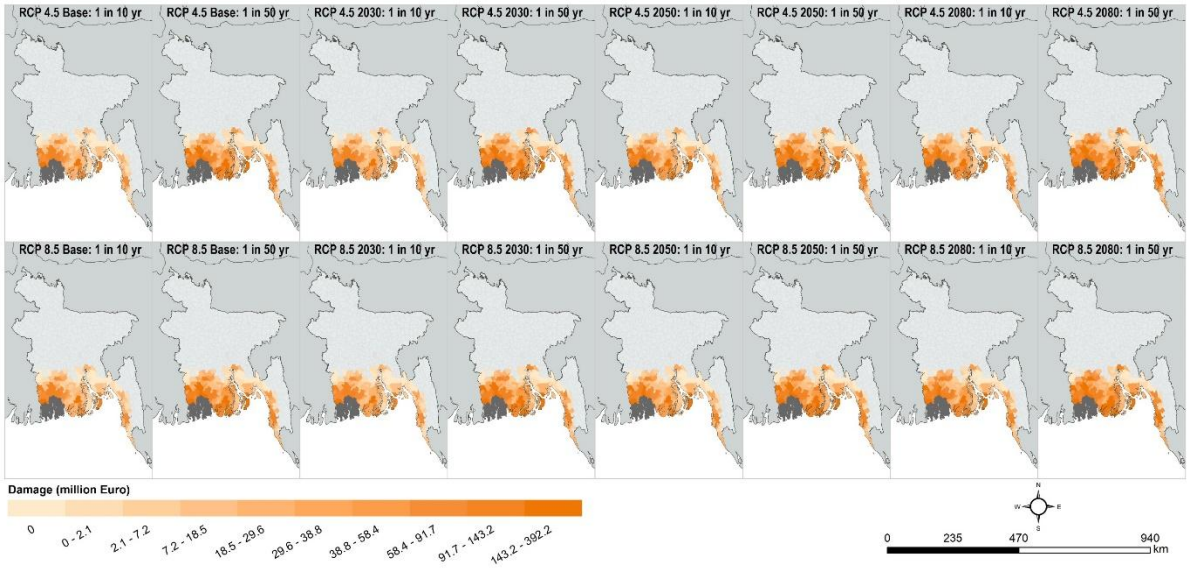

Figure B1. Estimated economic damage to road infrastructure due to coastal flooding under baseline and future climate conditions. The figure highlights the most affected regions and illustrates the spatial distribution of flood-related road damages across Bangladesh.

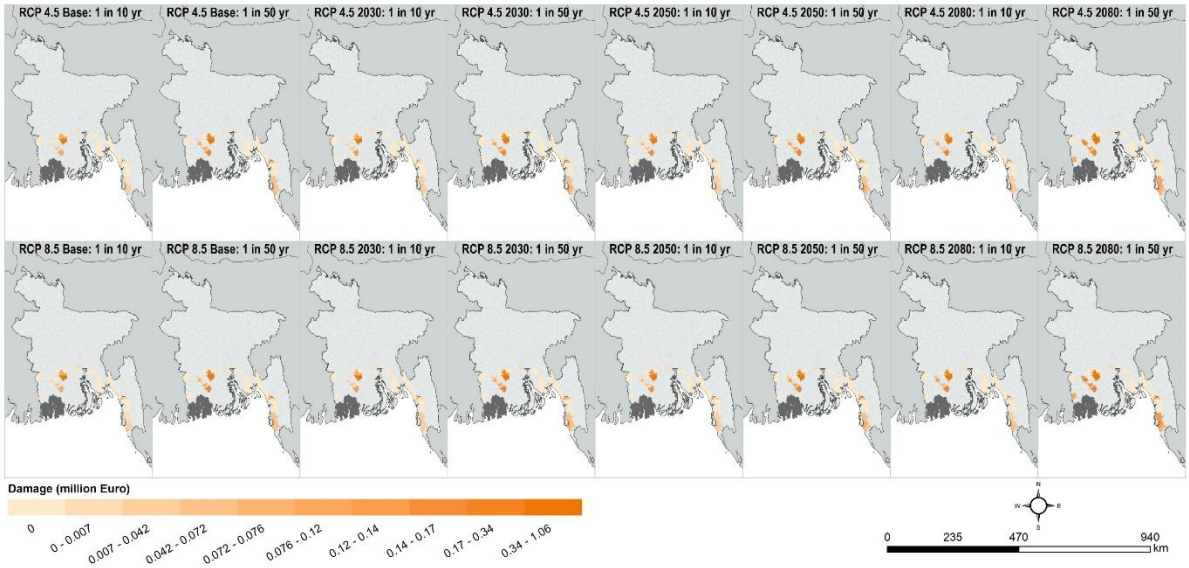

Figure B2. Estimated economic damage to railway lines due to coastal flooding under baseline climate conditions. The figure highlights the most affected regions and illustrates the spatial distribution of flood-related railway line damages across Bangladesh.

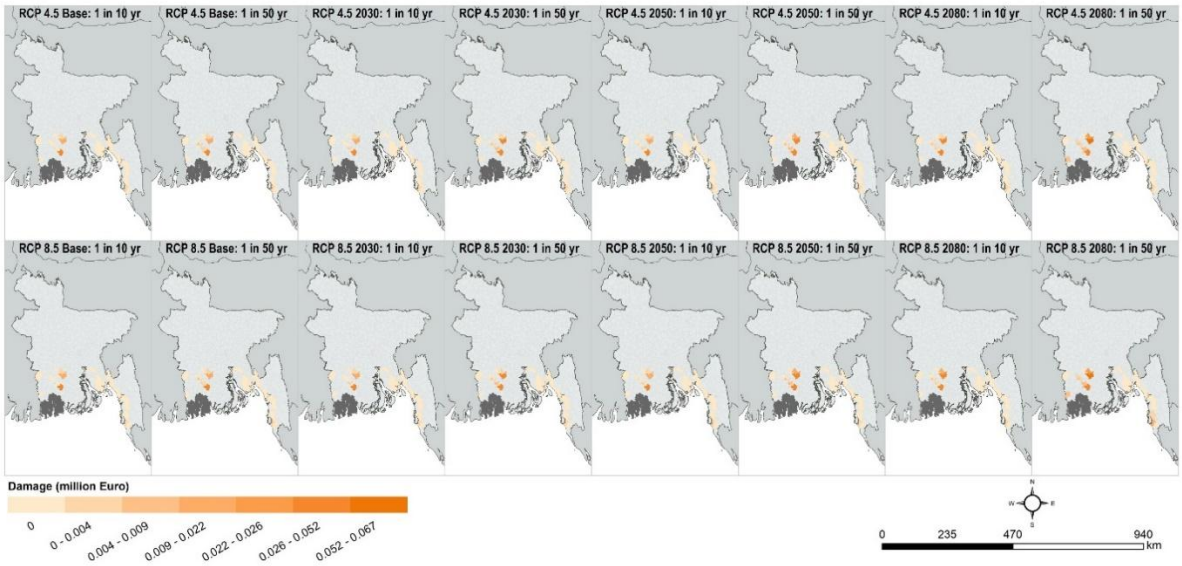

Figure B3. Estimated economic damage to railway stations due to coastal flooding under baseline climate conditions. The figure highlights the most affected regions and illustrates the spatial distribution of flood-related railway station damages across Bangladesh.

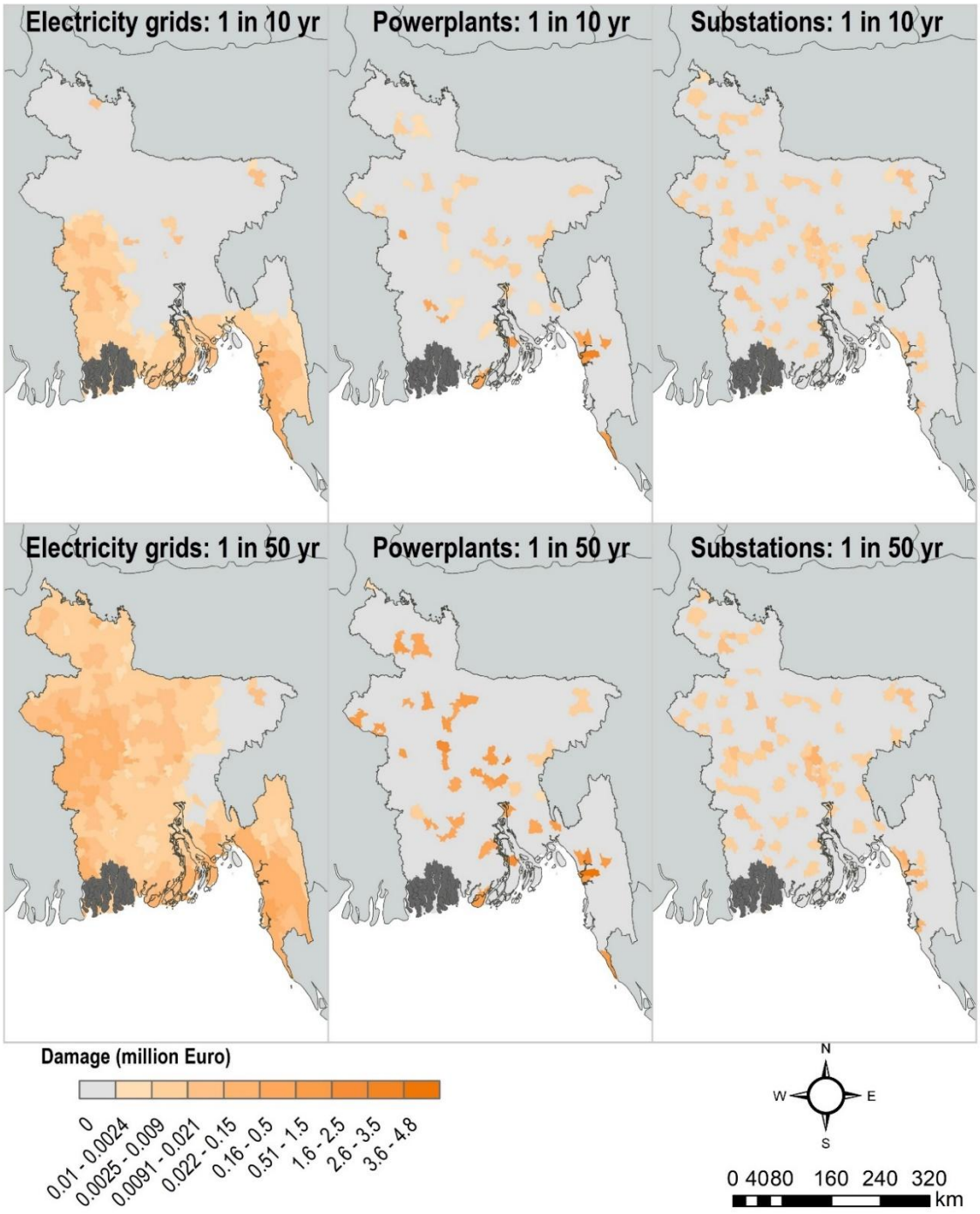

Figure B4. Estimated economic damage to energy infrastructure — including electricity grids, power plants, and substations — caused by cyclonic wind events under baseline climate conditions. The figure shows the spatial distribution of cyclone-related impacts across Bangladesh for 10-year and 50-year return period events, highlighting the most affected areas.

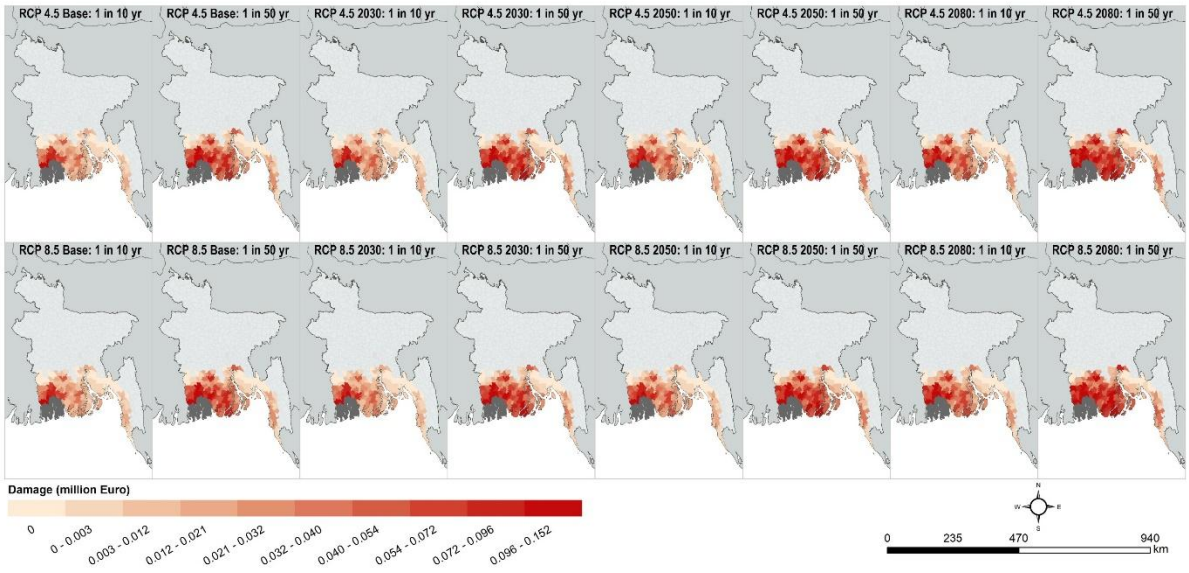

Figure B5. Estimated economic damage to education institutions due to coastal flooding under baseline climate conditions. The figure highlights the most affected regions and illustrates the spatial distribution of flood-related education institution damages across Bangladesh.

ANNEX2. DETAIL CONCEPT NOTE

CONCEPT NOTES ON TRANSPORT SECTOR INFRASTRUCTURE DEVELOPMENT

1.1 IMPROVING PORT RESILIENCE TO CYCLONE WIND EFFECTS

1. Introduction

Bangladesh's coastal and riverine ports play a critical role in trade, transportation, and economic development. However, these ports are highly vulnerable to cyclonic winds, storm surges, and flooding due to their geographical location. The ports in Bagerhat, Barisal, Chandpur, Chattogram, Faridpur, Jhalokati, Khulna, Madaripur, Manikganj, Munshiganj, Narayanganj, Pabna, Patuakhali, Pirojpur, Rajbari, and Sirajganj districts are particularly exposed to these threats. These regions are low-lying and experience frequent extreme weather events, necessitating targeted resilience measures to ensure port functionality and economic stability. Strengthening the resilience of port infrastructure is crucial to ensuring uninterrupted economic activities, safeguarding livelihoods, and protecting investments.

Figure 9: Road Infrastructure in Patuakhali

2. Objectives

- Enhance the structural resilience of ports to withstand cyclone wind effects.
- Minimize economic and operational disruptions caused by extreme weather events.
- Improve emergency preparedness and response capabilities at ports.
- Integrate nature-based solutions (NbS) to enhance long-term resilience.
- Ensure inclusive and gender-responsive resilience measures.

- Align the project outcomes with Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).

3. Justification for Selected Locations

The selected locations are strategically important for Bangladesh's trade and transport network. These districts are particularly vulnerable to cyclone-induced flooding, storm surges, and extreme weather, making them high-priority areas for investment in climate resilience. The justification for these locations is outlined in the table below:

District	Key Vulnerability Factors	Strategic Importance
Chattogram	Coastal exposure, frequent cyclones, storm surges	Major seaport, economic hub
Khulna	Low-lying delta, high risk of flooding and erosion	Industrial and inland water transport gateway
Barisal	Prone to tidal surges, inadequate protective infrastructure	Key river port for trade and transport
Narayanganj	Industrial zone, suffers from waterlogging and extreme weather events	Critical for logistics and supply chains
Patuakhali	Coastal erosion, rising sea levels	Important for fishing and agriculture exports
Sirajganj	Riverbank erosion, flood-prone	Key inland waterway transport link

4. Key Climate Resilience Measures

Infrastructure Strengthening

- Reinforce port buildings and warehouses to withstand high wind speeds, flying debris, and long-term exposure to saline conditions.
- Use corrosion-resistant materials (e.g., treated steel, marine-grade concrete) in construction and retrofitting to address salt-induced deterioration.
- Secure cranes, container stacks, and other essential equipment from both wind damage and corrosion due to salt-laden air and water.
- Install wind barriers and breakwaters to mitigate the impact of cyclones and tidal surges on critical infrastructure.
- Elevate key facilities to reduce exposure to both storm surges and saline water intrusion.
- Upgrade drainage systems with materials and designs suited to resist salinity-induced corrosion and blockage.

Nature-Based Solutions (NbS)

- Restore mangroves and coastal vegetation to buffer saline intrusion and reduce wind impacts.
- Create green buffer zones that also help absorb and filter saline runoff.
- Promote bioengineered flood defenses that include salt-tolerant vegetation to stabilize soil and reduce saline erosion.
- Integrate estuarine wetlands into port designs to improve natural drainage and minimize saline water stagnation.

Operational and Institutional Measures

- Regular training of port personnel on handling saline-induced degradation and cyclone response protocols.
- Update emergency response plans to include salinity risks and post-cyclone infrastructure inspections for salt damage.

- Implement real-time environmental monitoring systems to track salinity levels, in addition to weather conditions.
- Improve coordination among port authorities, environmental agencies, and local governments to address salinity-related vulnerabilities jointly.

5. Expected Outputs and Impacts

Expected Impact	Key Benefits
Reduction in cyclone-induced disruptions	Ensures year-round port functionality
Lower infrastructure maintenance costs	Enhances financial sustainability
Increased trade and economic stability	Boosts regional and national economic growth
Improved emergency preparedness	Reduces casualties and infrastructure losses
Enhanced ecological benefits from NbS	Strengthens biodiversity and environmental health

6. Gender and Social Considerations

- Actively involve women and marginalized groups in planning and decision-making processes related to port resilience.
- Develop evacuation and sheltering plans that address the specific needs of women, children, the elderly, and persons with disabilities.
- Promote local workforce capacity-building programs to enhance community participation in resilience planning.
- Implement gender-sensitive emergency response measures to ensure equitable access to relief and recovery resources.

7. Linkage to National Adaptation Plan (NAP) Projects

This project aligns with Bangladesh's National Adaptation Plan (NAP), particularly under the protection and management of potentially vulnerable areas due to tropical cyclones, sea-level rise, extreme storm surges, and flooding. The key linkages include:

- Strengthening critical transport infrastructure to enhance climate resilience.
- Integrating nature-based solutions to mitigate climate-induced risks.
- Improving disaster preparedness and response mechanisms for coastal and riverine ports.
- Supporting sustainable urban and industrial development by reducing climate vulnerabilities.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Challenges
Government Funding	National adaptation and infrastructure resilience programs	Ensures national ownership and policy alignment	Budget constraints and competing national priorities
Multilateral Development Banks (MDBs)	World Bank, Asian Development Bank, Green Climate Fund	Large-scale concessional financing with technical support	Lengthy approval process and compliance requirements
Public-Private Partnerships (PPPs)	Private investors, port authorities, shipping companies	Encourages private sector participation and efficiency	Risk-sharing complexities and regulatory hurdles
Climate Bonds & Concessional Loans	Green bond issuers, development finance institutions	Access to long-term low-cost financing	Requires strong creditworthiness and feasibility studies
Corporate Social Responsibility (CSR) Contributions	Logistics, maritime, and industrial corporations	Supports corporate sustainability goals	Limited funding scale and voluntary nature
Blended Finance	Combination of public and private funds	Leverages both public and private investments	Coordination challenges between multiple stakeholders

International Climate Grants	Global Environment Facility (GEF), Adaptation Fund	Grants reduce financial burden on the government	Highly competitive application process

9. Critical Considerations and Future Outlook
    - Long-Term Sustainability: Continuous monitoring, evaluation, and adaptation of resilience strategies based on climate trends and technological advancements.
    - Policy and Governance: Strengthening regulatory frameworks and integrating resilience requirements into national infrastructure policies.
    - Community Engagement: Ensuring local stakeholder participation in resilience-building efforts to maximize social and economic co-benefits.
    - Innovation and Research: Encouraging research partnerships for the development of cost-effective, nature-based, and technological solutions for port resilience.
    - Regional Collaboration: Enhancing cross-border cooperation for knowledge exchange, best practices, and coordinated disaster response mechanisms.
10. Estimated Investment Cost

The estimated investment cost will include:

- Structural reinforcements and retrofitting costs for port buildings and equipment.
- Procurement and installation of wind barriers, breakwaters, and storm-resistant materials.
- Training, capacity-building programs, and emergency preparedness measures.
- Technology integration for weather monitoring and real-time disaster management.

11. Economic and Financial Benefits
    - Significant reduction in the frequency and severity of road flooding, ensuring year-round functionality of coastal transport networks.
    - Decreased maintenance costs due to improved resilience of infrastructure.
    - Reduced economic losses from road closures and transport disruptions, ensuring uninterrupted access to markets, services, and emergency response routes.
    - Increased investor confidence in resilient and climate-proof infrastructure, fostering economic growth.
12. Stakeholder Consultations

Consultations were conducted in **Kalapara Upazila of Patuakhali District**, a cyclone-prone coastal region with critical port and logistics infrastructure. The focus was to gather insights from key institutional stakeholders, port users, and community members regarding cyclone impacts, infrastructure vulnerability, and potential resilience strategies.

Stakeholder Group	Role in the Project	Consultation Approach
Local Government Engineering Department (LGED)	Responsible for public infrastructure near ports including roads and embankments	Key Informant Interview (KII)
Project Implementation Office (PIO)	Coordinates public works projects and port-side development	Key Informant Interview (KII)
Male Community Members	Port laborers, boat operators, and logistics workers affected by cyclone wind damage	Focus Group Discussion (FGD) – Male
Female Community Members	Fish vendors, caregivers, and informal workers dependent on port access and services	Focus Group Discussion (FGD) – Female
Cyclone-Affected Households	End users of port services and dependents on port-based transport and livelihoods	Household Survey (n=100)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Port users and residents of Kolapara near major cyclone-exposed transport terminals

Key Observations:

- Cyclone Impact and Disruption:
- Port users highlighted that cyclone winds regularly damage jetties, destroy temporary shelters, and disrupt transport of goods.
- Women vendors expressed concern about absence of cyclone-resistant market stalls and lighting around ports.
- Safety and Mobility Challenges:
- During storms, cargo and passengers are stranded without access to safe evacuation routes.
- Children and elderly struggle to navigate collapsed structures and debris around port areas.
-
- Community ~~Suggestions~~suggestions~~:~~ include
  - ~~Install~~ installment of wind-resistant roofing and anchoring mechanisms at all terminals~~.~~
- ~~I~~, introduction of~~e~~ designated shelter areas and drainage-friendly port surfaces, and promoting local women's participation in emergency drills and response planning.~~.~~
- ~~Promote local women's participation in emergency drills and response planning.~~

Figure 10: FGD of Female Participants in Patuakhali

13.2 Household Survey Outcomes

Profile: 100 households from port-adjacent unions in Patuakhali

Key Findings:

- Exposure and Damage:
- 72% of households reported port-related access disruption during the last cyclone.
- 64% observed significant debris, damaged structures, or wind-torn materials near loading zones.
- Service Disruption and Risk:
- 57% experienced delayed access to food, fuel, or transport due to cyclone impacts at port facilities.

- 46% said emergency services took over 12 hours to reach port areas post-cyclone.
- Resilience Gaps:
- 84% demanded better warning systems and protected cargo handling zones.
- 69% supported the use of natural barriers (e.g., mangroves or sand dunes) to protect port facilities.
- Recommendations by Respondents:
- Elevate port platforms and storage depots.
- Integrate solar lighting and resilient roofing to support night operations and shelter use.
- Create gender-responsive shelter spaces and sanitation around port zones.

13.3 Key Informant Interviews (KIIs)

Interviewees: LGED Engineer and PIO Officer – Kalapara

Key Insights:

- Infrastructure Weaknesses:
- Ports lack consistent structural design standards; many use corrugated tin and bamboo components.
- Drainage near terminals is insufficient, leading to rapid flooding and waterlogging.
- Institutional Constraints:
- Cyclone preparedness exists on paper but lacks practical training or joint drills.
- Emergency response logistics are not aligned between port authorities and LGED.
- Strategic Recommendations:
- Develop engineering manuals for cyclone-proof port design.
- Use nature-based solutions like green buffer zones and water-sensitive construction materials.
- Link port response systems with Union Disaster Committees and civil society volunteers.

13.4 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Port facilities suffer wind damage and disrepair, disrupting local logistics and markets	Objective 1: Enhance structural resilience of ports	FGDs, KIIs, HH Survey
Cyclones delay access to basic goods and services for port-dependent communities	Objective 2: Minimize economic and operational disruptions	HH Survey, FGDs
Emergency response and evacuation logistics at ports are poorly planned and coordinated	Objective 3: Improve preparedness and response capabilities	KIIs, HH Survey
Communities support green buffers and natural reinforcements to protect infrastructure	Objective 4: Integrate nature-based solutions for long-term resilience	HH Survey, FGDs
Women face safety, sanitation, and mobility challenges around port areas during disasters	Objective 5: Ensure inclusive and gender-responsive resilience measures	FGDs (Female), HH Survey
Local recommendations align with SDGs on infrastructure, cities, and climate resilience	Objective 6: Align outcomes with SDGs 9, 11, and 13	FGDs, KIIs, HH Survey

14 Conclusion

Investing in climate-resilient port infrastructure is vital for ensuring the sustainability and efficiency of Bangladesh's transport and trade sectors. The proposed measures will help mitigate cyclone-induced damages, reduce economic losses, and enhance long-term resilience against climate change. By integrating structural, operational, and nature-based solutions, alongside comprehensive financing

strategies and multi-stakeholder collaboration, this project will set a benchmark for sustainable infrastructure development in climate-vulnerable regions. The alignment with SDGs further underscores the project's broader impact in fostering sustainable development and climate resilience.

1.2 BUILDING URBAN TRANSPORT RESILIENCE IN COASTAL DISTRICTS THROUGH CLIMATE-RESPONSIVE INFRASTRUCTURE DESIGN AND INTEGRATED PLANNING

1. Introduction

Bangladesh's urban coastal areas are increasingly facing the compounded effects of climate change—frequent flooding, extreme rainfall, sea-level rise, and storm surges. These phenomena place immense pressure on already fragile urban transport systems, particularly roads and related infrastructure. In low-lying urban zones, such as those in the 19 coastal districts of Bangladesh, climate-related damage to transport infrastructure is becoming more frequent, costly, and socially disruptive.

Transport systems are the backbone of urban economies. When these systems are disrupted, people cannot access jobs, markets, health services, or emergency relief. Repeated flood damage to roads causes long-term mobility challenges, loss of productivity, and social vulnerability, particularly among women, the elderly, and the urban poor.

This concept proposes to strengthen transport resilience in 19 coastal districts of Bangladesh through climate-responsive infrastructure design and integrated planning strategies. These interventions will ensure the long-term operability of roads and urban transport networks while promoting inclusive development and climate adaptation across vulnerable communities.

Figure 11: Road Infrastructure in Patuakhali

2. Objectives

- Implement climate-resilient infrastructure design in urban transport systems vulnerable to flooding and climate shocks.
- Reduce economic losses and disruptions through strengthened transport functionality and reliability.
- Promote integrated land-use and transport planning responsive to climate scenarios.
- Ensure inclusive, gender-equitable, and locally relevant transport infrastructure development.
- Align project outcomes with SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).

3. Justification for Selected Locations

The 19 coastal districts of Bangladesh are characterized by dense urban settlements, low elevation, inadequate drainage systems, and exposure to climate hazards. These districts regularly experience waterlogging, urban flooding, and saline intrusion, severely compromising their road networks. As urbanization accelerates, the lack of resilient transport planning further exacerbates risk exposure.

District	Key Vulnerability Factors	Strategic Importance
Chattogram, Khulna, Barisal	Coastal exposure, high urban density, flood-prone	Major economic, administrative, and port hubs
Satkhira, Bagerhat, Patuakhali	Regular tidal flooding, weak embankments	Key coastal municipalities requiring climate-resilient access
Noakhali, Bhola, Barguna	Storm surge exposure, limited urban drainage	Isolated yet populated districts with poor road reliability
Cox's Bazar, Laxmipur, Feni	Urban sprawl, erosion, high tourism dependency	Growing towns needing infrastructure investment
Patuakhali	Recurrent flooding, low road elevation	Crucial for rural-urban market connectivity

Investments in these districts are essential for ensuring sustained urban development, regional trade, and disaster resilience.

4. Key Climate Resilience Measures

Infrastructure Design

- Climate-Resilient Roads: Construct or upgrade roads using high-durability materials capable of withstanding extreme weather and saline conditions. Elevate roads in flood-prone urban sections to remain functional during heavy rainfall and tidal surges.
- Improved Drainage Systems: Integrate underground and surface drainage networks, including culverts, retention ponds, and pumping stations, to remove stormwater from roads and public spaces.
- Reinforced Intersections and Public Transit Corridors: Apply special design treatments at high-traffic urban nodes and transit corridors to improve flood resistance and maintain mobility during climate events.
- Use of Green Infrastructure: Incorporate bioswales, permeable pavements, and roadside greenery to enhance stormwater absorption and reduce heat islands.

Integrated Planning

- Land Use and Transport Planning: Mainstream climate adaptation into urban planning by aligning zoning, road design, and drainage with updated flood risk models.

- Transport-Oriented Development (TOD): Promote compact, walkable neighborhoods with multimodal access, reducing over-reliance on vulnerable roads.
- Data-Driven Risk Mapping: Develop and apply geospatial tools and urban climate data to prioritize resilience investments based on vulnerability and population exposure.

5. Expected Outputs and Impacts

Expected Output/Impact	Key Benefits
Improved resilience of urban roads	Ensures transport continuity during extreme weather events
Decreased maintenance and repair costs	Enhances financial sustainability of municipal budgets
Economic revitalization	Secures access to jobs, markets, and public services in urban areas
Reduced transport disruptions	Improves logistics, emergency response, and mobility for vulnerable groups
Climate-adapted planning practices	Embeds resilience into the urban development process

6. Gender and Social Considerations

Urban infrastructure must serve all, especially the most vulnerable. This project will address social inclusion by:

- Inclusive Planning: Actively involving women, youth, the elderly, and persons with disabilities in transport planning and feedback mechanisms.
- Employment Opportunities: Promoting gender-equitable hiring practices in road construction, maintenance, and drainage system management.
- Safety and Accessibility: Designing sidewalks, intersections, and public transport stops that are safe and accessible for all user groups, including lighting and signage improvements.
- Community-Led Maintenance: Creating local maintenance teams, particularly involving women, to oversee neighborhood-level upkeep and drainage clearing.

Figure 12: FGD of Female Participants In Patuakhali

7. Linkage to National Adaptation Plan (NAP) Projects

This project aligns with Bangladesh's NAP priorities on urban resilience and infrastructure protection, particularly:

- Integrating climate adaptation into **municipal planning and infrastructure design**.
- Strengthening **drainage, road, and public service systems** in cities exposed to climate hazards.
- Supporting **resilient urban mobility** to ensure connectivity during climate events.
- Promoting **inclusive, gender-responsive adaptation actions** at the local level.

It also complements the NAP objective of enabling climate-informed, spatial development for long-term urban growth.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Challenges
Government Programs	LGED, Ministry of LGRD&C, City Corporations	Aligns with national priorities	Limited fiscal space and budget trade-offs
Multilateral Development Banks	ADB, World Bank, AIIB, GCF	Access to concessional loans and technical expertise	Requires robust project preparation and safeguards
Public Private Partnership	Private Investors	Encourages cost recovery and private efficiency	Institutional readiness for local PPPs may be low

Climate Bonds and Grants	GCF, Adaptation Fund, Climate Resilience Bonds	Leverages capital markets for long-term investment	Creditworthiness and certification criteria may be strict
Blended Finance	Combining public funds, donor support, private equity	Unlocks large capital pools with shared risks	Coordination among diverse stakeholders required

9. Critical Considerations and Future Outlook

- Sustainability: Institutionalize climate resilience into urban road design standards, maintenance protocols, and municipal capacity-building programs.
- Policy Reforms: Update building codes, zoning regulations, and road design manuals to reflect climate exposure and resilience principles.
- Technology and Innovation: Use smart urban tools—sensors, apps, data dashboards—for climate monitoring, transport alerts, and citizen feedback.
- Private Sector Role: Engage private developers and construction firms to innovate on flood-resistant materials and green engineering.
- Replication and Scaling: Position this project as a scalable model for secondary cities in Bangladesh and climate-vulnerable urban zones in South Asia.

10. Estimated Investment Cost

The total investment will support:

- Road elevation and climate-proofing of key transport corridors
- Expansion and modernization of urban drainage networks
- Resilient upgrading of intersections, bus terminals, and sidewalks
- Planning tools and capacity development for integrated infrastructure management
- Community training and employment generation programs

11. Economic and Financial Benefits

- Reduction in annual damage costs from urban flooding, potentially saving millions in road repairs and loss of income.
- Increased labor productivity due to better commuting conditions and reduced downtime during flood events.
- Stimulation of local economies through job creation, market access, and reduced business disruption.
- Higher investor and land value confidence in flood-resilient infrastructure zones.
- Improved municipal creditworthiness through sustainable infrastructure asset performance.

12. Stakeholder Consultations and Field Data Observations

12.1 Stakeholder Consultations

Stakeholder consultations were conducted with key institutions and community groups in Baliatoli, Kalapara, Patuakhali, to ensure the project design reflects local needs and institutional capacities.

Stakeholder Group	Role in the Project	Consultation Approach

Bangladesh Water Development Board (BWDB)	Management of polders, embankments, and flood mitigation	KII with BWDB representative
Bangladesh Inland Water Transport Authority (BIWTA)	Oversight of inland water transport and river dredging	KII with BIWTA representative
Women and Men from Communities	Direct users and observers of road infrastructure	FGDs (separate for male and female participants)
Households in Affected Areas	Daily road users impacted by climate-related disruptions	Household surveys targeting diverse demographic groups

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Separate sessions were conducted with adult women and men from flood-affected areas in Baliatoli, Kalapara, Patuakhali.

Observations:

- Dependence on Poor Infrastructure: Residents rely heavily on the college road for daily activities, education, healthcare, and disaster survival. Poor road conditions severely limit access to essential services, forcing children to endure dangerous journeys to school and delaying emergency medical care.
- Climate Hazards and Impacts: Frequent floods, tidal surges, and heavy rainfall have worsened road conditions over the past 4–5 years, submerging homes and roads for 7–10 days annually. Erosion near culverts and steep areas has further damaged infrastructure, isolating communities.
- Lack of Repairs and Accountability: Residents are unaware of responsible authorities for road maintenance. Minimal temporary repairs (e.g., road-filling) have been done, but no sustainable solutions or new cyclone shelters have been implemented.
- Community Priorities: Both women and men emphasized the urgent need for climate-resilient roads and accessible cyclone shelters to reduce travel time to schools (currently 1 hour) and hospitals (1.5 hours), and to provide safe refuge during disasters.
- Economic and Environmental Benefits: Resilient infrastructure would cut repair costs, improve crop transport, reduce dust pollution, and boost livelihoods (e.g., van pullers, farmers). Tree planting along roadsides was suggested to mitigate environmental damage.
- Local Solutions and Challenges: Male participants proposed flood-resistant materials, elevated roads, and drainage improvements. Women highlighted safety risks, such as lack of lighting near shelters. The community unanimously supports infrastructure restoration but stressed the need for accountability and long-term maintenance.

13.2 Household Survey Outcomes

A total of 100 households were surveyed, representing farmers, transport workers, and other community members in Patuakhali.

- Access and Disruption: 73% reported roads become impassable during floods. 81% depend on transport infrastructure for daily activities, and 35% rely on it for livelihoods. 32% faced challenges reaching cyclone shelters during recent disasters.
- Community Preferences: 88% prioritized elevated roads made of reinforced concrete (RCC). 67% emphasized improved drainage systems to prevent waterlogging. 97% supported nature-based solutions like mangrove restoration and roadside tree planting.

- **Socioeconomic Impact:** 37% reported income loss due to damaged infrastructure, with 8% facing complete livelihood disruption. Women-headed households (4% of surveyed households) faced heightened challenges accessing services.

13.3 Key Informant Interviews (KIIs)

KIIs with institutional stakeholders provided system-level insights, with findings from BIWTA and BWDB summarized below.

BIWTA:

BIWTA respondent noted Rangabali's extreme vulnerability to cyclones due to unstable land and insufficient mangroves, making jetty construction unsustainable. Dependency on inland water routes has declined since the Padma Bridge, but rivers like Agunmukha and Tetulia exacerbate soil erosion. Continued dredging is prioritized to maintain navigable paths, and mangrove restoration was suggested to enhance natural protection. Technical questions were deferred to the Barishal Engineering division, highlighting coordination gaps.

BWDB:

BWDB respondent, overseeing polders in Golachipa, Mirjaganj, and Patuakhali Sadar, reported that vulnerable embankments urgently need repairs, with Mirjaganj most at risk. Funding shortages limit repairs, and delayed contractor payments discourage timely work. Flash floods inundate areas, though sluice gates help. Integrating road upgrades with polder restoration and using community labor for maintenance were recommended, alongside securing funds to address repair backlogs.

13.4 Synthesis of Total Findings and Objective Linkage

Key Findings	Linked Project Objectives	Evidence Reference
Roads are frequently submerged or eroded, disrupting access to markets, schools, and hospitals	Objective 1 & 3: Improve resilience and emergency access	FGDs, Household Survey (Chart 1), BWDB KII
Communities face income loss and livelihood disruptions due to damaged infrastructure	Objective 2: Minimize economic and operational disruption	Household Survey (Chart 2), Male FGD
Cyclone shelters are inaccessible or inadequate, posing risks to vulnerable groups	Objective 3: Improve evacuation and emergency response	Female FGD, Household Survey
Women and children face specific mobility and safety risks due to poor road conditions	Objective 4: Gender-responsive, inclusive road resilience	Female FGD, Household Survey (Figure 4)
Communities value nature-based solutions like tree planting and mangrove restoration	Objective 1 & 5: Localized, sustainable solutions	FGDs, Household Survey (Table 5), BIWTA KII
Drainage systems and polder maintenance are disconnected, exacerbating flood impacts	Objective 5: Holistic infrastructure systems	BWDB KII, Household Survey (Table 7)
Community support is high for climate-resilient infrastructure, with readiness for local involvement	Objective 4: Inclusive and participatory project planning	FGDs, Household Survey (Figure 12)
Local authorities are engaged and willing to coordinate implementation	Objective 3 & 5: Strengthen governance and SDG alignment	BWDB KII, BIWTA KII, FGDs

14. Conclusion

Climate-resilient urban transport infrastructure is indispensable for Bangladesh's sustainable future, especially in its 19 vulnerable coastal districts. As urban populations grow and climate hazards intensify, this concept provides a practical, inclusive, and scalable blueprint to secure roads, improve mobility, and safeguard urban livelihoods.

Through the integration of traditional infrastructure design with modern planning practices, this project aligns with global resilience goals and national adaptation pathways. It will not only protect physical infrastructure but also empower communities, reduce gender inequality, and unlock inclusive urban growth in some of Bangladesh's most climate-exposed regions.

1.3 STRENGTHENING ROAD INFRASTRUCTURE THROUGH TRADITIONAL ENGINEERING SOLUTIONS IN THE MOST VULNERABLE COASTAL UPAZILAS

1. Introduction

Bangladesh's coastal upazilas are lifelines for millions of people, supporting trade, agriculture, health services, and emergency response operations. However, these low-lying regions are highly susceptible to the adverse impacts of climate change, including storm surges, tidal floods, cyclonic winds, and salinity intrusion. The roads in these areas, typically constructed at low elevations with limited flood-resilient features, suffer recurrent damage, leading to long-term accessibility issues, economic losses, and isolation during emergencies.

Particularly vulnerable are the upazilas of Shyamnagar (Satkhira district), Patuakhali Sadar and Kalapara (Patuakhali district), and Hatiya (Noakhali district). These regions are exposed to cyclones, heavy rainfall, sea-level rise, and saline water intrusion. Frequent road washouts and severe infrastructure degradation hamper regular transport services, hinder access to healthcare, schools, and markets, and restrict timely evacuation during disasters. As climate events intensify, traditional engineering solutions can play a pivotal role in making road infrastructure more resilient, practical, and cost-effective in these vulnerable settings.

Strengthening road infrastructure using proven, traditional engineering methods is critical to ensuring year-round functionality, safeguarding lives and livelihoods, and maintaining the socioeconomic fabric of these high-risk areas.

Figure 13: Road Infrastructure in Hatiya

2. Objectives

- Enhance the structural resilience of critical road infrastructure to withstand cyclones, tidal surges, and floods.
- Minimize economic and operational disruptions caused by road damage and closures in extreme weather conditions.

- **Improve emergency evacuation and response capacity** by maintaining all-weather, safe road access routes.
- **Ensure community-focused, inclusive, and gender-responsive resilience measures** for road users and residents.
- **Align the project's outcomes** with Sustainable Development Goals (SDGs), particularly **SDG 9 (Industry, Innovation, and Infrastructure)**, **SDG 11 (Sustainable Cities and Communities)**, and **SDG 13 (Climate Action)**.

3. Justification for Selected Locations

The proposed upazilas are highly strategic and critical for local and regional connectivity. These areas are characterized by poor road conditions, chronic exposure to climate-induced hazards, and high dependence on functional road networks for socio-economic activities and disaster resilience.

Upazila	Key Vulnerability Factors	Strategic Importance
Shyamnagar (Satkhira)	Coastal floodplain, saline intrusion, cyclones	Key route for fisheries, agriculture, and cyclone shelters access
Patuakhali Sadar	Tidal flooding, storm surges, weak embankments	Main urban and administrative centre, critical market and service hub
Kalapara (Patuakhali)	Low-lying coastal area, cyclone-prone, erosion	Major tourism, fisheries, and transport hub; gateway to Kuakata beach
Hatiya (Noakhali)	Island upazila, storm surges, isolation risk	Critical for ferry and river transport, disaster response, and agriculture

These high-priority locations were selected based on their **exposure to extreme weather events, strategic transport value, and the significant socioeconomic risks posed by road failures**.

4. Key Climate Resilience Measures

Infrastructure Strengthening

- **Elevating Roads Above Flood Levels**: Raising the height of critical roads above the 50-year flood level to prevent regular inundation and allow continuous movement during emergencies.
- **Reinforcing Road Shoulders and Embankments**: Using durable, locally available materials such as compacted earth, concrete blocks, and stone pitching to reduce erosion and flood-induced washouts.
- **Improved Drainage Systems**: Constructing subsurface and side-drain systems with culverts and cross-drains to ensure fast stormwater discharge and minimize waterlogging during heavy rainfall.
- **Application of Flood-Resistant Road Materials**: Utilizing reinforced concrete, high-strength bitumen mixes, and sub-base materials that can resist saline and floodwater damage.
- **Protective Flood Barriers and Seawalls**: Where necessary, installing reinforced concrete flood walls, retaining structures, and revetments along vulnerable road stretches adjacent to rivers, canals, or open sea.

Operational and Institutional Measures

- **Routine Maintenance and Inspection**: Establishing a program for regular inspection, minor repairs, and prompt emergency response to infrastructure damage.
- **Early Warning System Integration**: Linking roads to existing flood and cyclone early warning systems for pre-emptive closures, diversions, or evacuation operations.

- **Staff and Community Training**: Developing capacity-building programs for local authorities, contractors, and communities on road safety, flood management, and emergency operations.

5. Expected Outputs and Impacts

Expected Impact	Key Benefits
Reduction in road disruptions and flooding	Ensures continuous movement of people, goods, and emergency services
Lower infrastructure maintenance costs	Decreases recurrent repair expenses and asset losses
Increased economic and social stability	Enhances access to markets, services, and employment opportunities
Improved evacuation and disaster response	Facilitates faster, safer relocation during extreme events
Enhanced safety and resilience of roads	Protects communities and supports sustainable development goals

6. Gender and Social Considerations

The project will prioritize **inclusive participation of women, persons with disabilities, and marginalized groups** throughout planning, implementation, and monitoring phases. Specific actions include:

- Actively involving women's groups and vulnerable households in community consultations and resilience planning.
- Creating targeted employment and skill-building opportunities for women in road maintenance, construction, and awareness programs.
- Designing roads with **gender-sensitive features**, such as safe waiting areas, lighting, and easy access to emergency shelters.
- Developing evacuation and emergency service plans that consider the specific needs of women, children, elderly, and persons with disabilities.

7. Linkage to National Adaptation Plan (NAP) Projects

This project aligns directly with **Bangladesh's National Adaptation Plan (NAP)** under its key thematic area of *"protection and management of potentially vulnerable areas due to tropical cyclones, flooding, and sea-level rise."* The core linkages include:

- Strengthening climate-resilient road infrastructure in vulnerable coastal upazilas.
- Improving stormwater drainage, embankments, and flood-protective structures.
- Enhancing disaster preparedness and emergency accessibility.
- Supporting sustainable, inclusive, and resilient rural and urban connectivity systems.

This project contributes to achieving the national priority of **reducing climate vulnerabilities and strengthening climate-resilient infrastructure systems** for long-term disaster risk reduction.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Challenges
Government Funding	Ministry of Local Government (LGED), ADP funds	Ensures national ownership, supports local priorities	Budget limitations, competing sectoral demands

Multilateral Development Banks	World Bank, Asian Development Bank, AIIB	Access to concessional, large-scale climate-resilient infrastructure financing	Lengthy approval processes, strict compliance standards
Public-Private Partnerships (PPPs)	Private construction firms, transport operators	Encourages private sector innovation and cost-efficiency	Risk-sharing complexities, local PPP policy constraints
Climate Bonds and Concessional Loans	Green bond issuers, development finance institutions	Access to low-cost, long-term financing for resilient infrastructure	Requires feasibility studies and solid financial structuring
CSR Contributions	Logistics and industrial companies operating locally	Strengthens local ownership and private sector community engagement	Voluntary nature, often limited in scale
Blended Finance	Combination of public, private, and concessional funds	Leverages diverse financing sources and spreads risks	Coordination and regulatory alignment between multiple actors
International Climate Grants	Green Climate Fund (GCF), Adaptation Fund	Eases government financing burden, promotes international alignment	Highly competitive and time-consuming application processes

9. Critical Considerations and Future Outlook

- Lifecycle Approach: The project will apply a full lifecycle perspective—covering planning, design, construction, routine maintenance, and rehabilitation—to ensure infrastructure durability and long-term value for money. Roads will be designed not only to withstand current climate conditions but also to remain functional under future climate scenarios.
- Long-Term Sustainability: Establish mechanisms for continuous road performance monitoring, maintenance, and adaptation based on evolving climate risks and technological options.
- Policy and Governance: Strengthen regulatory guidelines, technical standards, and road design manuals to incorporate climate resilience measures for coastal roads.
- Community Engagement: Involve local residents, NGOs, and women's organizations in planning, implementation, and maintenance to foster ownership and improve outcomes.
- Innovation and Research: Support partnerships with research institutions and universities for developing context-specific engineering solutions, innovative materials, and climate data analytics.
- Regional Collaboration: Facilitate knowledge exchange and cross-learning with other coastal regions of Bangladesh and South Asia to replicate good practices and improve regional resilience.

10. Estimated Investment Cost

The estimated investment cost will cover:

- Road elevation and embankment reinforcement
- Procurement of flood-resistant road construction materials
- Construction of drainage systems, culverts, and protective barriers
- Capacity building, community training, and emergency preparedness programs

- Procurement of equipment for regular inspections and minor maintenance
- Integration of early warning systems and digital monitoring tools

Preliminary assessments suggest an estimated requirement of USD 30–50 million for implementation across the four upazilas, subject to detailed feasibility studies and site-specific engineering design.

11. Economic and Financial Benefits

- Reduction in road flooding frequency and severity, securing uninterrupted road access.
- Decreased maintenance and reconstruction costs due to more durable, flood-resilient infrastructure.
- Minimized economic losses from transport disruptions, safeguarding access to markets, services, and emergency routes.
- Boosted investor and public confidence in resilient infrastructure, fostering private sector participation.
- Creation of local employment opportunities during construction, maintenance, and operational phases.

12. Stakeholder Consultations

Comprehensive consultations has been conducted with key stakeholders to ensure alignment with community priorities, technical standards, and operational capacity. The location of consultation wad in Hatiya Upazila of Noakhali District, one of the most climate-vulnerable coastal regions in Bangladesh

Stakeholder Group	Role in the Project	Consultation Approach
Local Government Engineering Department (LGED)	Road design, construction, and maintenance coordination	Key Informant Interviews (KIIs) with engineers at Upazila level
UNO Office (Upazila Nirbahi Officer)	Administrative oversight and coordination of disaster response	KII with UNO representative in Hatiya
DPHE (Department of Public Health Engineering)	Integration of WASH and drainage systems with road planning	KII in Hatiya upazila
Union Parishads and Local Key Persons (LKPs)	Local road prioritization, monitoring, and community mobilization	KIIs with Union Parishad representatives and community leaders
Male and Female Community Members	Road users, direct beneficiaries, and community observers	Focus Group Discussions (FGDs) with gender-segregated groups
Households in Hatiya	Daily road users, affected by disruptions and flood events	Household surveys targeting diverse demographic groups

13. Field Data and Observations

A field assessment will be undertaken to gather updated, site-specific data on road vulnerability, current conditions, and local adaptation practices. The findings will guide final project design and intervention planning.

13.1 Focus Group Discussions (FGDs)

Participants: Separate sessions were conducted with adult women and men from flood-affected unions in Hatiya.

Observations:

- Road Submersion and Inaccessibility: Participants reported that even short-duration rainfall can make roads unusable for 2–5 days. Women cited having to wade through knee-deep water to access clinics or markets during pregnancy or illness.
- Emergency Access Limitations: One group described how a cyclone warning led to a rush toward shelters, but broken or submerged road links caused delays and confusion, especially for those with disabilities or children.
- Traditional Adaptation Practices: Participants mentioned using bamboo planks, broken bricks, and woven coconut fibers to create temporary paths. These methods, while not permanent, reflect high local ingenuity.
- Demand for Community Monitoring: Male participants recommended setting up "village road committees" to report early-stage damage and organize basic repairs using local labor. Women's Safety Needs: The absence of roadside lighting and waiting areas near shelters and boat terminals emerged as a critical safety issue for women, especially during evening emergencies.

Figure 14: FGD of Male Participants in Hatiya

13.2 Household Survey Outcomes

Profile: 50 households surveyed, including women-led households, farmers, transport workers, and low-income families.

Observations:

- Impact of Road Failure:
    - 60% of farming families reported delays in taking perishable products to market, resulting in price drops and spoilage losses.
    - 78% experienced road closures lasting more than 3 days during the last cyclone season.
    - More than 40% used informal crossings—like makeshift bamboo bridges or private boats—when roads failed.
- Household Preferences:
    - 88% preferred elevated concrete roads over earth roads, even if built in segments.
    - 67% requested culverts or cross-drain systems to be included with roads in low-lying areas.

- Women respondents emphasized the need for shelters to be linked with all-weather paths.

- Disaster Evacuation Gaps:
    - 32% of respondents said they had never used formal cyclone shelters due to difficulty reaching them in time.
    - Most households relied on family-level or informal community plans rather than early warnings due to lack of road access.

13.3 Key Informant Interviews (KIIs)

Interviewed Stakeholders: Upazila LGED Engineers, UNO Office, DPHE, and Union Parishad members.

Observations:

- LGED Observations:
    - Field engineers confirmed that many rural roads in Hatiya lack proper sub-base or slope protection, making them highly vulnerable to erosion.
    - LGED supports use of layered bamboo reinforcement and RCC block pitching in certain stretches as cost-effective methods.

Figure 15: KII of LKP

- UNO Office:
    - Shared concern that in 2023, multiple cyclone evacuation alerts were not properly executed due to broken roads and flooded transport routes.

- Advocated for digital integration—using SMS and local loudspeakers to alert communities before road closures.

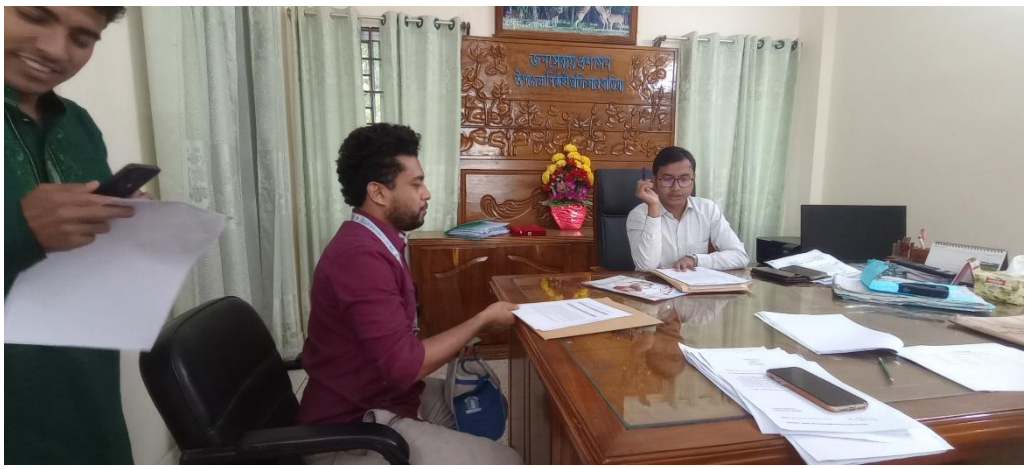

Figure 16: KII of UNO

- Union Parishad Feedback:
  - Local leaders proposed aligning new road development with embankment rehabilitation to maximize flood protection.
  - Suggested that maintenance budgets include allocations for community contracting and small tools/equipment.
- DPHE Coordination Insights:
  - Highlighted overlap between waterlogging in roads and poor drainage from sanitation systems. Joint planning was recommended to reduce cross-sector vulnerabilities.

Figure 17: KII of DPHE Official

13.4 Integration of Total Findings and Alignment with Project Objectives

The following findings integrate qualitative insights from FGDs and KIIs, alongside quantitative trends from household surveys. This composite view helps tailor interventions that are both technically sound and socially relevant, directly contributing to the project's core objectives.

Key Findings	Linked Project Objectives	Evidence Reference
Frequent road disruptions during floods, especially in low-lying and riverside unions	Objective 1 & 3: Improve structural resilience and maintain safe access during disasters	FGDs, KIIs, Household Survey
Perishable goods and daily livelihoods are impacted by road failure	Objective 2: Minimize economic disruption from road damage	Household Survey
Critical gaps in emergency evacuation due to poor connectivity with cyclone shelters	Objective 3: Improve disaster response capacity	FGDs, KIIs, Household Survey (*32% never reached cyclone shelters in time*)
Lack of lighting, road safety, and shelter access creates gender-specific risks	Objective 4: Ensure gender-responsive and inclusive resilience measures	FGDs – Women's Group
Locally tested, traditional engineering (e.g., raised paths, bamboo mat reinforcement) offers promising, low-cost techniques	Objective 1 & 5: Promote context-appropriate, sustainable resilience strategies	FGDs, KIIs
Drainage issues overlap with health risks; infrastructure planning must consider WASH	Objective 5: Align road resilience with wider sustainability goals	KII – DPHE
Strong potential for community-based maintenance systems and local contracting	Objective 4: Encourage inclusive, community-driven implementation	FGDs, KIIs, Household Survey
Institutional stakeholders are willing to coordinate efforts if technical and financial support is provided	Objective 3 & 5: Strengthen governance and align with SDG implementation	KIIs – LGED, UNO, Union Parishad

14. Conclusion

Strengthening road infrastructure in the most vulnerable coastal upazilas of Bangladesh is essential for ensuring **safe, reliable, and climate-resilient transport systems** that support livelihoods, social welfare, and economic growth. The proposed measures — based on traditional engineering practices adapted to current climate risks — will reduce infrastructure losses, improve emergency response capacity, and foster long-term resilience.

By combining **infrastructure improvements, institutional capacity building, and community engagement**, this project can serve as a practical, replicable model for climate-resilient infrastructure development across other coastal regions in Bangladesh. The alignment with national adaptation priorities and SDG goals further reinforces its strategic importance for sustainable, inclusive, and climate-resilient growth.

1.4 FLOOD-PROOFING COASTAL ROAD INFRASTRUCTURE USING NATURE-BASED SOLUTIONS

1. Introduction

Bangladesh's coastal road infrastructure is highly vulnerable to recurrent flooding, storm surges, and cyclonic events. These climate hazards increasingly jeopardize the structural integrity of roads, disrupt transport services, and endanger the safety of communities. Conventional hard-engineering approaches—though effective in the short term—often prove unsustainable, expensive, and ecologically disruptive in the long run. In contrast, **nature-based solutions (NbS)** harness ecosystem services to reduce flood risks, restore natural drainage, and enhance long-term infrastructure resilience.

This concept paper proposes the use of NbS—such as mangrove buffers, bioengineered embankments, vegetated swales, and wetland restoration—to **flood-proof vulnerable coastal roads** in Shyamnagar (Satkhira), Kalapara (Patuakhali), Hatiya (Noakhali), and Koyra (Khulna). These areas are repeatedly inundated by tidal surges, heavy rainfall, and riverine floods, making them ideal candidates for ecosystem-based flood resilience interventions. Drawing on the Green Roads for Water (GR4W) framework, the initiative aims to ensure that road infrastructure not only withstands flooding but also contributes to improved water management, soil stability, and long-term landscape resilience. This blended model supports more sustainable, adaptable, and water-sensitive infrastructure development in areas vulnerable to both tidal and riverine floods.

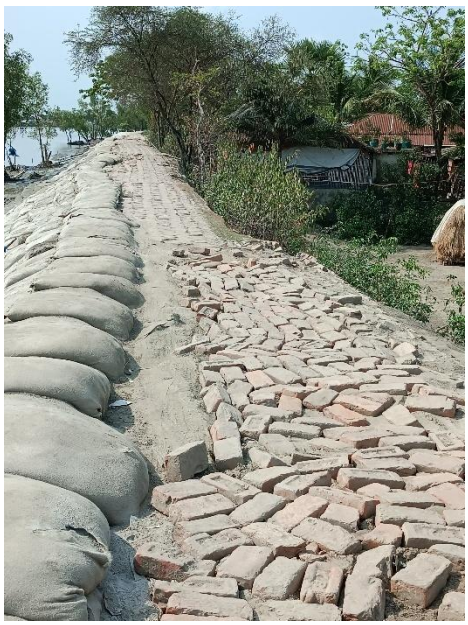

Figure 19: Road Infrastructure in Satkhira

Figure 18: Coastal Road Infrastructure in Satkhira

2. Objectives

- Reduce road flooding through natural water retention, drainage, and barrier systems.
- Restore and conserve coastal ecosystems that mitigate flood intensity and protect roads.
- Enhance long-term climate resilience using cost-effective, low-carbon solutions.
- Promote community stewardship and gender-inclusive participation in ecosystem-based road maintenance.
- Align with SDG 9 (Infrastructure), SDG 13 (Climate Action), and SDG 15 (Life on Land).

3. Justification for Selected Locations

The selected upazilas are flood-prone, ecologically significant, and host critical road corridors. These sites exhibit degraded natural buffers, poor drainage, and vulnerable communities.

Upazila	Key Vulnerability Factors	Ecological and Strategic Value
Shyamnagar (Satkhira)	Cyclones, saline floods, loss of mangrove buffer	Proximity to Sundarbans; essential for fishery and rice trade
Kalapara (Patuakhali)	Low-lying lands, tidal inundation, siltation	Access to Kuakata, aquaculture zone, tourism potential
Hatiya (Noakhali)	Estuarine flooding, sediment instability, embankment failure	Ferry routes, cyclone shelter access, and river connectivity
Faridpur	Riverine flooding, embankment erosion	Major regional hub for river trade and peri-urban connectivity
Koyra (Khulna)	Sea-level rise, cyclone-prone, degraded wetlands	Gateway to Sundarbans; critical for agriculture and safety nets

These areas urgently need integrated approaches combining green and grey infrastructure to improve road climate resilience.

4. Key Nature-Based Measures for Flood-Proofing

This project will adopt a hybrid flood-resilience strategy, integrating nature-based solutions (NbS) with conventional engineering techniques, in line with the Green Roads for Water (GR4W) framework.

Ecosystem Restoration and Buffering

- Mangrove Reforestation: Establishing mangrove belts alongside roads and embankments to act as wave attenuators and sediment traps.
- Salt-Tolerant Green Belts: Planting vetiver grass, nipa palm, and local shrubs along roadsides and embankments for slope stabilization.

Natural Drainage and Flood Attenuation

- Vegetated Swales and Bioswales: Creating roadside swales to absorb rainwater, reduce surface runoff, and filter pollutants.
- Constructed Wetlands and Infiltration Basins: Restoring natural wetlands near roads to retain floodwater and delay peak discharge.

Bioengineered Road Infrastructure

- Permeable Pavements: Using porous materials in low-traffic segments to enhance infiltration and reduce runoff.
- Hybrid Embankments: Combining RCC walls with vegetated outer layers to stabilize slopes and reduce erosion.

Institutional and Operational Measures

- Community-Based Ecosystem Monitoring: Engaging local groups in mangrove care, swale maintenance, and flood damage surveillance.
- Eco-sensitive Road Design Guidelines: Developing design templates and technical manuals incorporating NbS into rural road construction.

5. Expected Outputs and Impacts

Expected Impact	Key Benefits
Reduced flood damage to road assets	Natural buffers decrease direct water impact and erosion
Enhanced biodiversity and green cover	Mangroves, wetlands, and vegetated corridors restore degraded ecosystems

Lower maintenance and repair costs	Sustainable solutions reduce need for recurring hard infrastructure repairs
Community resilience and awareness	Local stewardship improves preparedness and sustainability
Contribution to NDC and SDG targets	Supports low-carbon, climate-smart infrastructure development

6. Gender and Social Inclusion Considerations

The NbS approach integrates equity and inclusion in both design and implementation:

- Community Planting Programs: Women's groups and youth clubs will be engaged in roadside greening and mangrove reforestation.
- Eco-guard Training for Vulnerable Groups: Skill-building in ecosystem monitoring, nursery management, and eco-tourism services.
- Gender-Sensitive Access Design: Roads will include safe waiting spaces, shade, and gender-aware signage for cyclone response.
- Participatory Planning Platforms: Inclusive decision-making through union-level committees representing women and marginalized groups.

7. Linkage to National Adaptation Plan (NAP)

The project aligns with the NAP thematic areas of "ecosystem-based adaptation," "infrastructure resilience," and "risk reduction in coastal zones." Key overlaps include:

- Integrating natural barriers into infrastructure protection strategies.
- Reducing climate risks through hybrid green-grey infrastructure.
- Promoting climate-resilient community development in coastal belts.
- Enhancing biodiversity and water regulation services.

8. Potential Financing Options

Source Type	Contributors	Benefits	Limitations
Government Programs	LGED, DoE, MoEFCC	Institutional support, national ownership	Budget gaps, slow disbursement
International Climate Funds	Green Climate Fund, LDCF, Adaptation Fund	Grants, innovation-friendly funding	Complex application, reporting burdens
Multilateral Development Banks	World Bank, ADB, IFAD	Climate-smart infrastructure financing	Lengthy preparation and loan conditionalities
NGO and Philanthropic Support	IUCN, WWF, regional climate alliances	Technical expertise, seed grants	Often project-specific, small-scale
Public Private Partnership	Private Investors	Encourages cost recovery and private efficiency	Institutional readiness for local PPPs may be low

9. Critical Considerations and Outlook

- Green Roads for Water Integration: The project will apply the GR4W framework to embed water management into road design, construction, and maintenance. Roads will function as both

transportation and water-regulation systems, enhancing flood resilience and groundwater recharge.

- Ecological Integrity: Ensure species selection is native and compatible with coastal ecosystems.
- Technical Capacity: Train LGED and contractors in NbS implementation and bioengineering techniques.
- Local Ownership: Embed NbS in local development plans with Union Parishad and community co-management.
- Policy Synergy: Align with Delta Plan 2100, Mujib Climate Prosperity Plan, and Local Government Road Master Plans.
- Replication Potential: Document learning for scaling up across the southern coast and other deltaic regions.

10. Estimated Investment Cost

Preliminary cost estimates suggest **USD 25–40 million** for four upazilas, depending on site-specific restoration needs and bioengineering design. The budget covers:

- Ecosystem rehabilitation (mangroves, swales, wetlands)
- Bioengineering materials and tools
- Road retrofitting and hybrid design implementation
- Community mobilization and training programs
- Monitoring, evaluation, and digital mapping of flood-prone corridors

11. Economic and Environmental Benefits

- Decreased frequency and duration of road flooding, reducing economic loss from transport delays.
- Increased ecosystem services (carbon sequestration, water filtration, habitat protection).
- Long-term reduction in infrastructure maintenance and climate-related reconstruction costs.
- New income sources through ecosystem services (e.g., eco-tourism, nursery management).
- Strengthened public-private-community partnerships for resilient development.

12. Stakeholder Consultations

Comprehensive consultations has been conducted with key stakeholders to ensure alignment with community priorities, technical standards, and operational capacity. The location of consultation was in Shyamnagar Upzila of Satkhira District, one of the most climate-vulnerable coastal regions in Bangladesh

Stakeholder Group	Role in the Project	Consultation Approach
Union Parishads and Local Key Persons (LKPs)	Local road prioritization, monitoring, and community mobilization	KIIs with Union Parishad representatives and community leaders
Male and Female Community Members	Road users, direct beneficiaries, and community observers	Focus Group Discussions (FGDs) with gender-segregated groups
Households in Shyamnagar	Daily road users, affected by disruptions and flood events	Household surveys targeting diverse demographic groups

13. Field Data and Observations

A field assessment was undertaken to gather updated, site-specific data on road vulnerability, embankment degradation, climate risks, and community priorities in the coastal upazilas of Satkhira.

These insights help tailor the project design around nature-based, climate-resilient infrastructure strategies.

13.1 Focus Group Discussions (FGDs)

Participants: Separate sessions were conducted with adult women and men from flood-prone unions in Shyamnagar Upazila, Satkhira.

Observations:

- Damaged Roads and Daily Inconvenience: Women highlighted that roads connecting Jhapa and Bailtola are often unusable during the rainy season, turning muddy and inaccessible. This restricts access to markets, jobs, and healthcare, particularly for households depending on seasonal income.
- Frequent Flooding and Embankment Collapse: Both groups reported that embankments break almost annually due to rising river tides and cyclonic surges, severely disrupting lives. Residents recalled Cyclones Aila and Sidr causing large-scale flooding, tree loss, and displacement.
- Salinity and Health Impacts: Since Cyclone Aila, local ponds have become saline, forcing families to cook with salty water. The loss of freshwater sources is now a major issue.
- Temporary and Local Repairs: Men noted that dams are often repaired informally by dumping soil or grass, without structural design or slope protection. Such efforts are unsustainable and fail under tidal pressure.
- Community Preferences: There is strong support for climate-resilient embankments and roads that integrate green solutions like slope greening, tree cover, and elevated paths.
- Constraints and Gender Concerns: Women raised concerns about displacement if embankments are built on private land, and emphasized the need for design considerations that avoid forced relocation.

Figure 21: FGD of Male Participants in Satkhira

Figure 20: FGD of Female Participants in Satkhira

13.2 Household Survey

Observations:

- Impact of Infrastructure Failure:

    - Annual embankment breaches lead to loss of homes, farmland, and aquaculture income.
    - Poor roads during monsoon cut off travel to workplaces, reducing income from seasonal gher work (~270 BDT/day).
    - Cyclones and tidal surges result in economic and physical isolation lasting several weeks or even months.
- Household Preferences:
    - Communities favor roads elevated and built inside the dam by ~100 ft.
    - Strong preference for tree-planting and block-reinforced roads.
    - Desire for rainwater harvesting tanks and proper sluice gates to reduce flood damage.
- Evacuation and Access Gaps:
    - Poor roads and embankments limit evacuation during disasters.
    - Salinization of ponds has worsened water insecurity and reduced resilience.
- Livelihood Shifts and Constraints:
    - Shift from agriculture to aquaculture has reduced labor needs.
    - Salinity has rendered land less fertile, reducing income opportunities.

13.3 Key Informant Interviews (KIIs)
Interviewed Stakeholders: Union Parishad Member of Jhapa 7 no, Shyamnagar.

Observations:

- History of Embankment Failure: The 2009 Cyclone Aila completely destroyed local dams. Harimor Street remained underwater for nearly a year.
- Design Suggestions: Climate-resilient dams should be at least 100 ft. long and 20 ft. high, with 24 ft. width on the top. Geo-bags and social forestry are crucial to long-term protection.
- Community-Led Repairs: Last year, residents dumped soil three times to build a temporary slope-dam, but lack of design led to its failure.
- Critical Infrastructure Gaps: Two large 36-inch pipes and several mini-gates allow floodwater entry but lack adequate control. It takes 3–4 months to drain floodwater due to lack of sluice gates.
- At-Risk Locations: Dams in East Jhapa, Chondipur, and Patrail are critically vulnerable.
- Economic Impacts: Shrimp farms and fish enclosures face huge losses. Salinity and waterlogging have made agriculture unviable.
- Recommendations: Integration of resilient dams, tree-based protection, geo-bags, and improved drainage should precede any new infrastructure project.

Figure 22: KII of Union Parishad Member in Satkhira

13.4 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Repeated embankment failures, road submersion, and long-term waterlogging in Satkhira	Objective 1 & 3: Improve structural resilience and maintain safe access during disasters	FGDs, KIIs
Key Findings	Linked Project Objectives	Evidence Reference
Economic disruption due to loss in aquaculture, seasonal income, and degraded road access	Objective 2: Minimize economic disruption from road and embankment damage	FGDs, Household Economic Insights
Lack of early evacuation and mobility due to impassable roads and failed embankments	Objective 3: Improve emergency response and reduce disaster exposure	FGDs, KII
Women's safety and water insecurity due to salinized ponds and road collapse	Objective 4: Ensure inclusive, gender-responsive infrastructure planning	FGDs – Women's Group
Local knowledge supports use of trees, geo-bags, and set-back road placement for resilience	Objective 1 & 5: Promote sustainable and context-relevant engineering approaches	FGDs, KII – Union Parishad
Absence of sluice gates and drainage systems results in prolonged flooding and health risks	Objective 5: Align road resilience with water management and climate adaptation strategies	KII – Union Parishad
Community willingness for co-implementation; emphasis on design, land, and material constraints	Objective 4: Strengthen local engagement and reduce relocation risks	FGDs, KIIs
Institutional knowledge exists but lacks technical and financial integration across sectors	Objective 5: Leverage governance systems for coordinated infrastructure and climate resilience	KII – Union Parishad

14. Conclusion

Nature-based solutions present an innovative, low-carbon, and community-friendly approach to flood-proofing road infrastructure in Bangladesh's vulnerable coastal zones. By restoring natural buffers, improving drainage, and promoting eco-engineered road systems, the project offers a holistic resilience strategy that supports both infrastructure and ecosystems.

Rooted in traditional knowledge and bolstered by modern bioengineering, this initiative aligns with national and global climate goals. It also strengthens the adaptive capacity of communities, reduces disaster risks, and paves the way for sustainable infrastructure in the climate-vulnerable delta landscape of Bangladesh.

1.5 ENHANCING FLOOD RESILIENCE FOR AIRPORT INFRASTRUCTURE

1. Introduction

Airports play a critical role in connectivity, trade, tourism, and emergency response. In Bangladesh, airports such as Cox's Bazar, Khan Jahan Ali (Bagerhat), and Osmani International (Sylhet) are increasingly exposed to flooding due to extreme rainfall, storm surges, and poor drainage. These flood events threaten the functionality of runways, taxiways, and aprons, disrupt flight schedules, endanger passenger safety, and inflict economic losses. Strengthening the flood resilience of airport infrastructure is essential to ensure operational continuity, safeguard assets, and support disaster response and recovery during extreme climate events.

2. Objectives

- Strengthen the physical and operational resilience of airports to extreme rainfall and flood events.
- Ensure continuity of critical airport functions during and after floods.
- Minimize economic losses and disruptions to aviation services.
- Enhance safety for passengers, staff, and surrounding communities.
- Incorporate inclusive and gender-responsive resilience strategies.
- Align project outcomes with SDG 9 (Infrastructure), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action)

3. Justification for Selected Locations

The airports in Cox's Bazar, Bagerhat, and Sylhet are geographically vulnerable due to their proximity to coastal zones and flood-prone areas. These regions experience seasonal flooding, flash floods, and inadequate drainage, which pose severe risks to aviation infrastructure and operations.

Airport	Key Vulnerability Factors	Strategic Importance
Cox's Bazar	Coastal location, cyclonic surges, heavy rainfall	Key tourism and humanitarian logistics hub
Khan Jahan Ali (Bagerhat)	Riverine flooding, drainage limitations	Regional airport for underserved areas
Osmani International (Sylhet)	Flash floods, high precipitation zones	Major link for northeastern region and international flights

4. Key Climate Resilience Measures

Infrastructure Enhancements:

- Raise runway, taxiway, and apron elevations to mitigate flood accumulation.
- Upgrade drainage systems for efficient water removal during heavy rains.
- Install levees and flood barriers around critical airport zones.
- Waterproof electrical and communications systems to prevent flood-related failures.
- Enforce rigorous maintenance and inspections of flood protection mechanisms.

Operational Measures:

- Develop and routinely update emergency preparedness and evacuation plans.
- Conduct regular flood simulation drills with airport staff and emergency responders.
- Establish real-time flood monitoring systems to support proactive responses.

5. Expected Outputs and Impacts

Expected Impact	Key Benefits
Improved airport functionality during floods	Ensures continuity of air services and disaster response
Reduced economic losses from disruptions	Protects aviation-linked revenues
Increased safety for all users	Safeguards lives and critical infrastructure

6. Gender and Social Considerations

- Ensure evacuation plans address the needs of women, children, the elderly, and persons with disabilities.
- Promote gender-inclusive employment in the design, implementation, and monitoring of flood resilience activities.
- Engage local communities, especially women's groups, in awareness and preparedness training.

7. Linkage to National Adaptation Plan (NAP) Projects

This concept aligns with Bangladesh's NAP objectives under climate-resilient infrastructure in high-risk areas. Specific linkages include:

- Building climate-resilient houses, education & communication infrastructure.
- Enhancing flood protection for transport infrastructure in flood-prone zones.
- Strengthening institutional capacity to respond to extreme weather in aviation.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Challenges
Government Budget	Ministry of Civil Aviation, CAAB	Alignment with national priorities	Competing funding needs
MDBs	ADB, World Bank, AIIB	Technical and financial support	Project preparation requirements
Climate Funds	Green Climate Fund, Adaptation Fund	Focus on resilience and adaptation	Competitive access
PPP Models	Airport operators	Encourages innovation and co-investment	Risk-sharing complexities

9. Critical Considerations and Future Outlook

- **Sustainability:** Regular upgrades and adaptive planning to match changing climate risks.
- **Governance:** Strengthening airport disaster risk management policies.
- **Community Engagement:** Mobilizing local stakeholders for flood preparedness.
- **Innovation:** Piloting smart drainage and sensor-based flood alert systems.
- **Coordination:** Aligning with national and local disaster risk reduction strategies.

10. Estimated Investment Cost

Investment areas include:

- Civil works (elevation, drainage upgrades, barriers)
- Technology (monitoring systems, waterproofing)
- Training and drills for emergency response

- Maintenance and inspection programs

11. Economic and Financial Benefits

- Reduced operational downtime and repair costs post-flooding.
- Improved reliability and safety boosts passenger and airline confidence.
- Enhanced capacity for emergency response and disaster logistics.
- Long-term cost savings from proactive flood mitigation.

12. Stakeholder Consultations

Stakeholder consultations were conducted in **Cox's Bazar**, home to one of the country's busiest coastal airports, which is frequently affected by extreme rainfall and urban flooding. Community members, particularly those living adjacent to the airport, participated in gender-segregated focus group discussions and a household-level survey. The purpose was to capture lived experiences related to airport flood impacts, service interruptions, safety concerns, and opportunities for inclusive resilience-building.

Stakeholder Group	Role in the Project	Consultation Approach
Male Community Members	Residents, small business operators, and airport-dependent transport workers	Focus Group Discussion (FGD) – Male
Female Community Members	Caregivers, informal workers, and dependents on airport-linked healthcare, transport, and jobs	Focus Group Discussion (FGD) – Female
Adjacent Households	Families impacted by flooding near the airport and associated access routes	Household Survey (n = 100)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Residents of flood-prone neighborhoods within a 2 km radius of Cox's Bazar airport

Key Observations:

- Residents described **repeated flooding** of access roads, parking zones, and airport boundary areas during monsoon rains, with water levels reaching up to **2–3 feet** within hours.
- Male participants noted that **taxis, buses, and cargo deliveries** often stop operating during floods, affecting both travelers and workers.
  Female participants emphasized **missed medical appointments, school delays, and food insecurity** during extended flood periods.
- Both groups highlighted fears of electrocution due to **open drains and electrical poles near the runway**. Women raised specific concerns about **lack of lighting and shelter near airport terminals** during nighttime floods.
- Community Recommendations:
  - Construct **elevated access roads and culverts**.
  - Improve **airport perimeter drainage systems**.
  - Install **solar lighting and emergency signage** for safer navigation.
  - Include **women and low-income communities** in airport disaster planning.

Figure 23: FGD of Female Participants in Cox's Bazar

Figure 24: FGD of Male Participants in Cox's Bazar

13.2 Household Survey Outcomes

Profile: 100 households from flood-exposed neighborhoods surrounding Cox's Bazar Airport

Key Findings:

- **Service Disruption and Losses**:
  - **62%** reported at least one missed or delayed flight due to airport access blockages.
  - **73%** experienced economic losses from disrupted travel, trade, or tourism work.
- **Safety and Shelter Gaps**:
  - **48%** felt unsafe accessing the airport at night during heavy rains.
  - Only **22%** had access to formal shelters or raised roads near their homes.
- **Adaptation and Resilience Preferences**:
  - **81%** supported nature-based flood barriers (e.g., vegetated berms or rain gardens).
  - **67%** preferred investment in solar lighting and **green-buffered evacuation routes**.
  - **72%** emphasized **gender-responsive planning**, especially in infrastructure near terminals and public rest areas.

13.3 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Airport perimeter and access routes flood frequently, disrupting travel and operations	Objective 1: Strengthen physical and operational flood resilience of airports	FGDs, Household Survey
Economic losses from canceled trips, lost cargo, and delayed tourism services are common	Objective 2: Ensure continuity of airport functions and minimize economic disruption	FGDs, Household Survey
Households and workers report safety hazards (electricity, poor lighting, open drains) near terminals	Objective 3: Enhance safety for passengers, workers, and local communities	FGDs – Female, Household Survey

Strong public support for green buffers, solar lighting, and inclusive planning forums	Objective 4: Incorporate inclusive and gender-responsive flood resilience strategies	FGDs, Household Survey
Aligns with climate adaptation goals and SDG 9 (infrastructure), SDG 11 (resilient cities), SDG 13	Objective 5: Align outcomes with SDG and national climate commitments	FGDs, Household Survey

14. Conclusion

Investing in flood-resilient airport infrastructure is vital for sustaining connectivity, safety, and economic growth in flood-prone regions of Bangladesh. Through structural upgrades, advanced planning, and inclusive design, the project will protect critical aviation services from climate-induced disruptions. The initiative not only safeguards infrastructure but also contributes to the broader goals of sustainable development, disaster risk reduction, and climate adaptation.

1.6 FLOOD-PROOFING RAILWAY INFRASTRUCTURE IN FLOOD-PRONE AREAS

1. Introduction

Railways form a vital component of Bangladesh's transport infrastructure, supporting the movement of people and goods across the country. However, the rail network, especially in flood-prone regions such as Chattogram, Gopalganj, Khulna, Faridpur, Bogura, Feni, Maulvibazar, Tangail, Rajbari, and Gaibandha, is highly vulnerable to seasonal flooding, waterlogging, and extreme weather events. These disruptions not only threaten passenger safety and operational continuity but also jeopardize economic activities, supply chains, and access to essential services. Strengthening the flood resilience of railway infrastructure is thus essential to protect vital transport assets and ensure year-round connectivity in the face of intensifying climate risks.

2. Objectives

- Enhance the structural integrity of railway infrastructure to withstand severe flood events.
- Reduce service disruptions and accidents caused by water damage and inundation.
- Improve drainage and flood management systems in railway corridors.
- Integrate climate-resilient design and materials in railway construction and maintenance.
- Align with national climate adaptation priorities and Sustainable Development Goals (SDGs) 9 (Industry, Innovation, and Infrastructure), 11 (Sustainable Cities and Communities), and 13 (Climate Action).

3. Justification for Selected Locations

The selected districts have a history of high exposure to monsoon flooding, river overflow, and flash flood events, resulting in frequent railway disruptions and infrastructure degradation. These regions are economically significant due to their population density, agricultural output, and industrial activity, making reliable railway services crucial for economic resilience and mobility.

District	Key Vulnerability Factors	Strategic Importance
Gaibandha	Prone to river flooding and embankment erosion	Key agricultural hub requiring stable logistics
Khulna	Low-lying delta region, high flood exposure	Industrial and export-focused area
Chattogram	Extreme rainfall and urban flooding	Gateway port city with high freight movement
Faridpur	Frequent flash floods and waterlogging	Rail link between Dhaka and the southwest
Tangail	Monsoon river overflow and erosion	Strategic inter-district passenger corridor
Bogura	Seasonal flooding and infrastructure wear	Regional transport and trade junction
Jamalpur	Frequent flooding from the Brahmaputra River	Critical northern rail corridor for trade and mobility
Feni	Heavy rainfall and drainage congestion	Important passenger and freight linkage to southeast
Maulvibazar	Hill slope runoff and flash flooding	Connects northeast tea and forest regions
Gopalganj	Floodplains and poor drainage	Serves rural and peri-urban areas with low access
Rajbari	Lowland flood-prone zone	Interconnects south-central districts via rail

4. Key Climate Resilience Measures

Infrastructure Strengthening:

- Elevation of Railway Tracks: Raise railway lines above projected maximum flood levels to avoid waterlogging and reduce the risk of submersion.
- Construction of Flood Embankments: Build embankments and levees along vulnerable rail sections to prevent overflow and flash flood impacts.
- Use of Water-Resistant Materials: Employ materials such as corrosion-resistant steel, treated concrete sleepers, and high-strength ballast to withstand water damage and erosion.

Drainage and Water Management:

- Advanced Drainage Systems: Install culverts and drainage systems to remove floodwaters quickly and protect structural integrity.
- Stormwater Management Zones: Create buffer zones and water retention basins alongside tracks to minimize floodwater pressure.

Monitoring and Preparedness:

- Flood Early Warning Systems: Deploy real-time monitoring tools and predictive weather models to inform train scheduling and preventive maintenance.
- Emergency Response Plans: Develop evacuation, rerouting, and rapid repair protocols to ensure swift recovery from flood events.

5. Expected Outputs and Impacts

Expected Impact	Key Benefits
Reduced Economic Losses	Minimizes railway downtime, ensuring continuity in transport and logistics.
Enhanced Infrastructure Resilience	Prolongs the service life of railway assets and lowers repair costs.
Improved Passenger Safety	Prevents derailments and accidents related to flood-damaged tracks.
Strengthened Connectivity and Equity	Ensures access for flood-affected rural and urban populations.
Support for Climate Adaptation Goals	Reinforces national adaptation strategies and SDG progress.

6. Gender and Social Considerations

- Reliable and safe railway services during and after flood events are essential for women, as they support mobility, access to essential services, and economic empowerment.
- Ensuring continued railway functionality during floods will reduce disruption to women's livelihoods, particularly for those engaged in informal work, caregiving, and market access
- The project will actively involve women in the planning, construction, management, and maintenance phases, with targeted skills training and employment opportunities

7. Linkage to National Adaptation Plan (NAP) Projects

This project supports the National Adaptation Plan (NAP) priorities focused on safeguarding critical infrastructure in vulnerable areas, enhancing early warning systems, and promoting climate-resilient transportation. Relevant NAP linkages include:

- Strengthening transportation systems in flood-prone areas through resilient design.
- Reducing infrastructure losses from climate-related hazards.

- Promoting inclusive, accessible mobility and emergency response networks.
- Building climate-smart transport systems aligned with sustainable development.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Challenges
Government Funding	Ministry of Railways, Climate Resilience Funds	Ensures national alignment and administrative control	Budget constraints and funding competition
Multilateral Development Banks	ADB, World Bank, Green Climate Fund	Access to technical assistance and concessional financing	Long lead times and procedural complexity
PPP Arrangements	Private construction firms, rail operators	Promotes innovation and private sector participation	Risk-sharing mechanisms and viability gap funding needed
Climate Bonds and Green Loans	Development finance institutions, green investors	Leverages green finance for infrastructure investment	Requires strong regulatory and credit frameworks

9. Critical Considerations and Future Outlook

- Sustainability: Establish maintenance and monitoring systems to adaptively manage railway resilience over time.
- Policy Integration: Embed resilience measures in national railway planning, infrastructure codes, and climate adaptation policies.
- Innovation: Explore smart rail technologies (e.g., flood sensors, automated alerts) for real-time risk response.
- Community Engagement: Involve local populations in project design, monitoring, and feedback loops to ensure buy-in.
- Regional Synergy: Collaborate with neighboring South Asian countries facing similar transport resilience issues for shared learning and innovation.

10. Estimated Investment Cost

The investment will encompass:

- Civil works for elevation and embankment construction.
- Procurement of water-resistant rail materials and drainage systems.
- Deployment of early warning systems and digital monitoring tools.
- Capacity-building, planning workshops, and social inclusion measures.

A detailed feasibility and costing study will be undertaken to refine financial estimates and identify phased investment opportunities.

11. Economic and Financial Benefits

- Reduced rail service delays and disruptions, boosting economic productivity.
- Lower maintenance and rehabilitation costs over the lifecycle of assets.
- Strengthened trade and regional connectivity due to reliable infrastructure.

- Increased investor and public confidence in climate-smart infrastructure planning.

12. Stakeholder Consultations

Stakeholder consultations will be carried out at national and subnational levels to ensure inclusive, transparent planning and design.

Stakeholder Group	Role in Project Implementation	Engagement Approach
Bangladesh Railway	Design, construction, and maintenance	Technical meetings, joint project development
DPHE (Department of Public Health Engineering)	Integration of WASH and drainage systems with road planning	KII in Hatiya upazila
Community Members	Rail users, direct beneficiaries, and community observers	Focus Group Discussions (FGDs) with gender-segregated groups

13. Field Data and Observations

Household Survey Findings:

A total of 100 households were surveyed around flood-prone railway areas in Jamalpur. Key findings include:

- Demographics: Average household size is 4.7. Most families (89%) are nuclear, with 97% of households male-headed and 93% residing in the area for over 20 years.
- Livelihoods: The primary occupations include transport work (25%), small business (24%), and day labor (15%), reflecting economic dependence on uninterrupted transport access.
- Disaster Impacts:
    - 83% experienced infrastructure damage, and 80% faced service disruption.
    - Flood impacts include drought (70%), river floods (27%), and waterlogging (16%).
    - 65% reported no direct household harm; however, 33% experienced service loss.
- Adaptation and Preferences:
    - Top coping measures: elevating structures (78%), improving drainage (60%).
    - 91% would benefit from climate-resilient infrastructure, mainly via reliable transport and disaster safety.
- Challenges:
    - Main obstacle: government-side issues (70%), followed by land and political barriers.
    - 100% took no post-disaster recovery action, indicating low adaptive capacity.
- Community Recommendations:
    - 88% seek improved transport efficiency through resilient infrastructure.
    - Preferred actions: raising infrastructure height (90%), better drainage (80%), and applying nature-based solutions (84%).

KII findings:

- Flooding Issues: The Jamalpur station area, especially between Ichapur and Dewanganj, frequently experiences severe waterlogging during floods and heavy rain, leading to disruption of train operations.

- Railway Points Affected: Water accumulates at the railway points, delaying train schedules as drainage is slow and inefficient.
- Drainage Inadequacy: The current drainage system is insufficient to cope with floodwater or heavy rainfall. It requires repair and expansion to function effectively.
- Limited Institutional Support: Station management currently handles flooding without structured government intervention, relying on ad hoc local committee efforts.
- Track Elevation Concern: Tracks are not elevated, making them vulnerable to submersion. Elevation of tracks is recommended as a long-term solution.
- Short-term Recommendation: Improve and maintain the drainage system through low-cost repairs and clearing, ensuring uninterrupted flow from one end to another.

Figure 23: KII of Station Master in Jamalpur

FGD findings:

- Limited Railway Use & Infrastructure Benefits: Locals rarely use the nearby station and gain minimal benefit; the train only stops briefly each day.
- Climate Impacts & Flooding: Flooding persists, though less severe than decades ago; stagnant water causes hygiene issues and restricts cooking and mobility, especially for women.
- Lack of Support & Infrastructure: No government or NGO initiatives have addressed drainage or assessed flood-related damages in the area.

- **Need & Support for Resilient Solutions:** Community supports drainage systems linked to the nearby river to prevent flooding, improve health, enable work, and raise incomes.

Figure 25: FGD of Male Participants in Jamalpur

Figure 24: FGD of Female Participants in Jamalpur

14. Conclusion

Flood-proofing railway infrastructure in Bangladesh's vulnerable districts is a strategic investment in climate resilience, economic continuity, and public safety. By integrating structural upgrades, water management innovations, and inclusive planning, this project aims to establish a replicable model for resilient transport systems. Its alignment with national adaptation priorities and global sustainability goals makes it an essential step toward future-proofing Bangladesh's infrastructure landscape.

1.7 ENHANCING RAILWAY STATION RESILIENCE TO FLOODING USING INTEGRATED ADAPTATION APPROACHES

1. Introduction

Bangladesh's railway stations are critical nodes for transportation, commerce, and daily mobility. However, many of them are increasingly vulnerable to climate change-induced flooding, particularly during the monsoon season. Districts such as Chattogram, Khulna, Bagerhat, Bogura, Feni, Gaibandha, Gopalganj, Faridpur, Jamalpur, and Chuadanga have experienced recurrent disruptions to railway services due to severe waterlogging and flooding. This disrupts passenger safety, cargo movement, and economic continuity. Enhancing the flood resilience of railway stations using integrated approaches that combine infrastructure reinforcement and nature-based solutions is essential to ensure uninterrupted railway operations and climate-adaptive growth.

2. Objectives

- Elevate critical railway station infrastructure above flood levels to prevent disruption.
- Integrate structural and ecological flood management solutions.
- Minimize operational losses and physical damage from flood events.
- Improve passenger and worker safety during flooding.
- Promote green infrastructure for flood mitigation and environmental benefits.
- Align interventions with SDGs 9 (Industry, Innovation and Infrastructure), 11 (Sustainable Cities and Communities), and 13 (Climate Action).

3. Justification for Selected Locations

These locations represent a mix of coastal and riverine zones highly vulnerable to seasonal and flash floods. They are vital to Bangladesh's national railway network and are key for regional connectivity and economic development.

District	Key Vulnerability Factors	Strategic Importance
Chattogram	Coastal exposure, intense monsoon flooding	Major transportation hub and seaport
Khulna	Low-lying terrain, tidal flooding	Gateway to southwestern trade and transport
Bagerhat	Cyclonic storm surge-prone, inadequate drainage	River port with regional trade importance
Bogura	Flash floods and drainage congestion	Inland trade and passenger movement center
Feni	Monsoon-induced urban flooding	Cross-regional railway transit point
Gaibandha	Riverine flooding from Brahmaputra basin	Rural passenger and agricultural transport link
Gopalganj	Recurrent flooding, lack of resilient infrastructure	Inter-district trade and commuter hub
Faridpur	Monsoon flooding, waterlogging	Agricultural and passenger transport corridor
Jamalpur	Waterlogging, station flooding during monsoon	Flood-affected rail link to northern districts
Chuadanga	Prolonged inundation, poor drainage	Key western rail network station

4. Key Climate Resilience Measures

Infrastructure Adaptation:

- Elevate platforms, control rooms, and ticketing facilities above predicted flood levels.
- Install mobile flood barriers and seal underground facilities.

- Upgrade drainage and water pumping capacity within station precincts.
- Use corrosion-resistant steel and marine-grade construction materials in all critical station structures—such as platform reinforcements, rail tracks, and footbridges—to ensure durability and reduce long-term maintenance needs in saline-prone environments.

Nature-Based Solutions:

- Develop green roofs and vertical gardens to absorb rainfall and reduce runoff.
- Restore surrounding wetlands and mangroves to buffer stormwater and surge impact.
- Introduce permeable paving in station surroundings to increase groundwater absorption.

Operational Measures:

- Implement real-time flood monitoring and early warning systems.
- Conduct regular emergency drills and resilience training for station staff.
- Establish rapid maintenance and restoration protocols to resume service quickly after flooding.

5. Expected Outputs and Impacts

Expected Impact	Key Benefits
Use of corrosion-resistant materials	Extends asset life, reduces maintenance costs in saline environments
Enhanced station operability during floods	Reduces delays, improves reliability
Reduced infrastructure repair costs	Lowers long-term expenditures
Improved ecosystem health	Supports biodiversity and green urban design
Increased passenger safety	Protects lives and enables continuous access

6. Gender and Social Considerations

- Reliable and safe railway services during and after flood events are essential for women, supporting mobility, caregiving, and economic activities.
- The project will actively involve women in planning, construction, management, and maintenance phases, offering targeted skills training and employment.
- Ensuring consistent station access during floods will help mitigate the disproportionate impact on women and marginalized groups.
- Evacuation and emergency procedures will include gender-sensitive provisions such as safe spaces and targeted communication.

7. Linkage to National Adaptation Plan (NAP)

This project is aligned with NAP goals focused on enhancing the resilience of transport, housing, and communication infrastructure in high-risk climate areas. Key linkages include:

- Developing climate-resilient public transport infrastructure.
- Integrating ecosystem-based adaptation for flood-prone infrastructure.
- Promoting gender and socially inclusive adaptation strategies.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Challenges
Government Funding	Ministry of Railways, Climate Resilience Funds	Ensures national alignment and administrative control	Budget constraints and funding competition
Multilateral Development Banks	ADB, World Bank, Green Climate Fund	Access to technical assistance and concessional financing	Long lead times and procedural complexity
PPP Arrangements	Private construction firms, rail operators	Promotes innovation and private sector participation	Risk-sharing mechanisms and viability gap funding needed
Climate Bonds and Green Loans	Development finance institutions, green investors	Leverages green finance for infrastructure investment	Requires strong regulatory and credit frameworks

9. Critical Considerations and Future Outlook

- **Long-term resilience:** Integration of flexible infrastructure designs and periodic climate risk reassessments.
- **Policy alignment:** Mainstreaming flood resilience into national railway standards.
- **Community engagement:** Enhancing local awareness and ownership of resilience efforts.
- **Innovation and research:** Promote context-specific green engineering and technology.
- **Scalability:** Potential to replicate across other vulnerable stations nationwide.

10. Estimated Investment Cost

- Elevated platforms and flood-proofing of station structures.
- Procurement of flood barriers, pumps, and green infrastructure.
- Installation of early warning systems and training programs.
- Restoration and creation of adjacent wetlands or bioswales.
- Procurement and use of corrosion-resistant steel and marine-grade materials for high-salinity stations

11. Economic and Financial Benefits

- Lower repair and operational costs from flood damages.
- Increased service reliability enhances economic activity and commuter confidence.
- Improved asset value and resilience attracts long-term investments.
- Reduced service disruption lowers indirect economic losses.

12. Stakeholder Consultations

Stakeholder consultations will be carried out at national and subnational levels to ensure inclusive, transparent planning and design.

Stakeholder Group	Role in Project Implementation	Engagement Approach
Bangladesh Railway	Design, construction, and maintenance	Technical meetings, joint project development

DPHE (Department of Public Health Engineering)	Integration of WASH and drainage systems with road planning	KII in Hatiya upazila
Community Members	Rail users, direct beneficiaries, and community observers	Focus Group Discussions (FGDs) with gender-segregated groups

13. Field Data and Observations

Household Survey output: 100 households surveyed in Jamalpur, including small business owners (43%), transport workers (17%), and low-income families.

Observations:

- Impact of Railway Failures:
    - 80% reported waterlogging disrupts rail services, cutting off vital transport links.
    - 79% faced structural damage to railway infrastructure during floods.
    - 51% experienced income loss or service disruptions during disasters.
- Household Preferences:
    - 94% prioritized flood-resistant railways for reliable transport and communication.
    - 81% supported improved drainage systems to prevent waterlogging.
    - 78% favored elevating railway lines in flood-prone sections.
- Disaster Response Gaps:
    - 85% took no action after disasters due to lack of resources or awareness.
    - Only 19% believed current early warning systems were effective without functional transport.
    - 41% cited political interference as a barrier to infrastructure upgrades.

KII findings:

- Railway Points Affected: Water accumulates at the railway points, delaying train schedules as drainage is slow and inefficient.
- Drainage Inadequacy: The current drainage system is insufficient to cope with floodwater or heavy rainfall. It requires repair and expansion to function effectively.
- Limited Institutional Support: Station management currently handles flooding without structured government intervention, relying on ad hoc local committee efforts.
- Track Elevation Concern: Tracks are not elevated, making them vulnerable to submersion. Elevation of tracks is recommended as a long-term solution.
- Short-term Recommendation: Improve and maintain the drainage system through low-cost repairs and clearing, ensuring uninterrupted flow from one end to another.

FGD findings:

- Limited Railway Use & Infrastructure Benefits: Locals rarely use the nearby station and gain minimal benefit; the train only stops briefly each day.
- Climate Impacts & Flooding: Flooding persists, though less severe than decades ago; stagnant water causes hygiene issues and restricts cooking and mobility, especially for women.
- Lack of Support & Infrastructure: No government or NGO initiatives have addressed drainage or assessed flood-related damages in the area.

- **Need & Support for Resilient Solutions:** Community supports drainage systems linked to the nearby river to prevent flooding, improve health, enable work, and raise incomes.

Figure 26: FGD of Male Participants in Jamalpur

Figure 27: FGD of Female Participants in Jamalpur

14. Conclusion

Flood-proofing railway infrastructure in Bangladesh's vulnerable districts is a strategic investment in climate resilience, economic continuity, and public safety. By integrating structural upgrades, water management innovations, and inclusive planning, this project aims to establish a replicable model for resilient transport systems. Its alignment with national adaptation priorities and global sustainability goals makes it an essential step toward future-proofing Bangladesh's infrastructure landscape.

1.8 Flood-Proofing Inland Water Transport Terminals Using Traditional Engineering Solutions

1. Introduction

Inland water transport terminals in Bangladesh, located in districts such as Chattogram, Khulna, Bagerhat, Bogra, Feni, Gaibandha, Gopalganj, Faridpur, Jamalpur, and Chuadanga, are critical for sustaining rural and urban connectivity. These terminals facilitate the movement of goods and passengers, providing essential access to healthcare, education, and markets, particularly for women in rural areas. However, these low-lying regions are increasingly vulnerable to climate change impacts, including recurrent flooding, storm surges, and rising water levels. Frequent inundation leads to operational disruptions, infrastructure damage, and safety risks, isolating communities during emergencies and causing significant economic losses. This concept paper proposes the use of traditional engineering solutions to flood-proof these terminals, ensuring year-round functionality, enhancing safety, and supporting the socioeconomic resilience of vulnerable regions.

2. Objectives

- Enhance the structural resilience of inland water transport terminals to withstand floods, storm surges, and rising water levels.
- Minimize operational disruptions and ensure continuous functionality of terminals during extreme weather events.
- Improve safety and accessibility for passengers, particularly women, children, and vulnerable groups, during flood events.
- Reduce economic losses caused by infrastructure damage, transport delays, and cargo losses.
- Align project outcomes with Sustainable Development Goals (SDGs) 5 (Gender Equality), 9 (Industry, Innovation, and Infrastructure), 11 (Sustainable Cities and Communities), and 13 (Climate Action).

3. Justification for Selected Locations

The selected districts are strategically important for regional connectivity and socioeconomic activities, yet they face significant climate vulnerabilities that threaten terminal operations.

District	Key Vulnerability Factors	Strategic Importance
Chattogram	Frequent flooding, storm surges	Major transport hub, critical for trade and connectivity
Khulna	Low-lying area, saline intrusion	Key for fisheries, agriculture, and passenger transport
Barishal	River erosion, storm surge	Central hub for southern inland water transport routes
Patuakhali	Cyclone exposure, embankment failures	High dependency on water terminals, gateway to remote upazilas
Bagerhat	Coastal flooding, cyclone exposure	Essential for rural connectivity and market access
Bogra	Riverine flooding, erosion	Important for agricultural goods transport
Feni	Tidal surges, heavy rainfall	Links rural communities to urban centers
Gaibandha	River flooding, isolation risk	Critical for passenger and goods movement in rural areas
Gopalganj	Low-lying, flood-prone	Key transport node for rural accessibility
Faridpur	Riverine floods, weak infrastructure	Supports agricultural trade and connectivity

Jamalpur	Flooding, erosion along rivers	Vital for rural passenger transport
Chuadanga	Seasonal flooding, infrastructure gaps	Connects rural areas to essential services

These locations were chosen due to their high exposure to flooding, strategic transport value, and the socioeconomic risks posed by terminal disruptions.

4. Key Climate Resilience Measures

Infrastructure Strengthening

- Raising Key Operational Areas: Elevate docks, loading platforms, storage areas, and passenger terminals above historical flood levels to prevent inundation.
- Installing Durable Flood Barriers: Construct concrete walls or levees around terminal perimeters as a first line of defense against floodwaters.
- Reinforcing Infrastructure: Use water-resistant materials like steel-reinforced concrete for docks and mooring facilities to withstand floodwater pressure and erosion.
- Upgrading Drainage Systems: Implement high-capacity pumps and efficient drainage systems to rapidly remove floodwater and prevent waterlogging.
- Elevating and Waterproofing Critical Systems: Protect electrical systems, control rooms, and communication hubs by elevating and waterproofing them to ensure operational continuity.
- Installing Floating Jetties: Deploy floating jetties that rise and fall with water levels, ensuring uninterrupted vessel access during floods.

Operational and Institutional Measures

- Routine Maintenance and Inspection: Establish a program for regular inspection, minor repairs, and prompt emergency response to infrastructure damage.
- Early Warning System Integration: Link terminals to flood early warning systems for pre-emptive operational adjustments or evacuations.
- Staff and Community Training: Develop capacity-building programs for terminal staff and local communities on flood management, safety protocols, and emergency operations.

5. Expected Outputs and Impacts

Expected Impact	Key Benefits
Reduced terminal disruptions	Ensures continuous passenger and goods transport during floods
Lower infrastructure maintenance costs	Decreases repair expenses and asset losses due to flood damage
Increased safety for vulnerable groups	Enhances accessibility for women, children, and other at-risk groups
Improved economic stability	Minimizes losses from transport delays and cargo damage
Enhanced climate resilience	Supports sustainable transport systems aligned with SDG goals

6. Gender and Social Considerations

The project will prioritize inclusivity by addressing the specific needs of women, children, and marginalized groups:

- Engage women's groups in planning and implementation to ensure their needs are met.
- Create employment opportunities for women in terminal maintenance and awareness programs.

- Design terminals with gender-sensitive features, such as safe waiting areas and lighting.
- Develop emergency plans that consider the needs of women, children, elderly, and persons with disabilities.

7. Linkage to National Adaptation Plan (NAP) Projects

This project aligns with Bangladesh's National Adaptation Plan (NAP) under the thematic area of building climate-resilient infrastructure in high-risk areas:

- Strengthens flood-resilient transport infrastructure in vulnerable districts.
- Enhances disaster preparedness and emergency accessibility.
- Supports sustainable and inclusive connectivity systems for rural and urban areas.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Challenges
Government Funding	Ministry of Shipping, ADP funds	National ownership, supports local priorities	Budget constraints, competing demands
Multilateral Development Banks	World Bank, Asian Development Bank	Access to large-scale climate financing	Lengthy approval processes
Public-Private Partnerships	Private transport operators	Encourages private sector innovation	Risk-sharing complexities
Climate Bonds	Green bond issuers	Low-cost, long-term financing for resilience	Requires feasibility studies
International Climate Grants	Green Climate Fund, Adaptation Fund	Eases government burden, international alignment	Competitive application processes

9. Critical Considerations and Future Outlook

- Sustainability: Establish mechanisms for continuous monitoring and maintenance of terminal infrastructure.
- Policy Integration: Update technical standards for terminal design to incorporate climate resilience measures.
- Community Engagement: Involve local communities in planning and maintenance to foster ownership.
- Innovation: Partner with research institutions to explore innovative flood-proofing materials and techniques.
- Regional Collaboration: Facilitate knowledge exchange with other flood-prone regions to replicate best practices.

10. Estimated Investment Cost

The estimated cost will cover:

- Elevation of terminal infrastructure.
- Construction of flood barriers and drainage systems.
- Procurement of water-resistant materials.
- Capacity building and community training.
- Integration of early warning systems.

Preliminary estimates suggest a requirement of USD 20–40 million, subject to detailed feasibility studies.

11. Economic and Financial Benefits

- Reduced flooding frequency, ensuring uninterrupted terminal operations.
- Decreased maintenance costs due to resilient infrastructure.
- Minimized economic losses from transport disruptions.
- Increased public confidence in climate-resilient transport systems.
- Creation of local employment opportunities during implementation

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12. Stakeholder Consultations

Consultations were conducted with key stakeholders in Patuakhali Launch Terminal, located in Patuakhali Sadar Upazila, Patuakhali District, to understand community needs and ensure alignment with local priorities. The stakeholder groups were selected based on their direct involvement with or dependence on the terminal.

Stakeholder Group	Role in the Project	Consultation Approach
Local Shopkeepers and Vendors	Depend on the terminal for business and economic activities	Focus Group Discussions (FGDs) with vendor groups
Female Community Members	Terminal users, direct beneficiaries, and community observers	FGDs with female groups
Households in Patuakhali Sadar	Daily terminal users, affected by disruptions and floods	Household surveys targeting diverse demographic groups

13. Field Data and Observations

Field assessments were conducted to gather site-specific data on terminal vulnerability, community dependence, and local adaptation practices in Patuakhali Launch Terminal. The findings guide the project's design and intervention strategies.

13.1 Focus Group Discussions (FGDs)

Participants: Sessions were conducted with female community members in Patuakhali Sadar, near the Patuakhali Launch Terminal.

Observations:

- Dependence on Infrastructure: Historically, the terminal supported livelihoods for laborers, rickshaw-pullers, and vendors. However, the construction of the Padma Bridge has reduced launch frequency, decreasing economic opportunities while residents remain dependent on the terminal for mobility.
- Climate-Induced Hazards: The terminal itself is structurally resilient, but surrounding areas suffer from cyclones, storm surges, heavy rainfall, and waterlogging. Poorly designed sluice gates and clogged drains exacerbate flooding, submerging homes and disrupting daily life.
- Damage Assessment: There's a lack of clarity on which authority is responsible for assessing infrastructure damage. No significant recent work on embankments or sluice gates was observed by residents.
- Community Needs: Participants highlighted the need for elevated and repaired sluice gates, upgraded drains, and strengthened embankments to reduce flooding impacts. Regular canal dredging and waste management were also deemed essential.

- Community Acceptance: The community is likely to welcome flood-proofing initiatives, seeing them as a way to reduce displacement, protect livelihoods, and enhance resilience.

Figure 29: FGD of Male Participants in Patuakhali

Figure 28: FGD of Female Participants in Patuakhali

13.2 Household Survey Outcomes

Profile: 100 households were surveyed in Patuakhali Sadar, including women-led households, transport workers, and small business owners.

Observations:

- Dependence on Terminal:
    - 48% of households depend on the terminal, primarily for transportation (41%) and livelihoods (22%). The remaining 52% use alternative transport modes.
- Climate Impacts:
    - 83% reported cyclones and storm surges, and 73% noted river flooding as major hazards affecting the terminal. Service disruptions were reported by 98%, with only 4% noting structural damage.
    - 63% experienced service disruptions, 27% faced income loss, and 12% reported livelihood loss. Mental stress was noted by 17%.
- Coping Mechanisms:
    - 47% took no action to cope with losses. Others reduced expenses (25%), took loans (13%), or used savings (9%). Some diversified income (7%) or changed occupations (6%).
- Preferences for Resilience:
    - 74% prioritized reliable services, 39% sought stable income, and 34% valued economic stability from resilient infrastructure. 21% each emphasized livelihood security and disaster safety.
- Proposed Measures:
    - 72% suggested using water-resistant materials, 52% supported improved drainage and emergency plans, and 47% advocated for strict maintenance plans.

13.3 Integration of Total Findings and Alignment with Project Objectives

The findings integrate qualitative insights from FGDs with quantitative trends from household surveys to tailor interventions that are both technically sound and socially relevant.

Key Findings	Linked Project Objectives	Evidence Reference
Frequent service disruptions due to floods, impacting surrounding communities	Objective 1 & 2: Enhance resilience and minimize disruptions	FGDs, Household Survey (98% reported service disruptions)
Income and livelihood losses from reduced terminal activity and flooding	Objective 4: Reduce economic losses	Household Survey (27% income loss, 12% livelihood loss)
Poor drainage and sluice gates exacerbate flooding, affecting community safety	Objective 3: Improve safety and accessibility for vulnerable groups	FGDs
Lack of maintenance and unclear responsibility for infrastructure damage assessment	Objective 1: Enhance structural resilience through maintenance programs	FGDs
Community support for resilient infrastructure, prioritizing reliable services and economic stability	Objective 2 & 4: Minimize disruptions and reduce economic losses	Household Survey (74% prioritize reliable services, 39% stable income)
Need for nature-based solutions like reforestation and green barriers to mitigate environmental impacts	Objective 5: Align with SDG 13 (Climate Action)	FGDs, Household Survey (84% support nature-based solutions)
Strong potential for community engagement and capacity building	Objective 3: Improve safety through community training	Household Survey (71% support community engagement)

14. Conclusion

Flood-proofing inland water transport terminals using traditional engineering solutions is essential for ensuring safe, reliable, and climate-resilient transport systems in vulnerable districts of Bangladesh. The field findings from Patuakhali Launch Terminal underscore the urgency of addressing drainage issues, reinforcing embankments, and enhancing community involvement to mitigate flood impacts. By improving infrastructure resilience, reducing economic losses, and ensuring safety and accessibility, this project will support sustainable development and climate adaptation, aligning with national and global goals.

CONCEPT NOTES ON ENERGY SECTOR INFRASTRUCTURE DEVELOPMENT

2.1: ENHANCING ENERGY SECTOR RESILIENCE THROUGH THE PROMOTION OF RENEWABLE ENERGY SOURCES

1. Introduction

Bangladesh's energy infrastructure is increasingly under threat from climate-induced disruptions, particularly in coastal and hazard-prone regions such as Raozan and Patiya Upazilas. These regions are vulnerable to cyclones, flooding, saltwater intrusion, and other environmental hazards that can damage centralized energy systems, cause prolonged grid outages, and impede critical services. Traditional energy systems in Bangladesh often rely on single-point generation plants and long transmission lines, which are prone to failure during extreme weather events.

Decentralized and renewable energy sources—such as solar, wind, and small-scale hydroelectric systems—offer a more resilient alternative for energy provision. These systems not only ensure continuous service during grid disruptions but also reduce greenhouse gas emissions, promote sustainability, and open up opportunities for local innovation and employment. Moreover, the deployment of clean energy technologies helps mitigate climate change by cutting emissions, while also increasing access to electricity in remote and underserved communities.

This concept proposes a community-based, decentralized renewable energy model for climate-vulnerable upazilas in Bangladesh, focusing on solar, wind, and small-scale hydro solutions. It aligns with national energy diversification goals and offers a strategic contribution to climate change adaptation and disaster risk reduction.

2. Objectives

- Promote energy diversification through decentralized renewable energy systems such as solar, wind, and mini-hydro.
- Reduce reliance on centralized power generation and mitigate the risks associated with grid failure during disasters.
- Enhance the climate resilience of essential services (healthcare, communications, water, and sanitation) through stable power supply.
- Generate local employment and entrepreneurship opportunities in renewable energy deployment and maintenance.
- Align with SDGs, specifically SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), and SDG 13 (Climate Action).

3. Justification for Selected Locations

Raozan and Patiya Upazilas in Chattogram District are high-priority locations for renewable energy intervention due to their combination of energy demand, grid instability, and exposure to climate threats. These areas represent a critical intersection of economic activity, population growth, and vulnerability to energy disruption.

Upazila	Key Vulnerability Factors	Strategic Importance
Raozan	Flood-prone, cyclone exposure, terrain suitable for solar/wind	Industrial zones, high energy demand, educational institutions, and rural settlements
Patiya	Waterlogging, grid unreliability, lack of resilient energy access	Agricultural and semi-urban hub; growing rural industries and critical health facilities

4. Key Climate Resilience Measures

Decentralized Renewable Energy Systems

- Solar and Wind Power Installations: Deploy solar PV systems and small wind turbines on rooftops of homes, schools, health clinics, and community centers. These systems will create localized microgrids that can operate independently during grid outages.
- Mini-Grid Development: Establish community-managed solar or hybrid mini-grids in rural clusters with no reliable electricity. Include battery storage systems for nighttime use and critical load management.
- Hybrid Mini-Grids: Pilot hybrid renewable energy mini-grids (e.g., solar-diesel or solar-hydro) in remote or disaster-prone areas, with battery storage and backup systems for critical loads.
- Small-Scale Hydropower: Explore micro-hydro power solutions in suitable local canals or rivers for powering remote hamlets with year-round water flow.
- Resilient Public Facilities: Prioritize installation of solar backup systems in hospitals, cyclone shelters, government offices, and emergency response facilities.

Energy-Smart Infrastructure Planning

- Integrated Power and Land Use Planning: Coordinate energy infrastructure placement with land zoning to reduce exposure to flood zones and high-risk areas.
- Smart Meters and Load Management: Use digital monitoring tools to optimize energy distribution, reduce wastage, and improve system performance.
- Disaster-Ready Energy Design: Elevate inverters, batteries, and equipment above flood levels; use salt-resistant materials and wind-tested mounting structures.
- Nature-Based Solutions: Explore tree belt installation or green roofing near energy installations to reduce heat stress and storm impact on infrastructure.

Energy Efficiency and Utility Coordination

- Promote household and community-level energy efficiency through smart meters, LED distribution, and user awareness.
- Strengthen coordination between local mini-grids and national utility grids to manage energy flow and avoid duplication or overload.

Disaster-Ready Infrastructure Design

- Elevate critical equipment and use corrosion-resistant materials in areas vulnerable to flooding and salinity.

5. Expected Outputs and Impacts

Expected Impact	Key Benefits
Reduced grid dependency and energy loss	Ensures stable electricity during disasters and peak demand periods
Continuous operation of critical facilities	Hospitals, schools, water pumps, and cyclone shelters maintain power access
Decreased emissions and fossil fuel dependency	Supports national climate goals and GHG mitigation targets
Enhanced community resilience and autonomy	Local power management increases disaster readiness and local problem-solving
Economic growth and rural electrification	Boosts livelihoods, small businesses, and digital connectivity in off-grid areas

6. Gender and Social Considerations

Gender equality and social inclusion are central to the project's design and implementation. Key gender-responsive actions include:

- Community-Based Planning: Actively involve women in energy access planning, site selection, and oversight committees.
- Job Creation and Training: Provide technical and non-technical training to women and youth on renewable energy installation, repair, and management.
- Improved Access for Women: Ensure power supply to public toilets, maternal health services, and night-time lighting in public spaces for enhanced safety and dignity.
- Ownership and Benefit-Sharing: Design local solar cooperatives or user associations where women can participate in governance and benefit-sharing models.

7. Linkage to National Adaptation Plan (NAP) Projects

This concept aligns directly with the **"Productive Use of Renewable Energy (PURE) Phase I"** outlined in the Bangladesh National Adaptation Plan. Key alignments include:

- Diversification of energy sources to reduce climate risks.
- Promotion of decentralized and locally managed renewable energy systems.
- Use of clean energy to power essential public services and community facilities.
- Support for gender-responsive community-based adaptation solutions.
- Capacity-building in rural energy access, resilience, and maintenance skills.

The project also supports Bangladesh's Intended Nationally Determined Contributions (INDCs) under the Paris Agreement by reducing energy sector emissions and improving access to sustainable energy.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Challenges
Government Renewable Energy Programs	SREDA, Ministry of Power, Rural Electrification Board	Strong policy alignment, implementation infrastructure in place	Budget limitations, high upfront costs
Multilateral Development Banks	World Bank, ADB, IDCOL, IFC	Access to concessional loans, technical expertise, and safeguards	Requires structured financing models and long application cycles
Climate Funds and Green Bonds	Green Climate Fund, Climate Investment Fund	Performance-based grants and low-interest capital	Competitive and time-consuming approval processes
PPP and CSR Initiatives	Private solar firms, telecom companies, local cooperatives	Encourages private sector innovation and efficiency	Requires strong regulatory framework and community trust
Blended Finance	Mix of donor, public, and private capital	Reduces risk and improves capital leverage	Coordination challenges between multiple funding parties

9. Critical Considerations and Future Outlook

- Implementation and Financing Models: The project will include a clear phased implementation roadmap and explore the **Opex model** to ensure affordable, long-term system sustainability, especially in poorer communities.

- **Community Engagement**: Engagement strategies will include **co-design workshops**, **user cooperatives**, and **feedback systems**, with special focus on involving women and youth.
- **Energy Storage & Hybrid Systems**: Storage is critical in off-grid and remote zones. The feasibility of **hybrid mini-grids** in **Raozan and Patiya** will be explored, considering both technical viability and community needs.
- **Scalability**: Lessons from the pilot sites will inform replication across other flood-prone and energy-insecure regions.
- **Institutional Coordination**: The project will support collaboration between **local utilities, SREDA, and the national grid** to ensure coherence in energy planning.

10. Estimated Investment Cost

The total estimated investment will include:

- Procurement and installation of solar PV and wind turbines.
- Deployment of **battery storage** and energy management systems
- Construction of mini-grid infrastructure and battery storage systems.
- Deployment of micro-hydro systems where feasible.
- Upgrading public facilities with renewable energy access and disaster-ready designs.
- Capacity-building programs and community energy planning sessions.

A phased rollout in **two upazilas (Raozan and Patiya)** is expected to require approximately **USD 15–25 million**, depending on system size, site conditions, and energy load requirements. Potential for cost-sharing with private firms and local communities will be explored.

11. Economic and Financial Benefits

- **Reduced outage-related economic losses** during disasters, supporting markets, health centers, and communications.
- **Job creation in the renewable energy sector**, from technical roles to administrative and outreach work.
- **Lower lifetime energy costs** for public facilities and rural households compared to diesel or kerosene alternatives.
- **New local enterprises** enabled by stable electricity—cold chains, water pumps, mobile charging, and micro-enterprises.
- **Improved investor confidence** in climate-resilient regions with decentralized energy networks.

12. Stakeholder Consultations

Stakeholder consultations were conducted in both target upazilas to identify local energy needs, preferred renewable systems, and community roles. The following groups participated:

Stakeholder Group	Role in the Project	Consultation Approach
Union Parishad and Ward Committees	Community mobilization, local planning	Village-level community consultations and briefings
Community Members	Rail users, direct beneficiaries, and community observers	Focus Group Discussions (FGDs) with gender-segregated groups

13. Field Data and Observations

13.1 KII findings:

It was stated by participants that, although major hazards are rarely experienced, seasonal crops are often damaged by flash floods during heavy rains. The river embankment is being broken due to illegal sand extraction, which is considered a serious issue. Only Aman rice is grown because sufficient water is not available; Boro cultivation is not possible. During the dry season, hill streams are dried up and electric pumps are relied upon, but irrigation is hampered by frequent load shedding. It has been estimated by

experts that a dam constructed at Amtoli Point in Simla Khal could generate 15 MW of electricity, enable irrigation of all cultivable land, provide stored water for households, and promote tourism. Strong support for the dam has been expressed by the community, as multiple benefits are expected to be gained.

Figure 30: KII of LKP in Chattogram

13.2 FGD findings:

Participants shared that while major climate hazards are uncommon, flash floods during heavy rains damage crops and cause minor waterlogging. The community, located in a montane area, has ample cultivable land but can harvest only once a season due to water scarcity—Boro cultivation is not possible. In the dry season, reduced hill water flow and load shedding affecting electric pumps leave much land uncultivated. People are forced to depend on alternative livelihoods. Climate change has worsened water crises, with ponds drying up and becoming polluted during extreme summer heat, affecting domestic water use.

Figure 32: FGD of Male Participants in Chattogram

Figure 31: FGD of Female Participants in Chattogram

14. Conclusion

Enhancing energy sector resilience through decentralized renewable energy systems is an urgent necessity in Bangladesh's climate-exposed coastal zones. The proposed interventions in Raozan and Patiya will demonstrate how solar, wind, and mini-hydro technologies can deliver clean, reliable, and resilient energy at the local level.

By combining technical innovation with inclusive planning, strong governance, and climate financing, this project will strengthen livelihoods, protect critical services, and pave the way for a just and sustainable energy transition in vulnerable communities.

2.2 SAFEGUARDING VULNERABLE SUBSTATIONS FROM CYCLONE AND MULTIPLE TYPES OF FLOODING

1. Introduction

Electric substations are the backbone of power distribution systems, ensuring energy delivery to urban centers, critical facilities, and residential areas. However, in coastal Bangladesh—especially in Chattogram and Cox's Bazar districts—these substations face growing exposure to multiple climate hazards, including storm surges, cyclones, and urban and riverine flooding. Many substations are located in low-lying, flood-prone areas, making them vulnerable to water ingress, equipment failure, and prolonged service disruptions.

Flooding not only damages costly infrastructure but also poses serious safety risks for utility workers and the public. Moreover, substation outages can trigger cascading failures across entire electric grids, affecting hospitals, emergency response, water supply, and communication systems.

This concept proposes a comprehensive set of micro- and meso-scale infrastructure upgrades to safeguard vulnerable substations against climate-induced flooding and wind impacts—ensuring continuity, reliability, and safety of power services in high-risk coastal zones.

2. Objectives

- Strengthen structural and operational resilience of substations to cyclonic wind and flood impacts.
- Reduce risk of service disruptions and safeguard personnel during extreme weather events.
- Minimize damage to critical energy infrastructure through physical protection and smart planning.
- Contribute to SDGs 7 (Clean Energy), 9 (Infrastructure), 10 (Reduced Inequalities), 11 (Sustainable Cities), and 13 (Climate Action).

3. Justification for Selected Locations

Chattogram and Cox's Bazar districts are prone to both coastal and inland flooding, coupled with high wind exposure during tropical cyclones. They host critical substations that feed electricity to key urban and rural population clusters.

Location	Risk Profile	Strategic Relevance
Chattogram	Storm surge, urban flooding, cyclone winds	Regional energy and logistics hub requiring grid stability
Cox's Bazar	Coastal inundation, salinity, high wind speeds	Fast-growing district with rising energy demand
Sylhet	Flash flooding, embankment overtopping, poor drainage	Inland urban center with rising flood-related power interruptions

4. Key Climate Resilience Measures

Micro-Scale Interventions

- Elevate and waterproof critical components (e.g., switchgear, transformers).
- Install **smart flood-triggered shutdown systems** for early damage prevention.

Meso-Scale Interventions

- Use climate hazard models to inform **strategic relocation** or fortification.
- Develop a **risk-based substation zoning map** using historical and projected hazard data.

Preventive and Predictive Maintenance

- Implement **seasonal maintenance protocols**, including inspections pre- and post-cyclone.
- Use sensors and **remote diagnostics** to monitor water ingress, heat, and equipment wear.

Rapid Response and Recovery

- Design infrastructure for **quick restoration**, with spare parts and modular units pre-positioned.
- Incorporate **solar backup power** to sustain basic services in disaster response centers.

5. Expected Outputs and Impacts

Impact Area	Key Benefits
Reliability of Power Supply	Prevents outages and minimizes downtime during and after storm events
Safety for Workers and Equipment	Reduces risk of electrocution, equipment damage, and flood-related hazards
Economic Efficiency	Decreases repair costs, improves system longevity, and ensures stable service delivery

6. Gender and Social Considerations

- **Inclusive Planning:** Conduct gender-sensitive stakeholder engagement and community consultations to integrate diverse perspectives.
- **Employment Equity:** Promote equal access for men and women in substation upgrade, maintenance, and monitoring programs.
- **Community Outreach:** Develop education campaigns that address the specific safety needs of different genders during electrical emergencies and disasters.
- **Gender-Specific Monitoring:** Implement evaluation tools that track how resilience interventions impact women, men, and marginalized groups differently.

7. Linkage to National Adaptation Plan (NAP) Projects

This project aligns with national priorities on:

- **Protecting critical energy infrastructure** from storm surges, sea-level rise, and flooding.
- **Reducing systemic vulnerability** of power systems in disaster-prone coastal regions.
- **Strengthening climate-resilient utility services** for long-term national development.

8. Potential Financing Options

Financing Source	Contributors	Benefits	Challenges

Public Utility Investment	BPDB, PGCB, BREB	National alignment, ease of integration into existing systems	Budget limitations and competing infrastructure priorities
Climate Resilience Funds	Green Climate Fund, Adaptation Fund	Access to concessional climate finance	Requires compliance with stringent proposal and reporting rules
MDBs and Donors	World Bank, ADB, GIZ, JICA	Technical support and scalability	Long due diligence and safeguard procedures
Private Sector Participation	EPC firms, local manufacturers, insurers	Leverages innovation and operational expertise	Needs structured PPP framework and regulatory coordination
Blended Finance Mechanisms	Mix of public, private, and donor financing	Spreads risk and mobilizes larger funds	Complex design and governance models needed

9. Critical Considerations and Future Outlook

- Vulnerability Mapping: Substations will be mapped and categorized by risk level using past disaster impact data, topographic modeling, and climate projections.
- Preventive Maintenance and Monitoring: Develop localized protocols for shutdowns, inspections, and waterproofing actions in cyclone- and flood-prone zones.
- Climate Modeling Integration: Use climate prediction tools to simulate risk exposure over time and guide long-term planning.
- Justification and Scaling: Cox's Bazar and Chattogram serve as coastal pilots, while Sylhet introduces inland resilience needs. Results will inform national-level risk zoning and infrastructure investment priorities.
- Rapid Restoration Planning: Design the system to minimize service downtime and restore operations quickly post-disaster.

10. Estimated Investment Cost

The proposed investment will cover:

- Structural retrofitting (elevation, barriers, drainage)
- Procurement of waterproof enclosures and mobile flood defenses
- Digital monitoring and control upgrades
- Community education and workforce training
- Development of vulnerability mapping and risk zoning tools

11. Economic and Financial Benefits

- Reduced Repair Costs: Saves money by preventing flood-related damages and frequent replacements.
- Improved Service Delivery: Ensures grid stability and fewer blackout incidents.
- Investor Confidence: Enhances perception of Bangladesh's grid reliability, encouraging industrial investment.
- Public Safety and Welfare: Reliable electricity supports hospitals, disaster response, and public trust during crises.

12. Stakeholder Consultations

Stakeholder consultations were conducted in Cox's Bazar, a coastal area prone to both cyclonic winds and multiple types of flooding (tidal surge, flash floods, waterlogging). The discussions aimed to understand public concerns, infrastructure risks, and priorities for resilience at electricity substations.

Stakeholder Group	Role in the Project	Consultation Approach
Male Community Members	Users of grid electricity, informal responders, and laborers around substations	Focus Group Discussion (FGD) – Male
Female Community Members	Household managers, primary caregivers, and dependents on electricity for essential services	Focus Group Discussion (FGD) – Female

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Residents of flood-prone wards in Cox's Bazar

Key Observations:

- Flood Impact on Substations:
    - Participants noted frequent flooding of substation grounds, leading to shut-offs and unsafe conditions.
    - Submerged transformers and control panels triggered blackouts lasting 1–3 days.
- Operational and Safety Hazards:
    - Both groups reported recurring sparks and loud noises from substations during heavy rainfall, causing fear of explosions or fire.
    - In many areas, substations are not fenced or elevated, leaving children and passersby exposed to electrocution risks.
- Gendered Vulnerabilities:
    - Female participants emphasized how outages halt access to water, lighting, and cooking—particularly affecting female-headed households.
    - Emergency health and sanitation needs become difficult to manage without power.
- Community Recommendations:
    - Elevate substation platforms, use concrete casing and barriers to prevent water entry.
    - Introduce real-time shutdown systems and digital sensors to avoid overloads.
    - Install solar backup systems for lighting and water pumps in critical areas.

Figure 34: FGD of Male Participants in Chattogram

Figure 33: FGD of Female Participants in Chattogram

13.2 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Substations frequently flood, damaging equipment and triggering area-wide blackouts	Objective 1: Strengthen structural and operational resilience of substations	FGDs – Male, Female
Flooding causes power cuts that disrupt community life, school, health, and sanitation services	Objective 2: Reduce service disruptions and safeguard personnel	FGDs
Lack of elevation, fencing, and emergency power shut-off creates electrical hazards	Objective 3: Minimize infrastructure damage and prevent safety risks	FGDs – Female
Residents support climate-smart upgrades and real-time grid controls aligned with national goals	Objective 4: Contribute to SDGs 7, 9, 10, 11, and 13	FGDs

14. Conclusion

Protecting substations in climate-vulnerable areas is essential for ensuring uninterrupted power delivery and safe energy infrastructure in Bangladesh. Through a combination of structural fortification, drainage improvements, and stakeholder-inclusive planning, this concept provides a scalable model for substation resilience under compound climate threats.

With alignment to the NAP and SDG framework, this initiative reinforces Bangladesh's pathway toward sustainable, secure, and climate-resilient energy infrastructure.

2.3 STRENGTHENING ELECTRIC GRIDS AGAINST CYCLONIC WIND IMPACTS

1. Introduction

Bangladesh's southern coastal districts are highly vulnerable to frequent cyclonic storms that often damage critical infrastructure—including the national electric grid. Cyclones cause power outages, destroy substations, damage poles, and disrupt energy distribution networks, leaving millions without power during emergencies. The districts of Chattogram, Cox's Bazar, and Bhola are particularly at risk due to their exposure to high wind speeds, storm surges, and the lack of wind-resilient design in many parts of the electric grid.

Interruptions to electricity supply affect not only household lighting and communication but also essential public services such as hospitals, water systems, and emergency response units. In light of increasing cyclone intensity due to climate change, the urgency to strengthen electric grids against high wind impacts is paramount.

This concept outlines key structural and system-level adaptations to reinforce the electric grid in cyclone-prone districts, ensuring continuous energy access and greater resilience of critical services during extreme weather events.

2. Objectives

- Enhance the physical and operational resilience of electric grid infrastructure to cyclonic wind events.
- Reduce the frequency, duration, and impact of power outages caused by storm-related infrastructure failure.
- Minimize risks to public safety by preventing electrical hazards during and after cyclones.
- Support uninterrupted delivery of essential services such as healthcare and emergency response.
- Contribute to the achievement of SDGs 7, 9, 11, and 13 by improving infrastructure, energy access, and climate resilience.

3. Justification for Selected Locations

The selected districts are repeatedly impacted by tropical cyclones and storm surges. These regions serve large populations and key public infrastructure that require uninterrupted electricity, particularly during disasters.

District	Climate Risk Factors	Strategic Relevance
Chattogram	High cyclone exposure, urban load density	Major port and industrial hub requiring power continuity
Cox's Bazar	Coastal winds, storm surges, remote settlements	High vulnerability and expanding tourism and refugee camp services
Bhola	Frequent cyclonic landfalls, fragile grid design	Island district with frequent grid failures during storms
Feni	Riverbank erosion, sediment shift, flash floods	Recent tower failure due to unpredictable river movement
Noakhali	Tidal flooding, wind exposure	Coastal power lines prone to damage from repeated surges

Lakshmipur	River erosion, rural grid vulnerability	Key REB (rural grid) zone needing structural upgrades

4. Key Climate Resilience Measures

Structural and Technological Interventions:

- Replace traditional wooden poles with wind- and flood-resistant steel or composite poles.
- Strengthen river-crossing towers using deep foundations and erosion-resistant base materials.
- Upgrade substations with elevated pads and waterproof casings.
- Integrate adaptive flood design criteria that exceed historical flood benchmarks.

Grid Vulnerability Mapping and Morphological Analysis:

- Conduct detailed vulnerability mapping of transmission and distribution lines based on historical flood, erosion, and cyclone data.
- Include river morphology studies at critical tower and substation sites to anticipate sediment movement and erosion threats.

Rural Grid Resilience (REB):

- Rehabilitate and climate-proof rural electrification board (REB) infrastructure in newly added districts.
- Pilot distributed energy backup systems in off-grid or high-risk rural areas.

Monitoring and Rapid Restoration:

- Deploy SCADA and sensor-based diagnostics to detect threats in real time.
- Prepare emergency response protocols and pre-positioned materials for rapid post-disaster repair.

5. Expected Outputs and Impacts

Output/Impact Area	Key Benefits
Grid Resilience	Maintains electricity supply during and after cyclones
Public Safety	Reduces risk of electrocution, fires, and infrastructure collapse
Economic Stability	Minimizes financial losses due to power outages affecting local economies
Essential Services Continuity	Ensures hospitals, water services, and emergency response remain operational

6. Gender and Social Considerations

- Inclusive Engagement: Ensure participation of women and marginalized groups in consultations and planning of grid improvements.
- Job Creation: Promote equitable employment in the construction, maintenance, and monitoring of resilient electric grids.
- Community Awareness: Design public safety campaigns tailored to gender and age-specific needs on cyclone preparedness and electrical safety.

7. Linkage to National Adaptation Plan (NAP) Projects

This intervention directly supports NAP objectives related to:

- The extension of resilient and eco-friendly materials in infrastructure planning;
- Engaging private sector partnerships through tax incentives for resilient design;

- Facilitating **urban climate adaptation** and emergency preparedness through utility strengthening.

8. Potential Financing Options

Financing Source	Contributors	Benefits	Challenges
Government Funding	BPDB, BREB, PGCB	Existing institutional setup for grid investment	May not prioritize climate adaptation features
International Climate Funds	Green Climate Fund, Adaptation Fund, NDC Support	Tailored to resilient energy infrastructure	Complex application, competitive access
Multilateral Lenders	World Bank, ADB, KfW, JICA	Large-scale financing with technical guidance	Lengthy procurement and compliance procedures
Public-Private Partnerships	Solar microgrid operators, rural electrification firms	Encourages local innovation and reduces public burden	Needs robust regulatory and risk-sharing mechanisms

9. Critical Considerations and Future Outlook

- **Flood and Erosion Risk Management**: Flood design criteria will be reassessed, particularly for river-crossing towers. River morphology will be integrated into design to anticipate sediment and erosion dynamics.
- **Climate-Responsive Grid Design**: The project promotes **adaptive and precautionary standards**, recognizing that future climate scenarios may exceed past flood and wind benchmarks.
- **REB Integration**: Climate-proofing of rural grid infrastructure under REB systems will be integrated to reduce rural exposure.
- **Scalability and Learning**: Lessons from this initiative will feed into national utility guidelines for climate-resilient grid expansion and maintenance.

10. Estimated Investment Cost

The project will cover:

- Procurement of cyclone-resistant poles and conductors
- Retrofitting substations and transformer enclosures
- Real-time monitoring system deployment
- Grid redesign for fault isolation
- Capacity-building for grid operators

11. Economic and Financial Benefits

- **Reduced Service Interruption:** Fewer and shorter outages, preserving business and household activities.
- **Lower Repair Costs:** Durable grid materials reduce the frequency and cost of post-disaster repairs.
- **Public Health and Safety:** Avoidance of life-threatening electric hazards during storm events.
- **Return on Investment:** Long-term savings outweigh initial infrastructure upgrade costs.

12. Stakeholder Consultations

Stakeholder consultations were conducted in **Chattogram**, a major urban and coastal hub highly vulnerable to cyclonic wind impacts. The focus was to assess the physical and operational weaknesses in the electric grid system, as well as to gather local perspectives on resilience needs, service disruptions, and safety issues during storm events.

Stakeholder Group	Role in the Project	Consultation Approach
Male Community Members	Consumers of electricity, often acting as informal responders during power outages and post-disaster cleanup	Focus Group Discussion (FGD) – Male
Female Community Members	Household managers, caregivers, and users of electricity-dependent services (e.g., water, sanitation, education)	Focus Group Discussion (FGD) – Female

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Residents of cyclone- and flood-exposed areas in Chattogram

Key Observations:

- **Cyclone-Induced Power Failures**:
  - Participants described multiple recent cyclones that damaged electric poles, snapped wires, and disabled transformers, leading to power outages lasting 3 to 7 days.
  - Respondents noted that wooden poles and makeshift electrical lines were highly vulnerable to storm winds.
- **Safety Hazards and Public Risk**:
  - Broken power lines often remained submerged in floodwater, posing fatal electrocution risks.
  - Women shared concerns over loss of electricity during emergencies, which disrupted lighting, water pumps, and communication.
- **Critical Service Disruption**:
  - Health centers and cyclone shelters in the area lack dedicated backup power, rendering them non-functional during blackouts.
  - School activities, food storage, and access to medical care were interrupted during each cyclone event.
- **Community Recommendations**:
  - Replace bamboo and wooden poles with wind-resistant steel or concrete ones.
  - Introduce solar hybrid microgrids in cyclone shelters and essential service centers.

- Install automatic shut-off systems and ground-level circuit protection to reduce fire hazards.

Figure 36: FGD of Male Participants in Chattogram

Figure 35: FGD of Female Participants in Chattogram

13.2 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Power infrastructure (poles, wires, transformers) is repeatedly damaged by cyclonic winds	Objective 1: Enhance physical and operational resilience of electric grid infrastructure	FGDs
Frequent outages disrupt household life and essential services like hospitals and schools	Objective 2: Reduce frequency, duration, and impact of power outages	FGDs
Downed wires and live electricity in waterlogged areas pose critical risks to public safety	Objective 3: Minimize risks to public safety by preventing electrical hazards	FGDsFemale
Health centers and emergency shelters lack power backup during cyclones	Objective 4: Support uninterrupted delivery of essential services	FGDs
Local recommendations emphasize hybrid systems and structural upgrades, supporting resilience and SDGs	Objective 5: Contribute to SDGs 7, 9, 11, and 13	FGDs

14. Conclusion

Strengthening the electric grid against cyclonic winds is critical for disaster-resilient development in coastal Bangladesh. By investing in durable infrastructure, smart monitoring, and inclusive planning, this initiative will protect lives, ensure uninterrupted essential services, and support sustainable economic growth.

The proposed model offers a forward-looking solution to climate-proof energy distribution systems while aligning with national goals under the SDGs and the NAP.

2.4 INCREASING FLOOD RESILIENCE OF GAS FIELDS

1. Introduction

Gas fields are essential to Bangladesh's national energy security and economic stability. They supply fuel for electricity generation, industrial operations, and household consumption. However, gas field infrastructure—especially those located in low-lying and flood-prone regions—is increasingly at risk from climate-induced hazards such as storm surges, heavy rainfall, and flash flooding.

The Bhola North-1 and Shahbazpur Gas Fields in Bhola District and the Bibiyana Gas Field in Habiganj District represent high-value energy assets that are exposed to significant flood risks. Damage to these installations not only disrupts production and processing but also creates cascading effects across energy supply chains and nearby communities.

This concept paper proposes robust adaptation measures to increase the flood resilience of gas field infrastructure, ensuring safety, reliability, and continuity of production during extreme weather events.

2. Objectives

- Strengthen critical gas field infrastructure to withstand and recover from flood events.
- Minimize interruptions to gas production and processing, safeguarding energy reliability and economic resilience.
- Enhance the safety of workers and surrounding communities by mitigating flood-related hazards.
- Integrate early warning systems and flood-proof engineering in national energy planning.
- Clearly identify and benefit public utilities, dependent industries, and surrounding communities, enabling transparent cost-benefit analysis.
- Ensure alignment with SDGs 9, 11, and 13, and explore framing the project under critical infrastructure adaptation rather than energy expansion.

3. Justification for Selected Locations

The targeted gas fields are situated in some of the most flood-prone regions of Bangladesh. Their strategic role in meeting national energy demands makes their protection a high priority.

Gas Field Location	Risk Profile	Strategic Importance
Bhola North-1 & Shahbazpur (Bhola district)	Coastal floodplain, tidal surges, poor drainage	Supplies gas to southern power plants and industries
Bibiyana (Habiganj district)	Flash floods, river overflows, high rainfall zone	One of the largest gas fields contributing to national grid

4. Key Climate Resilience Measures

Engineering and Operational Interventions

- Elevated Infrastructure Platforms: Raise control rooms, processing units, and storage tanks above projected flood levels.
- Flood Barriers and Berms: Construct levees and protective embankments around installations to block floodwaters.
- Waterproofing Measures: Apply sealants and coatings to equipment and structures to prevent water ingress.
- Drainage System Upgrades: Implement advanced drainage solutions to quickly discharge floodwater and prevent accumulation.

- **Early Warning Systems:** Establish digital alerts for staff and nearby communities to improve preparedness and response.

5. Expected Outputs and Impacts

Impact Area	Key Benefits
Infrastructure Resilience	Continuous gas production even during adverse weather
Operational Continuity	Reduces unplanned shutdowns and disruptions
Workplace and Community Safety	Minimizes risks of accidents and exposure to hazardous conditions
Energy Security	Ensures steady supply of gas for power generation and industrial use

6. Gender and Social Considerations

- **Inclusive Planning:** Engage women and marginalized groups in the design and implementation of gas field resilience projects.
- **Community Representation:** Ensure affected communities are consulted through participatory workshops and focus groups.
- **Safety Education:** Promote awareness campaigns targeting all genders on safe practices during flood-triggered gas emergencies.

7. Linkage to National Adaptation Plan (NAP) Projects

This concept aligns with NAP goals for:

- **Protecting essential infrastructure** in flood- and cyclone-prone areas.
- Strengthening emergency preparedness and safety in energy production zones.
- Integrating climate resilience into industrial and energy sector planning frameworks.

8. Potential Financing Options

Financing Source	Contributors	Key Advantages	Challenges
Government Energy Budget	Ministry of Energy, BAPEX, Petrobangla	Ensures ownership and institutional alignment	Limited fiscal space
International Climate Funds	Adaptation Fund, NAMA Facility	May support **infrastructure adaptation** if not directly linked to fossil fuel expansion	GCF and similar entities may restrict funding for fossil-fuel-linked assets
Multilateral Development Banks	World Bank, ADB, JICA	Technical assistance and concessional lending for resilience upgrades	Must clearly define adaptation benefits
Private Sector Co-financing	Chevron Bangladesh (private), BGFCL	Potential corporate investment in safeguarding operational assets	Requires realignment of private risk management policies
Blended Finance	Donor-public-private model	Spreads risk and supports scale	Coordination complexity

9. Critical Considerations and Future Outlook

- **Regulatory Integration:** Revise national gas infrastructure standards to mandate climate-resilient construction.
- **Cross-Sector Coordination:** Align with disaster management, energy, and environmental planning authorities.
- **Capacity Development:** Train engineers and plant managers on adaptive design and emergency preparedness.
- **Monitoring and Evaluation:** Establish KPIs for flood resilience performance and conduct regular infrastructure audits.
- **Replicability:** Use this model as a benchmark for other gas fields and industrial infrastructure across the country.

10. Estimated Investment Cost

Proposed investment will cover:

- Construction of elevated platforms and protective barriers
- Waterproofing of critical equipment
- Drainage system redesign and upgrades
- Real-time warning system development
- Safety training for field workers and emergency response teams

11. Economic and Financial Benefits

- **Targeted beneficiary identification** will enable clearer tracking of benefits across government utilities, industries, and dependent communities.
- Reduced downtime and repair costs through resilient engineering design.
- Maintains power generation and industrial productivity during flood events.
- Increases investor confidence in Bangladesh's energy reliability and disaster risk management.
- Framing the project as **infrastructure adaptation** rather than fossil fuel support will improve access to diversified funding streams.

12. Stakeholder Consultations

Community consultations were conducted near key gas field installations in **Habiganj**, a district with high flood exposure. The focus was on assessing the physical vulnerability of gas production zones, community awareness of flood risks, and shared recommendations for improving infrastructure safety and continuity of supply.

Stakeholder Group	Role in the Project	Consultation Approach
Male Community Members	Local residents and informal workers near gas fields; often first responders during flooding	Focus Group Discussion (FGD) – Male
Female Community Members	Caregivers and household managers impacted by flood-related safety hazards and service outages	Focus Group Discussion (FGD) – Female

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Residents of flood-prone unions surrounding the Habiganj Gas Fields

Key Observations:

- Flood Exposure and Safety Concerns:
    - Male respondents reported multiple instances of floodwaters encroaching into gas field boundaries, damaging periphery fencing, and submerging electrical installations.
    - There is no formal drainage system to redirect floodwaters away from core production zones.
- Community Risk Perception:
    - Female participants expressed fear of gas leaks, fire, or electrocution during monsoon floods.
    - Respondents highlighted the lack of safety barriers and evacuation plans for adjacent settlements.
- Workforce and Infrastructure Vulnerability:
    - Workers must wade through floodwater to access the plant, which increases risk and delays response.
    - Emergency backup systems like generators are not always functional or flood-protected.
- Community Suggestions:
    - Elevate control rooms and power systems.
    - Build retaining walls and reinforce embankments near vulnerable equipment zones.
    - Install flood alert sirens and create shelter points for nearby residents.

Figure 37: FGD of Male Participants in Habiganj

Figure 38: FGD of Female Participants in Hatiya

13.2 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Gas field installations lack structural protection against riverine floods and waterlogging	Objective 1: Strengthen gas field infrastructure for flood resilience	FGDs – Male, Female
Flood events regularly disrupt plant access and slow down production recovery	Objective 2: Minimize interruptions to gas production and ensure energy reliability	FGDs
Nearby communities face safety threats due to inadequate barriers and risk mitigation systems	Objective 3: Enhance worker and community safety by mitigating flood hazards	FGDs – Female
No early warning mechanisms or integration of real-time alerts into plant operations	Objective 4: Integrate early warning and flood-proof engineering into energy planning	FGDs
Community demand aligns with national and global priorities on resilient infrastructure and SDGs	Objective 5: Contribute to SDG 7, 9, 11, and 13 through climate-smart gas field interventions	FGDs

14. Conclusion

Building flood resilience in gas field infrastructure is crucial for ensuring uninterrupted energy supply and protecting surrounding communities. While the project involves fossil fuel-linked infrastructure, its primary focus is on **climate adaptation and infrastructure safety**, not energy expansion. With strategic design, clear beneficiary identification, and proper framing, this initiative can align with adaptation goals and international funding standards.

This concept offers a high-impact, regionally scalable solution to support Bangladesh's industrial resilience, energy security, and community protection in the face of climate-induced flood risks.

2.5 PROTECTING GAS PIPELINES FROM COASTAL AND RIVERINE FLOODING

1. Introduction

The gas transmission and distribution network in Bangladesh serves as a critical lifeline for domestic, commercial, and industrial energy supply. However, these infrastructures are increasingly exposed to the impacts of climate change—especially in coastal and riverine districts like Satkhira, Khulna, Pirojpur, Patuakhali, Barisal, Madaripur, Gopalganj, Munshiganj, and Brahmanbaria. These regions experience seasonal flooding, river erosion, tidal surges, and saline intrusion, all of which pose serious threats to the structural integrity and safety of gas pipelines.

Due to shallow burial depths, aged infrastructure, and limited monitoring capabilities, pipelines in these high-risk zones face heightened risks of rupture, leakage, corrosion, and service disruptions during and after flood events. The consequences are significant—not only in terms of service delivery, but also regarding environmental contamination and public safety.

This concept paper proposes a combination of traditional built-environment solutions and enabling policy mechanisms to enhance the resilience of gas pipelines to flood events, safeguard national energy security, and reduce socioeconomic risks from climate-related infrastructure failures.

2. Objectives

- Improve structural protection of gas pipelines through climate-resilient design and engineering upgrades.
- Minimize the risk of gas leaks and system failures during coastal and riverine floods.
- Protect ecosystems and public health by reducing the risk of environmental contamination from damaged pipelines.
- Ensure continuous transmission and distribution of gas during and after flooding events.
- Align interventions with national adaptation priorities and contribute to relevant SDG targets (SDG 7, 9, 11, and 13).
- Integrate pipeline protection planning into the national energy transition roadmap, supporting resilience while enabling future shifts toward cleaner energy sources such as distributed solar systems and low-carbon technologies.

3. Justification for Selected Locations

The selected districts represent a mix of high flood exposure, critical infrastructure vulnerability, and strategic energy transmission corridors. These areas are prone to tidal surges, riverbank erosion, and embankment breaches that frequently damage underground utilities.

District	Key Risk Factors	Strategic Importance
Satkhira, Khulna	Coastal flooding, saline intrusion, storm surges	Host significant transmission pipelines for southern Bangladesh
Patuakhali, Barisal	Tidal waves, embankment failure	Supply lines to coastal industries and river ports
Madaripur, Gopalganj	River erosion, high floodwater levels	Transit route for central-western gas connectivity
Munshiganj, Brahmanbaria	Floodplain zones, infrastructure stress	Key distribution points for household and commercial gas use
Feni	River erosion, recent tower and pipeline exposure events	Inter-district gas flow node; increasing risk from river morphology shifts

4. Key Climate Resilience Measures

Engineering and Operational Interventions

- **Deep Burial or Elevated Routing:** Bury pipelines deeper in flood-prone zones or elevate them on platforms where deep burial is infeasible.
- **Corrosion Protection:** Apply corrosion-resistant coatings and waterproof materials to prevent long-term water damage.
- **Physical Barriers and Levees:** Construct embankments and barriers along pipeline routes to protect from erosion and floodwater ingress.
- **Pipeline Re-routing:** Avoid known high-risk flood zones by adjusting pipeline alignments during retrofitting or new installation.
- **Flexible Design Integration:** Incorporate joints and expansion loops to allow movement and reduce rupture risk under hydraulic stress.
- **Leak Detection Systems:** Deploy advanced sensors for early identification of pipeline breaches or pressure anomalies.
- **Flood Monitoring Integration:** Install real-time monitoring along high-risk pipeline corridors to provide timely warnings and operational responses.
- **Routine Maintenance and Inspection:** Prioritize regular check-ups in vulnerable locations, ensuring functional integrity and safety.
- **Risk-Based Prioritization**: Focus initial investments on **pipeline segments and nodes** identified through vulnerability mapping, prioritizing those serving critical sectors and urban demand centers.
- **Salinity-Resistant Materials**: Use **marine-grade steel, epoxy coatings, and cathodic protection** in saline-prone zones like Khulna and Patuakhali.

5. Expected Outputs and Impacts

Impact Area	Key Benefits
Resilience of Gas Pipelines	Sustained gas supply even during severe flooding events
Environmental and Public Health	Lower risk of gas leaks and contamination in flood-hit areas
Economic Stability	Prevents revenue loss and service disruption, stabilizing energy-dependent sectors
Disaster Response	Allows safe and fast restoration post-flood, improving emergency response efforts

6. Gender and Social Considerations

- **Inclusive Participation:** Ensure meaningful involvement of women and vulnerable community members in planning and consultations related to pipeline safety and emergency planning.
- **Employment Equality:** Promote gender-balanced job opportunities in inspection, construction, and maintenance roles tied to pipeline resilience upgrades.
- **Public Awareness:** Engage both men and women in awareness programs on pipeline safety during floods, with tailored messaging to meet diverse needs.

7. Linkage to National Adaptation Plan (NAP) Projects

This initiative aligns with the NAP's thematic priority for **"Protection and management of potentially vulnerable areas due to tropical cyclone, sea-level rise, extreme storm surges and flooding."** It contributes by:

- Climate-proofing critical gas infrastructure in flood-prone regions.

- Reducing hazard-related disruptions in energy supply.
- Enhancing emergency preparedness and risk reduction in national energy networks.

8. Potential Financing Options

Financing Source	Potential Contributors	Advantages	Challenges
Public Infrastructure Investment	Ministry of Power, Energy, and Mineral Resources	National prioritization of energy security	Budget allocation constraints
Multilateral Climate Financing	GCF, Adaptation Fund, ADB, World Bank	Climate-focused, concessional funding for resilience in energy networks	Complex eligibility and reporting procedures
Private Sector Co-financing	EPC contractors, pipeline technology firms	Brings innovation, improves delivery timelines	Requires strong contractual frameworks and technical oversight
Blended and Insurance Models	Development banks + catastrophe insurance pools	Spreads risk and offers recovery buffers	Coordination complexity and need for cross-sectoral policy alignment

9. Critical Considerations and Future Outlook

- Institutional Coordination: Strengthen inter-agency collaboration among energy, environment, and disaster management authorities.
- Digital Integration: Use GIS, SCADA, and AI-based monitoring tools for predictive maintenance and risk alerts.
- Policy Updates: Update national pipeline design and safety standards to integrate climate resilience requirements.
- Capacity Building: Train engineers, emergency responders, and utility staff in flood-proofing and risk response.
- Scalability: Pilot in high-risk districts and replicate across the national grid following performance assessment.
- Emphasize use of salinity mapping and site-specific diagnostics to guide material selection.
- Develop a criticality-risk matrix to guide cost-benefit analysis and funding decisions.
- Explore p remains viable during and beyond fossil fuel dependency.

10. Estimated Investment Cost

A comprehensive resilience program for gas pipelines across the target districts will include:

- Advanced pipeline burial and structural retrofitting
- Construction of levees and protective barriers
- Installation of leak detection and real-time monitoring systems
- Joint expansion and flexible routing upgrades
- Workforce training and digital asset mapping

11. Economic and Financial Benefits

- Reduced Disruption Costs: Prevents gas outages that could halt factories, power generation, and essential services.
- Environmental Savings: Avoids costly clean-up and rehabilitation of flood-contaminated sites.

- Lower Insurance and Repair Costs: Decreases claims and operational downtime from pipeline rupture incidents.
- Increased Investor Confidence: Reliable infrastructure boosts confidence for future gas-based industrial investment.
- Targeted upgrades in high-priority segments will **maximize return on investment** by preventing systemic disruptions.
- Cost-benefit frameworks will incorporate both **infrastructure criticality and environmental exposure**, supporting efficient resource allocation and funding proposals.

12. Stakeholder Consultations

Stakeholder consultations were carried out in Jamalpur, an area with riverine flooding risks and active gas pipeline infrastructure. The goal was to understand flood-related threats to pipeline safety and explore community concerns, institutional practices, and local adaptation needs.

Stakeholder Group	Role in the Project	Consultation Approach
Titas Gas Field Engineer	Oversight of gas infrastructure maintenance and flood response in Jamalpur	Key Informant Interview (KII)
Male Community Members	Residents living near gas pipelines; informal responders during floods and erosion incidents	Focus Group Discussion (FGD) – Male
Female Community Members	Caregivers, household energy users, and environmental observers	Focus Group Discussion (FGD) – Female

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Residents of flood-prone areas in Jamalpur near major transmission and distribution pipelines

Key Observations:

- Risk of Infrastructure Exposure:
  - Male participants noted that flood-induced erosion has previously exposed gas pipeline segments, especially near riverbanks.
  - Villagers reported makeshift attempts to bury or protect exposed pipes using mud and sandbags.
- Environmental and Household Safety:
  - Female participants expressed concern over odor leaks and loud pressure sounds during heavy rain, fearing explosions or gas poisoning.
  - Most households had no formal emergency protocols related to gas safety.
- Community Recommendations:
  - Construct embankments and elevate pipeline beds in flood-vulnerable zones.
  - Conduct awareness sessions on leak reporting and emergency shut-off procedures.

Figure 39: FGD of Male Participants in Jamalpur

Figure 40: FGD of Female Participants in Jamalpur

13.2 Key Informant Interview (KII)

Interviewee: Field Engineer, Titas Gas Transmission and Distribution Company

Key Insights:

- Technical Vulnerabilities:
    - Pipelines in soft soil zones are vulnerable to displacement or breakage during monsoon flooding.
    - There's no standardized climate-resilient design code for underground pipelines in flood-exposed areas.
- Operational Gaps:
    - Monitoring systems are analog and depend on manual inspection.
    - Post-flood repair and restoration takes time due to access and safety constraints.
- Recommendations:
    - Introduce remote sensors for pressure and leak detection.
    - Upgrade pipeline alignment and casing materials to withstand hydraulic pressure and soil movement.
    - Include gas safety in local disaster management plans and training programs.

Figure 42: KII of LKP

Figure 41: KII of Titas Gas Manager

13.3 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Pipelines are exposed and vulnerable to physical damage due to riverine flooding and erosion	Objective 1: Improve structural protection through climate-resilient design	FGDs, KII
Leaks and damage go unreported or are addressed with delays, risking fire and gas poisoning	Objective 2: Minimize risk of leaks and system failure during flooding	FGDs, KII
Environmental contamination risks are high due to weak containment and lack of flood-proofing	Objective 3: Protect ecosystems and public health from contamination caused by infrastructure failure	FGDs (Female), KII
Disruptions in supply are common post-flood, affecting homes and small industries	Objective 4: Ensure continuous gas distribution during and after floods	FGDs, KII
Strong need for standards, digital monitoring, and integration into local disaster planning	Objective 5: Align with national adaptation planning and SDGs 7, 9, 11, and 13	KII, FGDs

14. Conclusion

Strengthening gas pipelines against coastal and riverine flooding is an essential step in protecting Bangladesh's energy infrastructure from the escalating impacts of climate change. Through engineering upgrades, real-time monitoring, and institutional coordination, this initiative offers a technically feasible and economically prudent path to safeguarding continuous gas supply.

This project directly supports national climate adaptation priorities and the SDGs by enhancing resilience, minimizing service disruptions, and fostering inclusive development. The proposed interventions—scalable and adaptable—can serve as a model for integrating resilience across other critical infrastructure systems.

CONCEPT NOTES ON WATER SECTOR INFRASTRUCTURE DEVELOPMENT

3.1 FLOOD RESILIENCE FOR WATER SUPPLY NETWORKS: PROTECTING CRITICAL INFRASTRUCTURE FROM FLOOD EVENTS

1. Introduction

As a rapidly growing megacity, Dhaka's demand for clean water is surging—placing immense pressure on its aging and climate-vulnerable water supply infrastructure. Flooding, exacerbated by climate change, poses one of the most significant risks to this critical urban system. Inundation during monsoon seasons and from increasingly frequent extreme weather events often leads to water source contamination, pipeline corrosion, and service disruptions that directly impact millions of residents.

The Dhaka City Corporation, responsible for maintaining an extensive network of water supply pipelines and treatment units, faces mounting challenges in protecting these lifelines from flood-induced damage. Traditional built-environment approaches—such as reinforced pipeline systems, advanced drainage channels, backflow prevention mechanisms, and digital monitoring tools—are now essential to safeguarding water supply services during emergencies.

This concept proposes targeted resilience interventions within the city's water supply infrastructure to minimize health risks, improve operational continuity, and protect public trust in municipal water services.

2. Objectives

- Reinforce water supply infrastructure to prevent floodwater intrusion, physical damage, and contamination.
- Ensure uninterrupted access to safe drinking water during and after flood events.
- Minimize repair and maintenance costs and avoid service downtime through proactive flood-proofing measures.
- Improve real-time disaster response capabilities using digital monitoring tools for early flood alerts.
- Contribute to Bangladesh's National Adaptation Plan and global SDGs (particularly SDG 6, 9, 11, and 13).

3. Justification for Selected Location

Dhaka City Corporation is among the most densely populated and flood-prone urban areas in Bangladesh. The combination of inadequate stormwater drainage, aging water pipelines, and increasing rainfall intensity amplifies the risk of water system failure.

Area	Key Vulnerability Factors	Strategic Importance
Dhaka City Corporation	Recurrent urban flooding, pipeline corrosion, poor drainage, and water contamination	Central urban hub supporting millions with piped water supply; failure would result in a large-scale public health crisis

4. Key Climate Resilience Measures

Infrastructure and System Upgrades

- **Pipeline Protection:** Upgrade key pipelines with flood-resistant materials and secure installation to reduce exposure to waterlogging and erosion.
- **Stormwater Management Improvements:** Construct retention basins, enhance culverts, and improve drainage systems around critical water supply infrastructure.

- **Backflow Prevention Mechanisms:** Install backflow preventers at strategic locations to stop floodwaters from contaminating potable water sources.
- **Real-Time Monitoring Systems:** Use flood forecasting and digital control platforms to trigger preventive measures (e.g., shutting vulnerable valves or switching to backup sources).
- **Emergency Access Points**: Develop ward-level elevated water tanks and contingency supply systems for service continuity during prolonged

5. Expected Outputs and Impacts

Expected Impact	Key Benefits
Uninterrupted Water Access	Ensures continuous supply of clean water even during flood emergencies.
Public Health Protection	Reduces risks of waterborne disease outbreaks and maintains hygiene during disasters.
Cost Savings	Decreases repair needs and lowers financial strain on utility services.
Community Resilience	Enhances capacity to cope with flood events through safer infrastructure and services.

6. Gender and Social Considerations

- **Health and Time Burden Reduction:** Ensuring consistent water supply reduces time women spend searching for safe water during floods, improving family health.
- **Protection for Vulnerable Groups:** Women, children, and the elderly are disproportionately affected by contaminated water; flood-resilient infrastructure protects their well-being.
- **Inclusive Participation:** Women's involvement will be encouraged in planning, monitoring, and awareness campaigns related to resilient water infrastructure.

7. Linkage to National Adaptation Plan (NAP) Projects

This initiative aligns directly with the NAP's thematic priorities of water security and urban resilience:

- Enhances protection of freshwater resources from salinity and flood contamination.
- Supports adaptation actions to secure essential services in highly vulnerable, urbanized zones.
- Reduces exposure to flood risks by building back better through infrastructure renewal and system upgrades.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Challenges
Government Funds	LGD, DWASA, DPHE	Institutional ownership, aligned with urban utility mandates	Limited fiscal space and competing sectoral demands
Multilateral Development Banks	World Bank, ADB, AIIB	Expertise in urban climate adaptation, long-term concessional financing	Long preparation cycles and extensive compliance requirements
International Climate Funds	Green Climate Fund, Adaptation Fund	Access to climate-resilience grants and concessional funds	Complex application and verification processes
Small PPP Models	Private utility firms and engineering service providers	Promotes private innovation and accountability	Requires risk-sharing frameworks and viable revenue models

9. Critical Considerations and Future Outlook

Policy Integration

- Update WASA and DPHE operational guidelines to mainstream flood-resilient design and water safety protocols.

Digital Transformation

- Prioritize the use of IoT-enabled real-time monitoring and automated shut-off systems in high-risk zones.

Public Awareness

- Build community trust and understanding of flood-proof water networks through citizen engagement campaigns.

Monitoring and Maintenance

- Establish digital asset management platforms for scheduled inspections and rapid repair response.

Replication and Scaling

- Leverage learnings from Dhaka for replication in other urban water utilities facing similar risks.

10. Estimated Investment Cost

The investment will focus on pipeline reinforcement, real-time monitoring technology, improved drainage infrastructure, and backflow prevention mechanisms.

- Pipeline protection: USD 3–4 million
- Digital monitoring systems: USD 0.5–1 million
- Drainage and stormwater improvements: USD 2–3 million
- Backflow prevention and system control upgrades: USD 1 million

Total Estimated Cost: USD 6.5–9 million, subject to detailed engineering assessments and feasibility studies.

11. Economic and Financial Benefits

- Reduced Waterborne Illnesses: Avoids treatment costs for water-related diseases during floods.
- Lower Repair Burdens: Reinforced systems lead to fewer emergency repairs and unplanned disruptions.
- Resilient Urban Economy: A dependable water supply is foundational for urban productivity and investor confidence.
- Enhanced Public Value: Long-term cost savings and reliable service delivery boost confidence in municipal systems

12. Stakeholder Consultations

Stakeholder consultations were conducted in multiple wards of Dhaka City, where water supply lines, pump stations, and underground reservoirs are highly exposed to urban flooding. Discussions focused on infrastructure vulnerabilities, user experiences during water outages, and citizen perspectives on resilience needs.

Stakeholder Group	Role in the Project	Consultation Approach
Local Key Person (Ward Leader)	Monitoring and oversight of basic services including flood alerts and utility coordination	Key Informant Interview (KII)
Male Community Members	Primary users of municipal water systems, informal infrastructure protectors during floods	Focus Group Discussion (FGD) – Male
Female Community Members	Main managers of household water collection, hygiene, and emergency coping practices	Focus Group Discussion (FGD) – Female

Households from Dhaka Wards	Directly dependent on WASA services and exposed to service disruptions during flood events	Household Survey (n=100)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Male and female water users from highly flood-prone neighborhoods in Dhaka

Key Observations:

- Infrastructure Vulnerability:
  - Both groups reported recurring flood-induced damage to underground pipes and booster pumps.
  - Water often turns turbid or muddy due to infiltration from sewage or standing floodwater.
- Household Impact and Gendered Experience:
  - Female participants described having to boil and store water for up to three days during outages.
  - Many women rely on unsafe hand pumps or shared tanks located in submerged alleyways.
- Community Recommendations:
  - Construct elevated pump houses and secure pipe joints with waterproof materials.
  - Install alarm systems linked to water pressure drops and real-time mobile alerts.

Figure 44: FGD of Male Participants in Dhaka

Figure 43: FGD of Female Participants in Dhaka

13.2 Household Survey

Profile: 100 households in flood-prone zones of Dhaka, comprising wage workers, small business owners, and informal laborers.

Key Findings:

- Flood-Related Service Failures:
  - 71% of respondents experienced water supply interruption for more than 24 hours during the last major flood.

- 58% reported visible water contamination (odor, discoloration) during flood periods.

- Coping Mechanisms:
  - 46% relied on neighbors' borewells or paid water vendors.
  - 29% stored water in drums but lacked purification options.
- Digital Readiness & Alerting:
  - 67% supported real-time mobile alerts about service outages or contamination risks.
  - 54% favored smart meters and leak detectors at household level.
- Public Recommendations:
  - Introduce digitally monitored water networks with pressure gauges and early warning apps.
  - Set up ward-level emergency water tanks and standard operating procedures for local repair teams.

13.3 Key Informant Interview (KII)

Interviewee: Ward-level local representative (LKP)

Key Insights:

- Infrastructure Challenges:
  - Current supply lines lack flood protection barriers or adaptive layout for sloped drainage areas.
  - Delays in pump restart post-flood worsen public frustration.
- Response System Gaps:
  - Emergency coordination among WASA, disaster authority, and community leaders is informal and reactive.
- Recommendations:
  - Install automatic shutoff and restart controls.
  - Integrate flood vulnerability data into city's water distribution master plan.

Figure 45: KII of LKP

13.4 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Pipes and booster systems are repeatedly damaged by floodwater intrusion and soil erosion	Objective 1: Reinforce water infrastructure against flood-induced physical damage	FGDs, HH Survey, KII
Service downtimes lead to unsafe coping strategies and health risks	Objective 2: Ensure uninterrupted access to safe water during and after floods	FGDs, HH Survey
Delayed repairs and informal processes increase maintenance costs and inefficiencies	Objective 3: Minimize repair costs and avoid downtime through proactive flood-proofing	FGDs, KII
Mobile alerts, pressure sensors, and flood maps are strongly supported by local users	Objective 4: Improve real-time disaster response through digital monitoring	HH Survey, FGDs
Strong alignment with SDGs and NAP goals via public demand for resilience, affordability, and inclusion	Objective 5: Contribute to SDG 6, 9, 11, and 13 and support national climate and infrastructure planning frameworks	HH Survey, FGDs, KII

14. Conclusion

Dhaka's water supply network is under imminent threat from climate-induced flood events. By implementing practical engineering upgrades and integrating real-time monitoring systems, this concept offers a sustainable pathway to safeguard essential water infrastructure.

Strengthening the resilience of water pipelines, drainage, and operational control systems not only ensures clean water delivery during emergencies but also protects public health, reduces economic losses, and supports the broader goals of urban climate adaptation. The proposed model offers a scalable and cost-effective approach that can serve as a benchmark for flood-resilient urban water systems across Bangladesh.

3.2 ENHANCING RESILIENCE OF WATER TREATMENT PLANTS TO FLOODING

1. Introduction

Water treatment infrastructure is essential to public health and urban sustainability, especially in densely populated and flood-prone regions such as Dhaka. The Saidabad Water Treatment Plant, a key facility for ensuring safe drinking water for millions, is increasingly at risk due to recurring urban floods, stormwater accumulation, and climate-induced extreme rainfall events. Situated near floodplain areas, the plant faces vulnerabilities that threaten its operational integrity, the safety of its stored chemicals and equipment, and the uninterrupted supply of clean water to the population.

As climate change intensifies the frequency and severity of flooding, there is a critical need to protect the physical assets and operational functions of water treatment facilities. Integrating traditional built environment solutions—such as elevation of components, flood barriers, drainage enhancements, and real-time monitoring systems—will help ensure that vital services are sustained even during extreme climatic events.

This concept focuses on enhancing the resilience of the Saidabad Water Treatment Plant by applying practical, proven infrastructure and operational measures to mitigate flood risks, minimize downtime, and safeguard public health.

2. Objectives

- Strengthen the physical resilience of the Saidabad Water Treatment Plant to withstand extreme flood events.
- Minimize operational disruptions and safeguard continuous access to clean and safe drinking water.
- Reduce public health risks by ensuring uninterrupted water treatment and supply during and after floods.
- Improve early warning, response capacity, and decision-making through real-time data and monitoring systems.
- Align the intervention with national adaptation planning and key SDG targets including SDG 6 (Water), SDG 9 (Infrastructure), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action).

3. Justification for Selected Location

The Saidabad Water Treatment Plant is a strategic urban asset and one of Dhaka's largest water treatment facilities, serving a densely populated area. Key reasons for prioritizing this site include:

Component	Description
Exposure to Flood Risk	Located in a low-lying floodplain zone, prone to waterlogging and drainage congestion during seasonal rains.
Critical Urban Function	Ensures daily water supply to over 10 million residents, making operational reliability a top priority.
Chemical and Electrical Vulnerability	Contains sensitive equipment and hazardous chemicals that require protection from flood damage.
Strategic Investment Value	Resilience upgrades can significantly reduce economic losses, service disruptions, and long-term infrastructure costs.

4. Key Climate Resilience Measures

The project focuses on targeted flood resilience upgrades at the Saidabad Water Treatment Plant to ensure continuity of service and operational safety:

- Elevation of Critical Assets: Raise control rooms, electrical panels, and chemical storage above flood levels to prevent damage.
- Flood Barriers and Waterproofing: Install barriers and sealant systems to protect plant interiors from water ingress.

- **Drainage and Pumping Enhancements**: Improve on-site drainage and stormwater management capacity to prevent waterlogging.
- **Real-Time Monitoring Systems**: Deploy sensors and dashboards for tracking water levels, rainfall, and equipment status.
- **Emergency Backup Systems**: Upgrade power redundancy and access to portable treatment solutions during extreme events.

5. Expected Outputs and Impacts

Impact Area	Benefits
Operational Continuity	Ensures uninterrupted water treatment and supply even during major flood events.
Health and Hygiene	Reduces the risk of waterborne diseases by maintaining access to clean water during crises.
Economic Stability	Prevents service shutdowns and reduces recovery costs and economic losses due to flood-induced damage.
Infrastructure Longevity	Lowers damage costs and enhances system durability

6. Gender and Social Considerations

The project will ensure that flood resilience measures in water infrastructure are inclusive and socially responsive by:

- Involving diverse community groups, especially women, in consultations regarding water supply and safety priorities.
- Designing inclusive emergency communication systems and contingency plans.
- Considering women's roles as primary water managers in households to reflect their specific needs and vulnerabilities.

7. Linkage to National Adaptation Plan (NAP) Projects

This intervention contributes directly to the NAP thematic priorities related to water security and urban resilience. Key linkages include:

- Improved management of freshwater resources in flood-prone urban zones.
- Integration of climate-resilient infrastructure in national urban water planning.
- Contribution to national SDG and climate action targets.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Challenges
Government Funding	Ministry of Local Government, DPHE, and WASA	Strong national ownership, facilitates integration with urban service delivery plans	Competing priorities and fiscal limitations in urban infrastructure investments
Multilateral Development Banks	World Bank, Asian Development Bank, JICA	Access to concessional loans, expertise in infrastructure resilience	Long approval cycles, need for detailed technical and safeguard compliance

9. Critical Considerations and Future Outlook

Long-Term Sustainability

- Implement asset management systems and schedule-based inspections to ensure ongoing maintenance and upgrades of resilience infrastructure.

Governance and Policy Alignment

- Strengthen water infrastructure design codes and disaster resilience standards under WASA and DPHE operational guidelines.

Community and Gender Integration

- Develop inclusive communication systems and feedback mechanisms involving women and vulnerable groups in disaster preparedness and water service delivery.

Digital Innovation and Research

- Invest in research and development for real-time monitoring tools and early warning systems tailored to flood-prone urban utilities.

Scalability and Replication

- Document and standardize practices from the Saidabad model for replication in other urban water treatment facilities in Dhaka and other secondary cities.

10. Estimated Investment Cost

The estimated investment cost will cover the following key components:

- Elevation of essential infrastructure (e.g., control rooms, chemical storage)
- Installation of flood barriers and waterproofing systems
- Modernization of drainage and pumping infrastructure
- Procurement of real-time monitoring and alert systems
- Capacity-building workshops for plant staff and emergency teams
- Equipment and tools for post-flood recovery and rapid response

Preliminary estimates suggest an investment range of USD 8–12 million, subject to final feasibility assessments and engineering designs specific to Saidabad's site characteristics and operational needs.

11. Economic and Financial Benefits

- **Reduced Downtime:** Continuous water treatment operations reduce revenue loss and prevent economic disruptions in urban industries and households.
- **Lower Recovery Costs:** Fewer damages during flood events lead to long-term savings on repair and reconstruction.
- **Health and Hygiene Gains:** Ensuring access to potable water prevents public health crises and medical expenditure surges.
- **Public Trust and Utility Reputation:** Maintaining service continuity boosts citizen trust in public water utilities and municipal governance.
- **Catalyst for Investment:** Climate-resilient infrastructure attracts development financing and increases donor and investor confidence in urban service delivery.

12. Stakeholder Consultations

Stakeholder consultations were conducted in Dhaka, focusing on communities served by the **Saidabad Water Treatment Plant**, which is exposed to flood risks from the Shitalakshya River. Discussions explored infrastructure vulnerabilities, public health implications, and adaptation priorities during extreme flood events.

Stakeholder Group	Role in the Project	Consultation Approach
Male Community Members	Primary users of piped water systems; experience flood-related service disruptions	Focus Group Discussion (FGD) – Male
Female Community Members	Water managers at household level and caregivers during health and hygiene crises	Focus Group Discussion (FGD) – Female

Urban Households (Dhaka South & East)	Directly affected by drinking water supply disruptions during flood periods	Household Survey (n=100)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Residents of flood-prone neighborhoods in Dhaka East and South

Key Observations:

- Water Supply Disruptions:
  - Men reported that even moderate flooding causes pressure drops, water discoloration, and sediment flow from household taps.
  - Some families resort to bottled water or rainwater when Saidabad WTP operations are interrupted.
- Public Health and Safety Concerns:
  - Female participants described difficulty accessing safe water for children, elderly, and postpartum women during floods.
  - Diarrhea, skin infections, and cholera risk were cited as increasing due to floodwater entering pipelines.
- Early Warning and Communication Gaps:
  - Respondents requested SMS alerts or community announcements when water quality is at risk.
  - No visible coordination between WTP officials and local communities for emergency response.
- Community Suggestions:
  - Elevate pump houses and protect generator rooms from water ingress.
  - Introduce chlorine tablets or rapid distribution of water purifiers during outages.

Figure 47: FGD of Male Participants in Dhaka

Figure 46: FGD of Female Participants in Dhaka

13.2 Household Survey Outcomes

Profile: 100 households across flood-affected wards in Dhaka city served by Saidabad WTP

Key Findings:

- Flood Impacts on Supply:

- 73% reported pressure loss and water discoloration during heavy rainfall/flooding events.
- 64% said they received no official notification or support during past service interruptions.

- Health & Risk Exposure:
  - 51% of households reported at least one family member falling ill due to unsafe water during floods.
  - Over 40% households stored water in open containers, increasing contamination risk.
- Recommendations by Respondents:
  - Invest in water quality sensors and monitoring dashboards accessible to local authorities.
  - Establish community water tanks on elevated platforms in each ward as contingency reserves.
  - Coordinate with public health departments for synchronized response and water quality testing.

13.4 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Saidabad WTP is vulnerable to flooding, causing service interruptions and unsafe water supply	Objective 1 & 2: Strengthen physical resilience and minimize operational disruptions	FGDs, Household Survey
Waterborne diseases spike during flood events due to pipeline breaches and low pressure	Objective 3: Reduce public health risks by ensuring uninterrupted treatment and delivery	FGDs (Female), HH Survey
Community lacks real-time alerts, early warnings, or clarity on water safety	Objective 4: Improve decision-making and early response through real-time monitoring systems	FGDs, HH Survey
Public strongly supports integration of WTP upgrades into urban climate planning and SDG alignment	Objective 5: Align with national adaptation goals and SDGs 6, 9, 11, 13	HH Survey, FGDs

14. Conclusion

Building climate resilience into critical urban infrastructure such as the Saidabad Water Treatment Plant is an urgent and strategic response to Dhaka's growing vulnerability to climate-induced floods. The proposed intervention—focused on elevating structures, upgrading drainage and pumping systems, installing flood defenses, and incorporating digital monitoring—presents a robust and cost-effective model for urban climate adaptation.

By aligning with national priorities, SDG commitments, and the goals of the National Adaptation Plan, this project ensures long-term service continuity, protects public health, and enhances resilience against future climate shocks. The approach is technically sound, socially inclusive, and financially viable—laying the foundation for scaling resilience interventions across Bangladesh's urban utility networks.

3.3: ENSURING DRINKING WATER SECURITY AGAINST COASTAL FLOODING IN BANGLADESH

1. Introduction

Bangladesh's coastal regions are increasingly facing freshwater scarcity due to climate-induced salinity intrusion, tidal flooding, and rising sea levels. In the 19 coastal districts, many communities struggle to access safe and reliable drinking water, particularly after storm surges and extreme rainfall events. These threats are further compounded by weak water infrastructure, low institutional capacity, and high population density.

Access to safe drinking water is fundamental to public health, food security, and climate resilience. During flood events, traditional water sources such as ponds, shallow tube wells, and community taps often become contaminated or inaccessible. Women, children, and elderly individuals—who bear the primary responsibility for water collection—face heightened physical and social vulnerabilities during water crises.

This concept proposes a comprehensive enabling environment to ensure drinking water security in Bangladesh's coastal districts. It integrates structural, institutional, and community-based approaches to protect drinking water sources, enhance local water governance, and prepare for climate extremes.

2. Objectives

- Safeguard public health and livelihoods by ensuring continuous access to safe drinking water before, during, and after coastal flooding.
- Strengthen institutional and community-based systems for managing climate-resilient drinking water infrastructure.
- Promote inclusive, affordable, and gender-responsive drinking water solutions across flood-prone districts.
- Integrate water security into national adaptation frameworks and disaster preparedness plans.
- Contribute to SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action).

3. Justification for Selected Locations

The selected 19 coastal districts are highly vulnerable to saline intrusion, flood-induced contamination, and infrastructure failure. Limited access to freshwater and the growing threat of climate-induced hazards necessitate urgent and coordinated intervention.

Districts	Key Vulnerability Factors	Strategic Importance
Satkhira, Khulna, Bagerhat	Severe salinity, cyclone exposure, shallow aquifer degradation	High-density areas with large-scale freshwater dependency
Bhola, Barguna, Patuakhali	Frequent storm surges, minimal elevated infrastructure	Island zones with urgent climate adaptation needs
Chattogram, Cox's Bazar, Barisal	Urbanization pressure, saline intrusion, and population displacement	Urban growth centers reliant on piped and alternative water systems
Noakhali, Feni, Laxmipur	Erosion-prone, unplanned water systems, low-lying riverine terrain	Rural-urban transition zones with fragile infrastructure

These districts collectively represent the epicenter of Bangladesh's drinking water vulnerability under future climate scenarios.

4. Key Climate Resilience Measures

- **Resilient Water Infrastructure:** Build elevated tube wells, rainwater tanks, and flood-protected storage to ensure access during and after floods.
- **Drainage-Integrated Design:** Include proper drainage features to prevent water stagnation and post-flood contamination.
- **Decentralized Solutions:** Deploy small-scale desalination units and mobile filtration kits in remote and island areas.

- **Rainwater Harvesting:** Promote household and community systems with filtration for year-round use.
- **Local Governance:** Support community-led water committees and integrate drinking water into local adaptation and disaster plans.

5. Expected Outputs and Impacts

Expected Output/Impact	Key Benefits
Safe drinking water accessible year-round	Improves public health and reduces waterborne disease outbreaks
Strengthened local water governance	Enhances sustainability and service accountability
Reduced disruption during floods and disasters	Ensures uninterrupted water supply to households and shelters
Increased use of rainwater and alternative sources	Reduces dependence on salinity-prone shallow aquifers
Elevated and flood-safe water systems	Continuous safe water access during climate events
Empowered community water management	Builds resilience and reduces social vulnerability

6. Gender and Social Considerations

- Promote the active participation of women, especially those from marginalized and low-income households, in water management committees and emergency planning groups.
- Design water collection systems with a focus on safety, accessibility, and dignity, especially for female-headed households.
- Introduce skills-building and employment pathways for women in maintenance of drinking water facilities and hygiene education.

7. Linkage to National Adaptation Plan (NAP) Projects

This adaptation concept is aligned with the NAP priority:
"Management of freshwater resources and monitoring of salinity for reducing vulnerabilities in existing and potential salinity-prone areas."

It also supports resilience measures under water supply infrastructure and emergency preparedness in disaster-prone districts.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Challenges
Government Budget (DPHE, LGD)	Ministry of LGRD & Cooperatives, DPHE	Established channels for water infrastructure	Limited fiscal allocation and budget prioritization
Multilateral Donors	World Bank, ADB, UNICEF, GCF	Technical expertise and climate alignment	Complex application processes and co-financing
Public-Private Partnerships (PPPs)	NGOs, water tech firms, social enterprises	Local innovation, shared risks	Weak regulation and low investor confidence
Climate Resilience Grants	Adaptation Fund, Green Climate Fund	Grant-based, promotes equity	Competitive and time-intensive approval cycles

9. Critical Considerations and Future Outlook

- **Maintenance & Monitoring**: Include O&M plans and community-based monitoring in all water security investments.
- **Integrated Planning**: Align water supply projects with climate forecasts, urban development, and WASH programs.

- **Policy Advocacy**: Support formulation of a national coastal water security strategy and updated standards for flood-resilient water infrastructure.
- **Scalability**: Pilot scalable water security solutions in priority districts, with potential replication in other vulnerable regions.
- **Innovation**: Encourage use of solar-based pumping, mobile water ATMs, and desalination microgrids for last-mile delivery.

10. Estimated Investment Cost

The total investment required will vary depending on the scale of interventions across the coastal districts and the integration of new technologies. The estimated cost components include:

- Climate-resilient infrastructure (elevated tube wells, treatment units, rainwater tanks)
- Pilot-scale desalination and solar-powered pumping systems
- Community-level rainwater harvesting and purification units
- Capacity building and training for local water governance bodies
- Water quality monitoring systems and GIS tools
- Communication campaigns and behavior change programs

A full cost breakdown will be provided in the feasibility phase.

11. Economic and Financial Benefits

- **Reduced healthcare expenditures** from waterborne disease outbreaks during and after flood events.
- **Decreased time and income loss**, especially for women and school-going children, by ensuring safe water is available nearby.
- **Lower disaster response costs** through advance planning and availability of decentralized emergency water solutions.
- **Increased agricultural and fisheries productivity** due to sustained freshwater access in climate-stressed districts.
- **Boosted investor confidence** in community infrastructure and PPP models as transparency, accountability, and functionality improve.
- **Improved resilience of social safety nets**, protecting vulnerable populations from climate-induced water insecurity.

12. Stakeholder Consultations

Stakeholder consultations were conducted in **Shyamnagar**, a low-lying coastal upazila severely affected by saline intrusion and periodic tidal flooding. The consultations aimed to assess barriers to safe drinking water access and identify inclusive, climate-resilient solutions suitable for both institutional integration and local adoption.

Stakeholder Group	Role in the Project	Consultation Approach
Male Community Members	Primary water collectors, informal system managers, and decision-makers	Focus Group Discussion (FGD) – Male
Female Community Members	Caregivers and water managers facing high health and safety burdens during water crises	Focus Group Discussion (FGD) – Female
Cyclone-affected Households	End users of drinking water systems experiencing contamination, disruption, and scarcity	Household Survey (n=100)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Men and women from salinity-prone areas of Shyamnagar

Key Observations:

- Water Contamination and Crisis:
    - During flood events, pond and tube well water becomes brackish and often unusable.
    - Both groups described needing to boil water or walk over 2 km to fetch safe drinking water.
- Gendered Burden and Safety:
    - Female respondents emphasized safety risks while fetching water, especially during evening hours or flood periods.
    - Lack of toilets near water points is a challenge for adolescent girls and elderly women.
- Community-led Coping:
    - Rainwater harvesting is used as a backup but is often insufficient after monsoon.
    - Men advocated for elevated platforms and protective walls for existing water tanks.
- Requests and Suggestions:
    - Demand for solar-powered water filtration units, public water tanks with metering, and free distribution during disasters.
    - Women urged for water user groups that include at least 50% female representation.

Figure 49: FGD of Male Participants in Satkhira

Figure 48: FGD of Female Participants in Satkhira

13.2 Household Survey :

Profile: 100 households across flood-prone unions of Shyamnagar, with primary occupations in agriculture, fishing, and day labor.

Key Findings:

- Water Source and Reliability:
    - 63% use pond water for drinking; 27% use rainwater harvesting; only 10% have access to intermittent piped supply.
    - 79% reported complete loss of safe drinking water for at least three days following a cyclone or flood.

- Health and Sanitation:
    - 48% reported recent cases of diarrhea and skin diseases linked to water contamination.
    - 31% said they avoided handwashing due to lack of clean water.
- Affordability and Access:
    - 62% rely on paid water vendors during disasters; 73% of female-headed households could not afford such purchases.
- Institutional Engagement and Inclusion:
    - Only 18% were aware of any local water governance or emergency response committee.
    - 81% supported forming **community-led water user groups**, recommending at least **50% female representation**.
- Recommendations from Respondents:
    - Construct **elevated water storage tanks** and install **flood-resilient tube wells** using waterproof materials.
    - Promote **solar-powered filtration units** and establish **community-managed public water points**.
    - Incorporate **nature-based solutions** like **constructed wetlands** and **watershed management** to prevent flood-related contamination.
    - Ensure inclusive water governance through local capacity-building and transparent, participatory decision-making processes.
    - Embed drinking water security into **local adaptation plans** and disaster preparedness frameworks.

13.3 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Drinking water access is frequently disrupted due to flooding, salinity, and lack of elevated infrastructure	Objective 1: Safeguard public health and livelihoods through continuous access to safe water during climate emergencies	FGDs, Household Survey
Rainwater systems and shallow wells are easily contaminated or damaged	Objective 2: Strengthen climate-resilient drinking water infrastructure and local maintenance systems	FGDs, Household Survey
Women and girls face safety, access, and affordability issues during crisis periods	Objective 3: Promote inclusive, affordable, and gender-responsive water solutions	FGDs (Female), Household Survey
Communities lack formal governance and disaster preparedness mechanisms for water management	Objective 4: Integrate water security into national/local adaptation and disaster preparedness plans	Household Survey, FGDs
Public health risks and SDG 6, 11, and 13 are directly impacted by water insecurity in coastal areas	Objective 5: Contribute to SDGs related to clean water, sustainable cities, and climate action	FGDs, Household Survey

14. Conclusion

Ensuring safe drinking water in Bangladesh's coastal regions is not only a matter of public health, but a foundational pillar of climate resilience. As sea levels rise and coastal flooding intensifies, communities are increasingly vulnerable to water contamination, service disruption, and social inequity. This concept proposes a comprehensive and inclusive approach that strengthens infrastructure, empowers local institutions, and promotes nature-based and technological solutions tailored to diverse geographic and social contexts.

By embedding water security into national adaptation planning, fostering local ownership, and leveraging climate finance, this intervention will contribute significantly to sustainable development and long-term resilience. The integration of gender-sensitive practices and community-driven governance ensures that the most vulnerable—particularly women and marginalized groups—are protected and empowered through equitable access to clean and safe drinking water. This enabling environment can serve as a scalable model for water resilience in climate-affected coastal regions across Bangladesh.

3.4: ENHANCING WATER SECURITY IN COASTAL REGIONS: BUILDING AN ENABLING ENVIRONMENT FOR CLIMATE-RESILIENT WATER RESOURCES MANAGEMENT

1. Introduction

Bangladesh's coastal districts are acutely vulnerable to climate-induced water insecurity due to sea-level rise, saline intrusion, cyclonic storms, and erratic rainfall patterns. These climate shocks compromise freshwater availability, disrupt irrigation systems, and impair the health and livelihoods of millions. The ongoing degradation of groundwater and surface water resources poses serious threats to drinking water supply, food systems, and public health — particularly in areas with fragile infrastructure and limited institutional capacity.

The need for a robust enabling environment that strengthens cross-sector coordination, empowers local actors, and integrates climate-smart water governance into national adaptation frameworks is more urgent than ever. This project seeks to create an institutional and policy landscape that enables coastal communities to access, manage, and protect water resources sustainably and equitably.

2. Objectives

- Strengthen institutional and regulatory frameworks to integrate water security into national and local adaptation strategies.
- Improve community resilience to water scarcity caused by saline intrusion, drought, and extreme weather.
- Promote inclusive and participatory water governance involving women and marginalized communities.
- Enhance cross-sectoral coordination between water, agriculture, fisheries, and planning authorities.
- Support the achievement of relevant SDGs, especially SDGs 5 (Gender Equality), 6 (Clean Water), 11 (Sustainable Cities), and 13 (Climate Action).

3. Justification for Selected Locations

The 19 coastal districts of Bangladesh are highly susceptible to the impacts of climate change, particularly in terms of water security. These areas face salinity intrusion, sea-level rise, storm surges, and prolonged water scarcity due to erratic rainfall and groundwater depletion. Inadequate institutional capacity and fragmented water governance systems further exacerbate these challenges. Ensuring water security in these districts is critical to safeguard public health, livelihoods, and climate resilience.

District	Key Vulnerability Factors	Strategic Importance
Satkhira, Khulna, Bagerhat	High salinity, poor groundwater recharge, tidal surges	Vital agricultural zones with heavy dependence on surface water
Bhola, Barguna, Patuakhali	Limited access to safe drinking water, coastal flooding	Key rural districts with water-stressed populations
Noakhali, Laxmipur, Feni	Inadequate water infrastructure, erosion, saline intrusion	Densely populated areas needing integrated water supply solutions
Chattogram, Barisal, Cox's Bazar	Urban water demand, salinity, pressure on water utilities	Coastal economic hubs requiring resilient water resource systems

These districts have been prioritized due to their combined exposure to climatic stressors, high population densities, and existing institutional constraints in delivering safe and sustainable water access. Addressing water security here offers scalable, high-impact outcomes for climate adaptation.

4. Key Climate Resilience Measures

Policy and Institutional Reform

- Develop national and regional water security policies tailored to coastal challenges.
- Integrate water resilience into climate adaptation and development plans at all governance levels.
- Integrated Water Infrastructure Planning: Develop climate-resilient, year-round water systems that combine flood-protected supply, decentralized storage, and stormwater drainage infrastructure tailored to local demand and hydrology.
- Post-Flood Drainage Integration: Design embankment and supply systems to allow controlled drainage after storm surges and floods, reducing water stagnation that damages homes and cropland.
- Localized Demand Mapping and Monitoring: Conduct community-level water demand assessments to inform infrastructure sizing and technology selection, ensuring responsiveness to seasonal and demographic variations.
- Climate-Smart Technologies: Pilot solutions like solar desalination, treated rainwater storage, and elevated distribution systems to serve both remote and flood-exposed areas sustainably.
- Governance and Oversight: Strengthen water user groups, local institutions, and public-private partnerships to co-manage water assets and ensure long-term system sustainability.

5. Expected Outputs and Impacts

- Coastal populations gain reliable access to safe drinking water during both regular and extreme conditions.
- Strengthened institutional capacity and integration of water planning in development processes.
- Improved community health, food security, and disaster resilience through stable water access.
- Reduced water-related conflict and stronger collaboration between sectors.
- More inclusive, transparent, and gender-sensitive water governance.
- Reduced vulnerability to saline intrusion and drought

6. Gender and Social Considerations

The project will ensure that women, children, and marginalized communities are central to planning, implementation, and decision-making processes. Measures include:

- Actively involving women's groups in task forces and local water user committees.
- Building leadership capacity among women for water system maintenance and emergency response.
- Ensuring water facilities are safe, accessible, and inclusive for all users.
- Addressing specific health and hygiene concerns for women in water access planning.

7. Linkage to National Adaptation Plan (NAP) Projects

This initiative aligns with Bangladesh's NAP priority on the **"management of freshwater resources and monitoring of salinity for reducing vulnerabilities in salinity-prone areas."** It contributes to:

- Climate-smart governance of freshwater systems;
- Salinity monitoring and early warning systems;
- Community-based adaptation for water access and safety.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Key Challenges

Government Funds	LGD, DPHE, local authorities	Ensures integration with national systems	Budget limitations
Multilateral Banks	ADB, WB, IFAD	Scalable, climate-financed loans or grants	Long approval cycles
International Donors	GCF, Adaptation Fund, JICA	Alignment with international goals	Competitive application
PPP	Private water technology firms	Fosters innovation and cost-effectiveness	Needs regulatory clarity
Blended Finance	Mix of grants and loans	Spreads risk and aligns incentives	Requires robust design and governance

9. Critical Considerations and Future Outlook

- **Sustainability**: Build institutional capacity for long-term water governance and infrastructure maintenance.
- **Policy Alignment**: Embed water security into climate and development policies at all levels.
- **Data and Monitoring**: Develop real-time monitoring systems for salinity, water levels, and supply quality.
- **Replication Potential**: Pilot-tested strategies will be scalable across other vulnerable regions in Bangladesh and South Asia.

10. Estimated Investment Cost

The investment cost covers:

- Policy formulation and institutional development
- Capacity building and training
- Infrastructure planning and technology pilots (e.g., desalination units, solar pumps)
- Community-level demand assessment and participatory planning, ensuring accurate water use projections and locally appropriate design.
- Infrastructure planning and technology pilots, such as climate-resilient water storage, drainage-integrated embankments, solar desalination units, and rainwater harvesting systems.

11. Economic and Financial Benefits

- Reduction in health-related costs from unsafe water and salinity exposure.
- Improved productivity and time savings, especially for women and children involved in water collection.
- Stabilized agriculture and fisheries dependent on freshwater availability.
- Increased investor confidence in coastal development and service delivery systems.

12. Stakeholder Consultations

In-depth stakeholder consultations were conducted in Shyamnagar, Satkhira—one of the most climate-vulnerable coastal regions in Bangladesh. The consultations included community members, local authorities, and water resource users affected by saline intrusion, tidal flooding, and extreme water stress.

Stakeholder Group	Role in the Project	Consultation Approach
Border Guard Bangladesh (BGB Camp Representative)	Local institutional knowledge; monitoring cross-border water flow and embankment status	Key Informant Interview (KII)
Male Community Members	Primary users of agricultural, domestic, and aquaculture water systems	Focus Group Discussion (FGD) – Male

Female Community Members	Household water managers and caregivers most affected by water scarcity and salinity	Focus Group Discussion (FGD) – Female
Cyclone- and salinity-exposed households	Directly impacted by water scarcity, salinity, and climate variability	Household Survey (n=100)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Farmers, shrimp cultivators, homemakers, and informal water system users from flood-prone unions in Shyamnagar

Key Observations:

- Salinity and Scarcity:
  - Both groups highlighted growing dependency on canal and pond water due to groundwater salinity.
  - Women walk long distances to collect water, and schools lack potable water for students.
- Governance Issues:
  - Participants noted lack of oversight in sluice gate operations and mismanagement of canal systems.
  - Local conflict exists over water sharing between agriculture and shrimp farmers.
- Adaptive Practices:
  - Community members are installing household-level rainwater tanks and building elevated water storage areas.
- Community Recommendations:
  - Create water user groups at ward level, engage women in water governance, and improve embankment-drain connectivity.

Figure 51: FGD of Male Participants in Satkhira

Figure 50: FGD of Female Participants in Satkhira

13.2 Household Survey Outcomes

Profile: 100 households in saline-prone rural areas of Satkhira with diverse livelihoods: agriculture, fisheries, day labor, and small trade.

Key Findings:

- Water Access and Source:
    - 57% depend on pond water; 32% on harvested rainwater; 11% on distant piped supply.
    - 84% reported water shortages during March–June due to high salinity and heatwaves.
- Institutional Engagement:
    - Only 24% knew of any local water governance committee.
    - 73% wanted women and youth representation in water user groups and planning processes.
- Cross-Sector Conflict:
    - 62% experienced water-related disputes between farmers and shrimp cultivators.
    - 49% cited a lack of joint planning between local water boards and agricultural offices.
- Policy and Resilience Needs:
    - 77% supported including water in local development plans.
    - 89% supported cross-agency coordination and early warning for seasonal water stress.

13.3 Key Informant Interview (KII)

Interviewee: Representative of Border Guard Bangladesh (BGB), Shyamnagar

Key Insights:

- Strategic Observations:
    - The BGB monitors embankment breaches and reports on saline water inflow during high tides.
    - Emphasized coordination gaps between local government, BWDB, and community.
- Security and Governance:
    - Local disputes sometimes arise over illegal pumping or blocking of canals.
    - Recommends formalized joint task forces and village-level conflict resolution forums.
- Infrastructure Needs:
    - Urged that water infrastructure planning must consider border conditions and rising water levels.

Figure 52: KII of BGB Representative

13.4 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Saline intrusion and seasonal water scarcity threaten agriculture, drinking, and hygiene needs	Objective 2: Improve community resilience to water scarcity caused by climate change	FGDs, HH Survey
Lack of coordination between agencies managing water, agriculture, and embankments	Objective 4: Enhance cross-sectoral coordination across water-dependent sectors	KII, HH Survey, FGDs
Existing policies do not integrate climate-resilient water planning or user group participation	Objective 1 & 3: Strengthen institutional frameworks and promote participatory water governance	FGDs, KII, HH Survey
Women and youth face the greatest burden but are excluded from governance	Objective 3 & 5: Promote inclusive water governance and support SDG 5 and 6	FGDs (Female), HH Survey
Strong community demand exists for integrated, locally-led, and gender-responsive water policy	Objective 1, 3, and 5: Link water security to national adaptation strategies and SDGs 11 and 13	HH Survey, FGDs

14. Conclusion

Enhancing water security in Bangladesh's coastal districts through an enabling environment is not only a climate imperative but a socio-economic necessity. This initiative will bridge policy gaps, empower local institutions, and ensure that coastal communities — particularly the most vulnerable — have access to clean, reliable water in the face of growing climate risks.

4.1 DEVELOPMENT OF CLIMATE-RESILIENT HEALTH CARE FACILITIES IN COASTAL DISTRICTS OF BANGLADESH

1. Introduction

Bangladesh's coastal regions face escalating climate threats—cyclones, tidal surges, flooding, and salinity intrusion—that jeopardize critical public infrastructure, especially health care facilities (HCFs). During extreme weather events, access to safe, functional medical services becomes limited, further endangering lives, particularly those of women, children, the elderly, and people with disabilities.

The districts of **Khulna, Chattogram, Gopalganj, Satkhira, Pirojpur, Patuakhali, Bagerhat, Barisal, Jhalokati, and Barguna** have repeatedly experienced health facility disruptions due to water damage, power outages, and lack of climate-adaptive designs. As climate hazards intensify, the resilience of health systems must be strengthened—not only structurally, but also through inclusive planning and operational preparedness.

Developing climate-resilient health care facilities (CR-HCFs) will ensure continuity of health services, enhance community trust in public health systems, and protect vulnerable groups during emergencies.

2. Objectives

- **Enhance structural and operational resilience** of health care facilities to withstand flooding, storms, and cyclones.
- **Ensure inclusive design** of HCFs to accommodate the needs of women, children, the elderly, and persons with disabilities.
- **Improve emergency readiness** of health care facilities during climate-induced disasters.
- **Build institutional capacity** for climate-responsive health infrastructure planning and management.
- **Align project outcomes** with national and international goals, including SDG 3 (Health), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).

3. Justification for Selected Locations

District	Key Vulnerability Factors	Strategic Importance
Khulna, Satkhira, Bagerhat	Coastal flooding, salinity, storm surge	Regional health service hubs for coastal populations
Chattogram	Cyclone-prone, flash floods, erosion	Densely populated, hosts critical referral hospitals
Patuakhali, Barguna, Pirojpur	Riverine and island exposure, poor connectivity	Disaster-prone and underserved in health infrastructure
Gopalganj, Barisal, Jhalokati	Urban-rural drainage issues, frequent storms	Transitional zones with expanding health service demand
Cumilla	Flash floods, drought pressure	Rapid urbanization with rural health coverage gaps
Noakhali	Flood and tidal surge zones	High population density and health infrastructure strain
Feni	Inland flooding, low elevation	Urban-rural access node vulnerable to cyclone spillovers

These districts were selected based on exposure to climate risks, healthcare system dependency, and population vulnerability.

4. Key Climate Resilience Measures

Infrastructure and Design Measures

- **Elevated Facility Construction:** Raise new or retrofitted HCFs above 50-year flood levels.

- **Salinity-Resistant Materials:** Use corrosion-resistant materials for long-term durability.
- **Improved Drainage and WASH Systems:** Install robust sanitation and stormwater discharge systems.
- **Renewable Power Backups:** Solar panels with batteries and fuel-efficient generators for energy resilience.

Operational and Institutional Measures

- **Inclusive and Universal Design:** Ensure accessibility for all users, including those with mobility limitations.
- **Emergency Preparedness Training:** Equip staff with disaster management and emergency response protocols.
- **GIS-based Planning:** Use geospatial tools to identify climate risks and guide investment prioritization.
- **SRHR Service Integration**: Ensure all facilities offer secure, accessible **sexual and reproductive health and rights (SRHR) services**, especially for women, adolescents, and marginalized groups, including privacy, family planning, maternal care, and menstrual health management.

5. Expected Outputs and Impacts

Expected Impact	Key Benefits
Enhanced resilience of health services	Facilities continue operations during climate events
Improved health outcomes	Reliable access to care during floods and storms
Inclusive and equitable care	Safe access for women, children, elderly, and persons with disabilities
Strengthened institutional capacity	Trained staff and upgraded systems for climate-health integration

6. Gender and Social Considerations

- **Inclusive Participation:** Engage women, youth, and persons with disabilities in planning and decision-making.
- **Design Adaptations:** Include ramps, railings, gender-segregated WASH facilities, and private maternity care spaces.
- **Responsive Evacuation Planning:** Ensure facilities and shelters are accessible to all, especially during emergencies.
- **SRHR Inclusion**: Climate-resilient HCFs will provide **dedicated SRHR service spaces** and trained staff to deliver safe, inclusive, and confidential care—especially during emergencies when women's health risks increase significantly.

7. Linkage to National Adaptation Plan (NAP) Projects

This project directly aligns with Bangladesh's NAP thematic priority on: **"Establishment of climate-resilient health care facilities in urban areas."**

Key NAP linkages include:

- Structural upgrading of vulnerable health centers
- Enhancing service continuity through resilient power, WASH, and access systems
- Community-based inclusive emergency health planning

8. Potential Financing Options

Source	Potential Contributors	Advantages	Challenges
Government Budget	Ministry of Health and MoDMR	Ensures national alignment	Budget limitations, inter-agency overlap
Multilateral Banks	World Bank, ADB, AIIB	Scalable financing, concessional terms	Approval time, compliance processes
Climate Funds	GCF, Adaptation Fund	Grant opportunities, global alignment	Highly competitive and complex entry
PPP Models	NGOs, private health tech/firms	Innovation and sustainability	Local regulatory capacity
Blended Finance	Public-private-donor collaborations	Shared risks, diversified capital	Coordination burden

9. Critical Considerations and Future Outlook

- **Sustainability:** Institutionalize facility maintenance and update protocols based on climate risk evolution.
- **Policy Integration:** Embed climate-resilience in MoHFW health infrastructure guidelines.
- **Community Engagement:** Leverage local knowledge to design culturally sensitive and practical interventions.
- **Innovation:** Integrate telemedicine, mobile diagnostics, and solar cold chains.
- **Scalability:** Use learning sites to replicate success across other at-risk districts.

10. Estimated Investment Cost

Covers:

- Elevation and retrofitting of HCFs
- Water, sanitation, and backup energy systems
- Training and capacity-building initiatives
- GIS-based risk planning and digital monitoring tools

Estimated Cost: Approximate USD 25–40 million, depending on site-specific design and facility needs.

11. Economic and Health Benefits

- Reduced service disruption and infrastructure loss during climate events
- Improved public health security and reduced burden on emergency services
- Increased institutional trust in government health systems
- Local job creation in resilient construction and health service delivery
- Improved productivity from healthier and safer communities

12. Stakeholder Consultations

Stakeholder consultations were conducted in Shyamnagar Upazila, Satkhira District, one of the most climate-vulnerable locations identified for health care resilience. These discussions captured institutional perspectives and local priorities.

Stakeholder Group	Role in the Project	Consultation Approach
NGO Hospital	Health service provision and response planning	KII with Senior Medical Officer
Community Representatives	First responders, facility users	Focus Group Discussion

Households in Shyamnagar	Beneficiaries, primary health access group	Structured household survey (n=50)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

FGDs were conducted with community members from flood-prone unions in **Shyamnagar, Satkhira**, to understand their experiences with accessing health care services during climate-induced emergencies.

- Participants shared that health facilities are often **inaccessible during moderate rainfall**, with roads submerged and transport unavailable. In some cases, patients must walk long distances or be carried on foot.
- **Emergency medical care is delayed or avoided** during cyclones and floods due to fear of injury, long travel times, and absence of reliable communication with clinics.
- There is a strong demand for **small satellite health centers or mobile services** closer to remote communities, especially for maternal care and chronic conditions.
- Men emphasized the need for **solar power backups** in health facilities, including lighting, refrigeration for vaccines, and functional communication systems during power cuts.
- Community members expressed interest in **volunteering for emergency logistics**, such as patient transport or minor first aid, if trained and equipped.
- Traditional practices, such as boiling water and herbal remedies, are used during crises due to lack of access to formal health services.

Figure 53: FGD of Male Participants in Satkhira

Figure 54: FGD of Female Participants in Satkhira

13.2 Household Survey Outcomes

- **Disruption and Access Issues:**
  - 72% reported major disruption in accessing health care during floods.
  - 48% said their nearest clinic was closed during the most recent cyclone event.
  - Many rural families relied on informal, untrained support for emergency care.
- **Facility Improvement Preferences:**
  - 88% requested elevation of facilities and installation of flood barriers.
  - 67% asked for solar power, backup water, and mobile health services.
  - 58% supported the integration of medical services at cyclone shelters.
- **Gender and Inclusion Considerations:**

- 65% of women reported difficulty using existing WASH facilities at clinics.
- Elderly respondents emphasized handrails, rest areas, and seated waiting zones.
- Families with disabled members requested dedicated transport and ramp access.

13.3 Key Informant Interviews (KIIs)

Interviewee: Health Practitioner – Non-Profit Hospital, Shyamnagar

- The hospital, though licensed for 20 beds, routinely serves over 50 patients, with specialized services including maternal care, eye and dental treatment, diagnostics, and physiotherapy.
- Climate impacts—especially salinity, high-voltage electricity, and waterlogging—have damaged essential medical equipment, increasing maintenance costs and disrupting operations.
- Limited staffing and infrastructure, including the absence of ICU and 24/7 services, restrict emergency readiness. Plans exist to expand services and facilities in a phased manner.
- Outreach is supported by 72 community health workers (FCMAs), who conduct screenings and referrals, particularly where access is limited.
- Research is underway on cataracts, cervical cancer, and maternal hypertension, with suspected links to climate factors like salinity and prolonged water exposure.
- Social barriers, including women's limited decision-making power and misconceptions about costs, hinder access, despite affordable services.
- The facility is seeking donor support to expand resilient infrastructure, improve inclusivity, and strengthen climate-health integration.

Figure 55: KII of Health Practitioner in Satkhira

13.4 Integration of Total Findings and Alignment with Project Objectives

Finding	Linked Objective(s)	Evidence
HCFs are inoperable during floods	Obj. 1 & 3	FGD, KII, Survey
Barriers to access for women, elderly, disabled	Obj. 2 & 4	Survey (
Need for resilient energy, water, sanitation	Obj. 1 & 3	FGD, KII
Community endorses solar, local first aid, shelter-based services	Obj. 1 & 5	FGD, Survey
Coordination among MoHFW, LGI, and DPHE needed	Obj. 3 & 5	KII

14. Conclusion

Developing climate-resilient health care facilities in Bangladesh's coastal districts is essential for protecting health outcomes in the face of growing climate threats. Grounded in field evidence and aligned with national priorities, this concept proposes practical, inclusive, and cost-effective solutions for safer, more reliable health systems. The project's broadened geographic scope—from coastal districts to flood- and drought-affected inland zones—ensures national impact. By integrating SRHR services and targeting climate-vulnerable populations beyond the coast, the initiative supports a more equitable and resilient health system across Bangladesh.

Through integrated infrastructure upgrades, institutional capacity building, and community participation, this project can become a flagship model for climate-health adaptation in Bangladesh and beyond.

4.2: MAKING HEALTHCARE FACILITIES RESILIENT TO CYCLONES AND COASTAL FLOODING

1. Introduction

Bangladesh's coastal districts are frequently affected by cyclones, storm surges, and tidal floods, which pose severe threats to the integrity and functionality of healthcare facilities. Many of these facilities are located in low-lying areas with poor drainage and lack structural reinforcement to withstand extreme weather events. As a result, health service delivery is often interrupted precisely when communities need it most.

To ensure uninterrupted access to emergency medical care during and after disasters, this concept proposes the development and retrofitting of healthcare infrastructure that is climate-resilient, flood-proof, and functionally robust. The intervention also includes improvements in emergency preparedness, drainage, and community engagement.

Figure 56: Health Center in Patuakhali

2. Objectives

- Ensure operational continuity of healthcare services during cyclones and floods.
- Build and retrofit facilities to withstand high wind speeds and flood levels.
- Protect critical utilities (electricity, water, medical gas) from damage.
- Improve drainage and incorporate nature-based stormwater management.
- Enhance emergency preparedness and response among health personnel.
- Promote gender-sensitive, inclusive healthcare design.

3. Justification for Selected Locations

Districts	Key Vulnerability Factors	Strategic Importance
Bagerhat, Khulna, Satkhira	Frequent cyclones, saline intrusion, flood-prone terrain	High population zones with district hospitals vulnerable to service failure
Barisal, Bhola, Patuakhali	Inadequate drainage and aging health infrastructure	Densely populated towns with cyclone shelter hospitals
Pirojpur, Gopalganj	Limited flood-resilient design, difficult access routes	Essential for rural catchment health coverage and referral networks

These districts represent priority zones for infrastructure investments that ensure lifesaving services are protected during emergencies.

4. Key Climate Resilience Measures

- New Construction on Elevated Platforms: Build healthcare facilities above projected flood levels to prevent service disruption.
- Retrofitting Existing Facilities: Upgrade structural components such as walls, roofs, and foundations with flood- and wind-resistant materials.
- Utility Protection: Elevate and seal electrical panels, medical gas systems, and water supply systems to prevent flood damage.
- Backup Systems: Install generators with secure fuel storage to maintain operations during power outages.
- Drainage Improvements: Implement advanced systems to quickly remove water and reduce risk of waterlogging.
- Nature-Based Solutions: Incorporate bioswales, retention ponds, and permeable pavements to manage stormwater runoff.
- Emergency Preparedness: Regularly update cyclone/flood response plans, including patient evacuation and surge capacity planning.
- Safe Access and Site Selection: Prioritize facility siting outside high-risk zones and along all-weather evacuation routes.

5. Expected Outputs and Impacts

Expected Outputs	Expected Impacts
Strengthened design and elevation of new and existing healthcare facilities	Enhanced ability to withstand and recover quickly from cyclones and coastal floods, ensuring continuous service delivery
Backup power, water, and gas systems integrated with facility operations	Reduced risk of service disruptions and medical equipment failure during emergencies
Drainage improvements and green infrastructure surrounding hospitals	Reduced waterlogging around facilities, safer patient access, and improved surrounding health conditions
Emergency preparedness plans and staff trained in cyclone/flood protocols	Timely and coordinated medical response during disasters, minimizing loss of life and health complications
Gender-sensitive infrastructure designed for universal access	More inclusive, dignified care environments for women, elderly, children, and persons with disabilities

6. Gender and Social Considerations

- Gender-Sensitive Facility Design: Ensure access to healthcare for women, children, elderly, and persons with disabilities through dedicated amenities and safe spaces.
- Inclusive Participation: Engage women's groups and marginalized voices in facility planning and design consultations.

- Universal Accessibility: Ensure ramps, private recovery zones, and safe waiting areas for vulnerable groups.
- Community Engagement: Promote training of female health workers in emergency preparedness and patient support.
- Ensure healthcare infrastructure and emergency response plans account for the **mobility, sensory, and communication needs of persons with disabilities**, including accessible restrooms, signage, and examination areas.

7. Linkage to National Adaptation Plan (NAP) Projects

This initiative aligns with:

- CRC11 – Establishment of climate-resilient healthcare facilities in urban areas

It also supports the Health Sector Climate Adaptation Framework, Bangladesh Delta Plan 2100, and contributes to SDG Targets 3, 9, 11, and 13.

8. Potential Financing Options

Financing Source	Potential Contributors	Advantages	Challenges
Government Development Budget	Ministry of Health & Family Welfare, LGED	National alignment, easier implementation	Fiscal limitations, competing priorities
Multilateral Banks	World Bank, ADB, Islamic Development Bank	Technical and financial support	Time-consuming approval and compliance processes
Climate Funds	Green Climate Fund, Adaptation Fund	Focus on resilience, grants and concessional loans	Complex proposal preparation and competition
Philanthropic Organizations	Gates Foundation, Wellcome Trust	Health-centered, rapid disbursement potential	Small-scale, often project-specific
Public-Private Partnerships	Local contractors and healthcare operators	Efficiency, shared risk	Regulatory limitations in PPP in health infrastructure

9. Critical Considerations and Future Outlook

- Institutionalize resilience standards in national health facility design guidelines.
- Establish a dedicated coordination cell within MoHFW to oversee climate-resilient health infrastructure.
- Promote innovation (e.g., IoT sensors, remote diagnostics) for post-disaster operation.
- Build local contractor capacity in resilient construction practices.
- Strengthen coordination between Ministry of Health, LGED, MoDMR, and local governments.

10. Estimated Investment Cost

- Estimated total investment covering:
    - Elevation and retrofitting of 50–70 healthcare facilities
    - Backup power and drainage infrastructure
    - Training, emergency planning, and green infrastructure components

11. Economic and Financial Benefits

- Reduced infrastructure repair and replacement costs post-disaster
- Increased system reliability and public trust in health access during crises

- Improved health outcomes for pregnant women, elderly, and children during emergencies
- Boosted local employment through climate-resilient construction and facility maintenance
- Safeguarded public health budgets by minimizing long-term climate impact on essential services

12. Stakeholder Consultations

Consultations were conducted in **Patuakhali District**, a cyclone-prone coastal area. The objective was to assess the current state of healthcare infrastructure and gather feedback on gaps, challenges, and local priorities for resilience. Inputs were collected through institutional interviews, FGDs, and household surveys.

Stakeholder Group	Role in the Project	Consultation Approach
UHFPO (Upazila Health & Family Planning Officer)	Oversight of Upazila-level healthcare operations and emergency response planning	Key Informant Interview (KII)
Male Community Members	Direct users of health services and emergency shelters	Focus Group Discussion (FGD) – Male
Female Community Members	Primary caregivers and maternal/child healthcare users	Focus Group Discussion (FGD) – Female
Households in Patuakhali	End users affected by climate disruptions and healthcare facility failures	Household Survey (n=100)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Adult male and female respondents from cyclone-affected rural areas in Patuakhali
Key Observations:

- **Facility Access Issues**:
  - Most healthcare centers are not accessible during cyclones or after heavy rainfall.
  - Roads to Union Health Centers and UHFPO offices are submerged or damaged, especially for pregnant women or children.
- **Gender-Specific Concerns**:
  - Women described unsafe conditions in cyclone shelters due to lack of privacy and sanitation.
  - Demand for separate women-friendly spaces within healthcare facilities and during emergencies.
- **Infrastructure Needs**:
  - Communities recommended elevating health centers, adding solar power backups, and ensuring safe water access.
  - Suggested coordination between disaster shelters and nearby health facilities.

Figure 57: FGD of Male Participants in Patuakhali

13.2 Household Survey Outcomes

Profile: 100 households from cyclone-vulnerable unions in Patuakhali
Key Findings:

- Disruption & Exposure:
    - 62% of respondents reported interrupted access to healthcare during the last cyclone.
    - 40% experienced delays in maternal care due to submerged or closed facilities.
- Preferences for Improvement:
    - 84% support elevating health centers and roads to ensure all-weather access.
    - 73% suggested adding cyclone shelters to or near healthcare centers.
    - 61% called for mobile clinics and local volunteers during post-disaster recovery.
- Gender & Vulnerability:
    - Female-headed households emphasized lack of nighttime services and female doctors.
    - Over 30% of households reported difficulty accessing child vaccination services after floods.

13.3 Key Informant Interview (KII)

Interviewee: Upazila Health and Family Planning Officer (UHFPO), Patuakhali
Key Insights:

- Operational Challenges:
    - Power outages, road disconnection, and waterlogging restrict services for days after cyclones.
    - Many union-level health centers lack proper waste disposal, backup generators, or elevated structures.
- Resilience Priorities:
    - Proposed integration of WASH facilities, improved drainage, and emergency water filtration.

- Recommended deploying community health volunteers for rapid medical outreach during disasters.

- Institutional Barriers:
  - Limited budget and lack of disaster-specific infrastructure guidance hinder adaptation efforts.
  - Urged closer collaboration with LGED and MoDMR for co-designing resilient health outposts.

Figure 58: KII of UHFPO

13.4 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Health facilities are frequently inaccessible during floods and cyclones due to low-lying access roads and unprotected locations	Objective 1: Ensure operational continuity of healthcare services during cyclones and floods	FGDs, Household Survey
Buildings and surrounding areas lack elevation, flood-proof design, and structural wind resistance	Objective 2: Build and retrofit facilities to withstand high wind speeds and flood levels	FGDs, KII
Disruption of power, water supply, and sanitation systems during disasters limits health service delivery	Objective 3: Protect critical utilities (electricity, water, medical gas) from damage	Household Survey, KII
Waterlogging and poor site drainage create stagnant water and increase health risks	Objective 4: Improve drainage and incorporate nature-based stormwater management	Household Survey, FGDs
Lack of medical staff availability and preparedness for rapid response in emergencies	Objective 5: Enhance emergency preparedness and response among health personnel	KII – UHFPO, FGDs
Female respondents highlighted safety, privacy, and lack of gender-sensitive spaces in shelters	Objective 6: Promote gender-sensitive, inclusive healthcare design	FGDs (Female), Household Survey
Community supports integration of solar panels, elevated walkways, and co-located cyclone shelters	Objective 1, 2, 3 & 6: Ensure resilient, inclusive and self-sustaining health facility design	FGDs, Household Survey

Households desire improved coordination between health and disaster management authorities	Objective 5: Strengthen institutional response and coordination capacity	KII, Household Survey

14. Conclusion

Healthcare systems form the backbone of disaster response and public well-being. Ensuring their resilience to climate risks such as cyclones and coastal flooding is essential to saving lives and maintaining social stability. By integrating structural upgrades, utility protection, emergency preparedness, and inclusive design, this concept offers a scalable model for resilient healthcare delivery in Bangladesh's most vulnerable regions. This investment will strengthen health security, reduce economic losses, and improve climate justice for the coastal population.

4.3: REDUCING DAMAGE TO MARKET CENTRES AGAINST COASTAL AND RIVERINE FLOODING

1. Introduction

In Bangladesh, market centres are critical for sustaining rural and urban livelihoods, providing food, goods, and employment to millions. However, many market centres located in coastal and riverine districts are highly vulnerable to flooding, resulting in damaged infrastructure, spoiled goods, disrupted trade, and loss of vendor income. Structural weaknesses, lack of drainage, poor emergency preparedness, and absence of insurance mechanisms compound these risks.

This concept outlines a comprehensive approach combining infrastructure upgrades, nature-based solutions, vendor-focused planning, and institutional coordination to reduce damage to market centres from flood events and promote economic resilience.

2. Objectives

- Enhance flood resilience of market infrastructure in flood-prone districts.
- Protect livelihoods and business continuity for vendors and traders during disasters.
- Integrate green infrastructure and permeable surfaces to manage stormwater.
- Establish emergency response and contingency systems tailored for markets.
- Promote inclusive planning and insurance access for vulnerable market actors.

3. Justification for Selected Locations

Districts	Key Vulnerability Factors	Strategic Importance
Khulna, Satkhira, Bagerhat, Barisal	Cyclone-prone, frequent riverine flooding, poor drainage in major bazars	Key southern markets linked to fisheries, agriculture, and daily trade
Chattogram, Patuakhali, Pirojpur	Low-lying markets with saline water intrusion and tidal flooding	Regional commerce hubs serving both urban and rural consumers
Sunamganj, Barguna, Kishoreganj	Haor and riverbank locations with seasonal flooding and weak infrastructure	Trade-dependent districts with vulnerable small traders and wet markets

These districts are prioritized due to their exposure to flood risks and importance in ensuring food security, rural-urban supply chains, and poverty reduction.

4. Key Climate Resilience Measures

- **Elevated Platforms**: Construct raised stalls and storage areas to keep goods above flood levels.
- **Flood-Resistant Materials**: Use water-resistant materials to renovate existing market centres.
- **Structural Reinforcement**: Strengthen foundations, walls, and roofs to withstand inundation.
- **Drainage Systems**: Install and maintain proper drainage around market centres.
- **Permeable Paving**: Apply permeable paving to allow natural water infiltration and reduce runoff.
- **Green Infrastructure**: Develop retention ponds and vegetated buffers to absorb excess water.
- **Early Warning Integration**: Connect market operations with real-time weather forecasts.
- **Emergency Plans**: Design response protocols including evacuation and goods protection.
- **Mobile Market Planning**: Identify temporary locations for mobile markets during disasters.
- **Vendor Insurance**: Promote access to affordable insurance for flood-affected market vendors.
- Adoption of flood-resilient infrastructure in market centres faces practical challenges such as the **cost and technical complexity of elevating platforms**, **reinforcing existing structures**, and integrating **locally appropriate flood-resistant materials**

5. Expected Outputs and Impacts

Expected Outputs	Expected Impacts
Elevated, flood-proof market structures	Enhanced ability of market centres to withstand and quickly recover from flooding, ensuring continuous trade
Structural upgrades and effective drainage installed	Minimized economic losses associated with flood damage to infrastructure and goods
Weather forecasting systems and emergency response plans in place	Enhanced safety for vendors and customers by reducing flood-related risks
Vendor-focused insurance and relocation mechanisms developed	Protected livelihoods of market vendors, especially low-income groups, ensuring operations during and after floods

6. Gender and Social Considerations

- Provide targeted support for **female market vendors** to access resources and post-flood recovery aid.
- Engage **women and marginalized groups** in market infrastructure planning and emergency response design.
- Ensure **diverse representation** in consultation and planning workshops.
- Incorporate **gender-sensitive infrastructure** (lighting, secure stalls, toilets) into upgraded market centres.

7. Linkage to National Adaptation Plan (NAP) Projects

This intervention aligns with the following NAP priorities:

- **CRC2** – Expansion and conservation of green and blue infrastructures for improvement of the urban environment and drainage system.
- **WRM8** – Drainage management of economic/industrial zones and critical infrastructure, and reinforced climate resilience through risk assessment.

8. Potential Financing Options

Financing Source	Potential Contributors	Advantages	Challenges
Government Funding	Local Government Division (LGD), City Corporations	National alignment and implementation authority	Competing urban development priorities
Multilateral Climate Finance	Green Climate Fund, Adaptation Fund, UNDP	Concessional financing for climate resilience	Application complexity, long approval cycles
Private Sector Investment	Retail associations, market operator cooperatives	Incentivizes innovation and market-led solutions	Limited capital base among SMEs
PPP	Local governments and private vendors	Joint responsibility for infrastructure and maintenance	Legal and coordination challenges in informal markets
Blended Finance	Multilateral donors + private insurers	Spreads risk, improves financial viability	Requires governance and regulatory support

9. Critical Considerations and Future Outlook

- Promote vendor cooperatives to manage insurance access and resilience planning.
- Develop a market resilience design manual for city governments.
- Institutionalize market flood mapping and asset risk registers at the local level.
- Pilot nature-based flood protection models in open-air markets.

- Build capacity of local authorities to maintain green and grey infrastructure post-construction.
- Implementation Challenges and Capacity Building: Adoption of resilient designs will require training for local engineers, knowledge transfer of flood-resistant construction technologies, and vendor engagement to ensure designs are practical, cost-effective, and locally maintained. A technical support system will be developed to bridge gaps in structural design, materials sourcing, and maintenance planning.

10. Estimated Investment Cost

- Investment covers:
    - Market infrastructure upgrades (elevation, drainage, reinforcement)
    - Retention ponds and permeable paving installation
    - Weather forecast systems, emergency planning tools
    - Insurance scheme development and outreach
    - Training and stakeholder engagement workshops

11. Economic and Financial Benefits

- Reduction in post-flood repair and reconstruction costs
- Protection of small business assets and market-based income
- Continuity in food and retail supply chains during disasters
- Boosted financial inclusion through vendor insurance schemes
- Strengthened local economies and public revenue from uninterrupted trade

12. Stakeholder Consultations

Consultations were conducted in Sunamganj, one of the most flood-affected districts in Bangladesh. The aim was to understand how market infrastructure and livelihoods are affected during floods and what adaptations are locally prioritized. The stakeholder engagement covered market authorities, traders (male and female), and municipal actors.

Stakeholder Group	Role in the Project	Consultation Approach
Market Management and Local Authorities	Oversight of market operations, drainage, disaster recovery, and regulations	Key Informant Interview (KII)
Male Traders and Business Owners	End users of market infrastructure; primary economic stakeholders	Focus Group Discussion (FGD) – Male
Female Vendors and Shopkeepers	Vulnerable users with limited resources, often excluded from planning	Focus Group Discussion (FGD) – Female

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Male and female traders operating in central and rural market centers of Sunamganj

Key Observations:

- Market Flooding Impacts:
    - Repeated flash flooding renders market areas inaccessible for days.
    - Goods are destroyed, stalls submerged, and many vendors lose income due to stalled operations.
- Drainage and Infrastructure Issues:
    - Both groups cited poor drainage, waterlogging, and no designated flood outlets.
    - No elevated platforms or embankments exist in most market centers.
- Coping Practices:

    - Vendors raise platforms with bamboo, store goods on makeshift lofts, or close business entirely.
    - Female vendors store goods in neighbors' homes or stop vending during heavy rain seasons.
- Gendered Constraints:
    - Women lack access to secure stalls, capital for loss recovery, or participation in market decisions.
    - Sanitation and safe sheltering during disasters are urgent needs voiced by female participants.

Figure 59: FGD of Male Participants in Sunamganj

Figure 60: FGD of Female Participants in Sunamganj

13.2 Key Informant Interview (KII)

Stakeholder: Market authority staff, local traders' association representatives

Key Insights:

- Flood Risk:
    - Seasonal water surge from nearby rivers directly floods ground-level stalls.
    - Drainage channels around markets are blocked with waste and sediment.
- Operational Gaps:
    - No formal risk assessment or flood-resistant design is in place.
    - There's a lack of contingency plans or designated recovery funds for traders.
- Recommendations:
    - Raise market floors above historic flood levels.
    - Improve market layout with proper drainage and permeable paving.
    - Introduce market-level disaster response protocols and emergency coordination teams.
    - Expand access to insurance schemes and financing for small vendors.

Figure 61: KII of Market authority staff

13.3 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Market centers are routinely flooded during monsoon and flash flood events	Objective 1: Enhance flood resilience of market infrastructure in flood-prone districts	FGDs (Male & Female), KII
Floods disrupt daily trading, cause inventory losses, and impact vendor incomes	Objective 2: Protect livelihoods and business continuity for vendors and traders during disasters	FGDs, KII
Water stagnation due to poor drainage and lack of permeable surfaces increases damage	Objective 3: Integrate green infrastructure and permeable surfaces to manage stormwater	FGDs, KII
No formal emergency preparedness plans or support mechanisms exist in market areas	Objective 4: Establish emergency response and contingency systems tailored for markets	KII, FGDs
Women traders lack shelter access and face exclusion from post-disaster recovery schemes	Objective 5: Promote inclusive planning and insurance access for vulnerable market actors	FGDs (Female), KII
Market infrastructure is built haphazardly without elevation, drainage outlets, or flood barriers	Objective 1 & 3: Improve structural resilience and stormwater management	FGDs, KII
Traders demand insurance access and early warning dissemination specific to market areas	Objective 4 & 5: Tailor disaster response and risk finance tools for market stakeholders	FGDs, KII

14. Conclusion

Bangladesh's market centres are economic lifelines that must be safeguarded from increasing flood risks. This concept paper outlines a strategic package of interventions—from infrastructure upgrades and green drainage to inclusive planning and vendor insurance—to protect livelihoods, stabilize local economies, and ensure continuity of essential goods and services. With the right institutional support and financing, this initiative can transform flood-vulnerable markets into hubs of resilience and prosperity.

4.4: ENHANCING WETLAND CONSERVATION EFFORTS IN URBAN ENVIRONMENTS

1. Introduction

Urban wetlands serve as critical ecological buffers that help regulate stormwater, reduce flood risks, support biodiversity, and enhance urban livability. However, rapid and unplanned urbanization in Bangladesh has led to significant wetland degradation, particularly in major cities like Dhaka, Chattogram, Khulna, and Rajshahi. These areas have experienced increased urban flooding, loss of biodiversity, and declining environmental quality due to wetland encroachment and pollution.

This concept paper outlines a nature-based and community-centered approach to restoring and conserving urban wetlands. Through policy integration, green infrastructure, and active public engagement, the project aims to improve flood resilience, urban ecology, and recreational value.

2. Objectives

- Strengthen urban flood resilience by conserving natural drainage systems and wetlands.
- Promote biodiversity and ecosystem services through wetland restoration.
- Improve public awareness and community involvement in wetland conservation.
- Integrate wetland protection into urban development policies and planning.
- Enhance recreational and eco-tourism potential in urban settings.

3. Justification for Selected Locations

Urban Centre	Justification
Dhaka	Rapid encroachment, loss of natural khals, extreme urban flooding
Chattogram	Wetland drainage for construction, poor stormwater retention
Khulna	Urban sprawl along riverbanks, declining water bodies, and pollution
Rajshahi	Dried seasonal wetlands converted to roads and housing
Sylhet	Flash flood vulnerability; degradation of low-lying peri-urban wetlands

These cities are selected based on the severity of wetland loss, vulnerability to urban flooding, and the potential for multi-benefit conservation.

4. Key Climate Resilience Measures

- Urban Wetland Conservation: Legal protection and zoning of wetlands to prevent encroachment and degradation.
- Recreational Facilities: Development of walkways, green corridors, and community spaces along wetland edges.
- Awareness and Education: School programs, city campaigns, and local exhibitions to foster public stewardship.
- Policy Integration: Wetland preservation integrated into Detailed Area Plans (DAP), Master Plans, and climate policies.
- Community Co-Management: Empowerment of local groups to monitor, manage, and restore degraded wetlands.
- Nature-Based Engineering: Implementation of floating wetlands, sedimentation ponds, and native vegetation buffers.

5. Expected Outputs and Impacts

Expected Outputs	Expected Impacts
Demarcation and zoning of protected urban wetlands	Climate Resilience: Reduced flooding and urban heat through improved water retention
Restoration of degraded wetlands	Environmental Benefits: Increased biodiversity and ecosystem services in dense urban environments
Creation of walkways and green recreational zones	Economic Benefits: Enhanced eco-tourism and increased property value near rehabilitated wetlands
Awareness and education programs across communities	Strengthened civic ownership and long-term sustainability of conservation initiatives

6. Gender and Social Considerations

- Inclusive Access: Ensure wetlands and adjacent recreational areas are accessible to women, children, elderly, and persons with disabilities.
- Community Participation: Actively involve women and marginalized communities in wetland co-management and planning.
- Livelihood Enhancement: Explore employment and entrepreneurship in wetland-based eco-tourism, waste management, and nursery development for women and youth.

7. Linkage to National Adaptation Plan (NAP) Projects

This concept aligns with the following NAP priority actions:

- CRC2 – Expansion and conservation of green and blue infrastructures for improvement of the urban environment and drainage system.
- WRM8 – Drainage management of economic/industrial zones and critical infrastructure, and reinforced climateresilience through risk assessment.

8. Potential SDG Targets Influenced

- SDG 6 – Clean Water and Sanitation
- SDG 13 – Climate Action
- SDG 15 – Life on Land

9. Critical Considerations and Future Outlook

- Policy Enforcement: Strengthen enforcement of the Wetland Conservation Act and ensure integration with local DAPs and masterplans.
- Sustainability: Design long-term O&M (Operation & Maintenance) strategies involving local communities and municipal support.
- Data-Driven Monitoring: Use GIS and drone imagery for wetland boundary monitoring and encroachment tracking.
- Replication and Scaling: Pilot successes in Dhaka or Khulna can be expanded to secondary cities with similar risk profiles.
- Institutional Coordination: Ensure inter-agency collaboration between LGED, RAJUK, Department of Environment, and city corporations.

10. Estimated Investment Cost

Estimated budget range: USD 12–18 million over five years, covering:

- Wetland demarcation and legal zoning
- Restoration and reforestation of degraded wetlands

- Development of walkways, signage, and eco-friendly facilities
- Public education campaigns and school programs
- Community-based wetland management tools and training

11. Economic and Financial Benefits

- **Property Value Gains**: Up to 15% increase in surrounding property value from improved wetland aesthetics and reduced flood risk.
- **Lower Urban Flood Costs**: Natural water retention reduces reliance on hard infrastructure and emergency flood response.
- **Job Creation**: Opportunities in construction, wetland maintenance, tour guiding, and community education.
- **Tourism and Recreation**: Boost to local micro-economies from visitors, eco-walks, and environmental awareness events.

12. Stakeholder Consultations

Stakeholder consultations were conducted in **Rajshahi City**, focusing on urban wetlands that are under threat from encroachment, pollution, and unregulated development. The consultations engaged government agencies, wetland authority representatives, and community members to understand challenges and opportunities for conservation.

Stakeholder Group	Role in the Project	Consultation Approach
DPHE (Department of Public Health Engineering)	Oversight of drainage and sanitation systems connected to urban wetlands	Key Informant Interview (KII)
UNO (Upazila Nirbahi Officer)	Local administrative governance, coordination of land and environmental management	Key Informant Interview (KII)
Borendro Wetland Management Authority	Responsible for wetland preservation and ecosystem regulation	Key Informant Interview (KII)
Male Community Members	Local residents, wetland users, and informal vendors	Focus Group Discussion (FGD) – Male
Female Community Members	Households affected by urban flood risks and interested in recreational space development	Focus Group Discussion (FGD) – Female
Urban Households in Rajshahi	Residents impacted by wetland loss, flood hazards, and environmental degradation	Household Survey (n=100)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Residents and vendors living near urban wetlands and low-lying areas of Rajshahi city.

Key Observations:

- **Urban Pressure on Wetlands**:
  - Participants observed that most wetlands are shrinking due to construction, garbage dumping, and illegal encroachment.
  - Rainwater now floods neighborhoods that used to have natural drainage routes.
- **Loss of Ecosystem Benefits**:
  - Local fish and birds have disappeared in areas once rich in biodiversity.
  - Wetlands that supported seasonal farming or water collection are now inaccessible.

- Community Suggestions:
    - Residents proposed wetland fencing, regular garbage clearance, and school-level awareness campaigns.
    - Female participants emphasized the need for family-friendly walking trails and picnic spaces.

Figure 62: FGD of Male Participants in Rajshahi

Figure 63: FGD of Female Participants in Rajshahi

13.2 Household Survey Outcomes

Profile: 100 urban households across Rajshahi city, primarily composed of nuclear families with mixed-income backgrounds.

Key Findings:

- Perception of Wetland Importance:
    - 78% of respondents considered wetlands important for flood protection and environmental quality.
    - 61% were unaware of any legal status or city planning guidelines protecting wetlands.
- Wetland Services and Hazards:
    - 42% of respondents experienced waterlogging in recent years due to blocked natural canals and filled wetlands.
    - Most respondents identified wetlands as valuable for air cooling, groundwater recharge, and aesthetic value.
- Community Preferences:
    - 69% supported wetland restoration projects if they included safe recreational areas.
    - 82% recommended stronger monitoring and inclusion of wetlands in urban development plans.
- Behavioral Trends:
    - Few residents actively participated in any wetland clean-up or awareness efforts.
    - Public support was strong for youth education and eco-tourism activities around wetlands.

13.3 Key Informant Interviews (KIIs)

Stakeholders: DPHE, UNO Rajshahi, and Borendro Wetland Management Authority

Findings:

- Institutional Challenges:
    - All three stakeholders noted overlapping jurisdiction and lack of urban wetland zoning.
    - DPHE highlighted poor drainage connectivity between man-made drains and natural khals.
- Legal and Planning Gaps:
    - The UNO noted the absence of updated wetland boundaries in urban master plans.
    - Borendro representatives pointed out that enforcement of wetland protection laws is weak due to limited resources.
- Proposed Solutions:
    - All parties supported integrating wetlands into Rajshahi's green urban infrastructure strategy.
    - Suggested actions include wetland mapping, community co-management, and eco-park development with educational signage.

Figure 64: KII of DPHE Representative

Figure 65: KII of UNO

13.4 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Unplanned urban expansion and waste dumping are degrading natural wetland systems	Objective 1: Strengthen urban flood resilience by conserving natural drainage systems and wetlands	KIIs – DPHE, FGDs, HH Survey
Communities observed declining bird, fish, and plant species due to loss of wetland ecosystems	Objective 2: Promote biodiversity and ecosystem services through wetland restoration	FGDs, HH Survey
Majority of households and vendors are unaware of wetland importance or legal protections	Objective 3: Improve public awareness and community involvement in wetland conservation	HH Survey, FGDs
Institutional overlap and absence of wetland zoning in city master plans undermine protection efforts	Objective 4: Integrate wetland protection into urban development policies and planning	KIIs – UNO, DPHE, Borendro Authority
High support among youth and vendors for walking trails, bird zones, and eco-friendly parks	Objective 5: Enhance recreational and eco-tourism potential in urban settings	HH Survey, FGDs

Local actors propose participatory campaigns and eco-education centers for youth engagement	Objective 3 & 5: Build awareness and use wetlands for environmental education and tourism	FGDs (Female), KII – UNO
Urban drainage systems are choked due to encroachment and loss of natural retention areas	Objective 1 & 4: Conserve wetlands to reduce flood risk and improve policy enforcement	KIIs, HH Surve

14. Conclusion

The conservation and restoration of urban wetlands is an urgent priority for building climate-resilient, livable, and sustainable cities in Bangladesh. These ecosystems play a vital role in natural flood management, ecological health, and recreational space. The proposed concept offers a multidimensional approach that combines nature-based solutions, inclusive participation, urban planning integration, and environmental education.

By investing in wetland protection today, Bangladesh can prevent future urban disasters, uplift urban quality of life, and achieve progress toward the SDGs and NAP implementation. This initiative can be a model for replicable, people-centered urban resilience strategies in other climate-vulnerable nations.

4.5: FLOOD-RESILIENT SCHOOLS: BUILDING A SAFER FUTURE FOR EDUCATION

1. Introduction

Floods are a recurring hazard across many parts of Bangladesh, causing severe disruptions in access to education. Schools located in low-lying or riverine areas are often submerged or rendered inaccessible for weeks during monsoon seasons. This not only damages infrastructure but leads to long-term learning loss, especially for children from marginalized communities. In many cases, schools double as cyclone shelters, further stressing already vulnerable facilities.

This concept outlines a comprehensive strategy to make school infrastructure flood-resilient through elevation, drainage improvement, emergency preparedness, and policy integration—ensuring safe, inclusive, and uninterrupted access to education.

2. Objectives

- Improve structural resilience of schools in flood-prone areas
- Ensure continuous access to safe and inclusive education during and after flood events
- Establish emergency protocols and shelter functionality in school infrastructure
- Integrate flood-resilient school development into national and local adaptation plans

3. Justification for Selected Locations

Districts	Key Vulnerability Factors	Strategic Importance
Khulna, Satkhira, Bagerhat	Tidal flooding, cyclone-prone, low-lying infrastructure	High exposure zones where schools also function as cyclone shelters
Chattogram, Sunamganj	Urban and flash flooding, inaccessible routes	Urban hubs with high student populations
Patuakhali, Barguna, Barisal	Frequent monsoonal flooding and poor drainage	Coastal education zones affected by seasonal school closures
Pirojpur, Gopalganj	Riverbank erosion, prolonged waterlogging	Requires safe and inclusive school access for scattered rural students

These districts were prioritized due to repeated learning disruptions, infrastructure damage, and the role of schools as disaster shelters.

4. Key Climate Resilience Measures

- Elevated Construction: Raise floors above known flood levels
- Flood-Resistant Materials: Use RCC structures, waterproof paints, and non-perishable fittings
- Drainage Improvement: Construct school-specific stormwater drainage channels
- Multi-Use Design: Design classrooms as dual-purpose shelters with kitchen, water, and sanitation access
- Rainwater Harvesting and Solar Lighting: To ensure basic services during disasters
- Raised Walkways and Access Routes: Ensure safe student access during floods
- Green Buffer Zones: Integrate natural flood barriers such as trees and retention ponds around school areas
- Integrated Health Services: Climate-resilient schools will incorporate basic primary healthcare facilities, including designated rooms for first aid, maternal and child health support, and emergency health supply storage

5. Expected Outputs and Impacts

Expected Outputs	Expected Impacts
Flood-resilient school infrastructure constructed or retrofitted	Reduced disruption in education due to flood-related closures

Safe sanitation facilities and raised pathways developed	Improved access for girls and children with disabilities during emergency and normal periods
Multi-use school-cum-shelter models designed and piloted	Enhanced community preparedness and reduced cyclone shelter burden
Drainage and water discharge systems installed around school premises	Decreased waterlogging, structural damage, and risk of waterborne diseases
Solar-powered lighting and rainwater harvesting introduced in schools	Ensured functionality of essential services during emergencies
Community-based school disaster preparedness committees activated	Increased local ownership and effective coordination during flood events
School facilities include primary healthcare rooms and supplies	Improved access to basic health services during floods, especially for children and women
Technical guidelines developed for resilient school design and retrofitting	Institutionalized resilience in future school planning across vulnerable regions

6. Gender and Social Considerations

- Prioritize girls' safety through gender-segregated toilets and safe waiting zones
- Ensure inclusive access for children with disabilities through ramps and raised paths
- Involve mothers and women-led committees in school design and shelter protocols
- Address safety and sanitation as part of resilience infrastructure investments
- Promote girl-friendly shelters to reduce absenteeism during crisis events
- Ensure that **primary health services are accessible within school shelters**, particularly for **pregnant women, children, and people with chronic conditions**, during flood-induced displacement.

7. Linkage to National Adaptation Plan (NAP) Projects

This initiative supports actions under:

- **CRC1** – Building climate-resilient houses, education, and communication infrastructure in high-risk areas
- **EED1** – Promoting inclusive education and access in the face of climate-related disruptions

8. Potential Financing Options

Financing Source	Potential Contributors	Advantages	Challenges
Government Education Budget	Ministry of Education, LGED	Public ownership, links to national curriculum	Competing priorities for infrastructure allocation
Climate Funds	Green Climate Fund, Adaptation Fund	Dedicated to resilience and social equity	Complex application and monitoring requirements
Development Partners	UNICEF, ADB, Save the Children, UNESCO	Technical support and education sector focus	Grant cycles and fund disbursement delays
Local Government Resources	Union Parishads, Municipalities	Local ownership and sustainability	Limited revenue base in rural locations
PPP or CSR Schemes	Local construction firms, education donors	Innovation and supplementary financing	Needs enabling legal framework and technical oversight

9. Critical Considerations and Future Outlook

- Schools must be designed for both learning and crisis response, particularly in coastal and riverine areas
- Teacher and staff capacity building should include disaster awareness and evacuation protocol training

- A national inventory of vulnerable schools should guide phased investments
- School infrastructure guidelines should mandate climate-proofing as a core requirement
- Digital learning infrastructure should be supported to enable education continuity during closures

10. Estimated Investment Cost

Investment includes:

- Elevation of school buildings and site development
- Drainage systems and sanitation upgrades
- Shelter-standard multi-use facilities (WASH, solar lighting, storage)
- Community training and simulation drills

11. Economic and Financial Benefits

- Reduction in infrastructure damage and reconstruction costs
- Prevention of long-term learning loss among vulnerable children
- Protection of teaching materials and public assets from flood damage
- Improved attendance and learning outcomes through safer environments
- Enhanced resilience capacity at community level through shelter-school systems

12. Stakeholder Consultations

Consultations were conducted in **Pirojpur District**, where schools face seasonal flooding and service disruption. Stakeholder engagement included school leadership, parents, and community members to identify barriers to resilient education infrastructure and collect ideas for inclusive, safe school design.

Stakeholder Group	Role in the Project	Consultation Approach
Head Teacher (Govt. Primary School, Pirojpur)	Oversees daily school operations and disaster preparedness coordination	Key Informant Interview (KII)
Male Community Members	Parents, guardians, and laborers with experience supporting school access and safety	Focus Group Discussion (FGD) – Male
Female Community Members	Mothers and caregivers with firsthand knowledge of child needs during flood events	Focus Group Discussion (FGD) – Female

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Parents, community leaders, and guardians from flood-prone areas of Pirojpur

Key Observations:

- **Flood Disruption and Risk**:
  - Parents reported frequent school closures due to waterlogging and unsafe access roads.
  - Many families refrain from sending children to school during moderate rain due to drowning risks or contaminated water.
- **Gender-Specific Challenges**:
  - Mothers noted that girls stop attending school earlier during flood periods due to the lack of sanitary facilities and safe mobility.
  - Female participants stressed the absence of designated child-safe spaces in shelters located in school premises.
- **Community Suggestions**:
  - Build raised plinths and protective boundary walls around schools.
  - Include rainwater harvesting and mobile toilets during emergencies.

- Install early warning systems tied to school evacuation protocols.

Figure 66: FGD of Male Participants in Pirojpur

Figure 67: FGD of Female Participants in Pirojpur

13.2 Key Informant Interview (KII)

Interviewee: Head Teacher, Government Primary School, Pirojpur

Key findings:

- Facility Limitations:
  - The school lacks raised construction and becomes fully inaccessible for 2–4 days during each flood event.
  - The institution does not have backup lighting, toilets suited for flood situations, or alternative teaching options during closures.
- Educational Continuity Risks:
  - Attendance drops drastically post-disaster and remains low for weeks due to psychological trauma and damaged infrastructure.
  - Female students are disproportionately affected in terms of dropout and retention.
- Proposed Measures:
  - Introduce multi-use flood shelters integrated with schools, with drinking water, WASH, and basic health kits.
  - Establish school-level disaster management committees and early-warning broadcast tools.

Figure 68: KII of Head Teacher in Pirojpur

13.4 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Schools are frequently closed or inaccessible during floods, disrupting education	Objective 1: Improve structural resilience of schools in flood-prone areas	FGDs, KII
Absence of elevated infrastructure, storm drainage, and flood-safety design causes student dropout	Objective 2: Ensure continuous access to safe and inclusive education during and after floods	FGDs, KII
Schools lack emergency tools, shelter readiness, and flood-period operations	Objective 3: Establish emergency protocols and shelter functionality in school infrastructure	KII – Head Teacher
Community members support mainstreaming resilient school design in local and national policies	Objective 4: Integrate flood-resilient school development into national and local adaptation plans	FGDs, KII
Female students face mobility, sanitation, and safety barriers more acutely	Objective 2 & 3: Ensure inclusive education and school-based sheltering for all genders	FGDs (Female)

14. Conclusion

Flood-resilient school infrastructure is essential for safeguarding the right to education in flood-prone regions of Bangladesh. The proposed interventions will enable continuity of learning, enhance child safety, reduce damage costs, and strengthen overall community resilience. With proper financing and policy backing, this project can serve as a national model for climate-proof education systems.

4.6: FLOOD-RESILIENT EDUCATIONAL INSTITUTIONS THROUGH STRENGTHENING THE ENABLING ENVIRONMENT

1. Introduction

In climate-vulnerable districts of southern Bangladesh, schools are not only educational spaces but also vital community hubs during disasters. However, existing educational institutions lack the systemic resilience needed to cope with increasing flood risks driven by climate change. This includes a lack of disaster risk planning in infrastructure design, poor coordination between relevant agencies, and limited awareness among students and staff.

Strengthening the enabling environment for school-based resilience includes embedding flood risk considerations into institutional planning, developing staff and student capacities for emergency preparedness, and aligning educational infrastructure projects with broader climate resilience objectives. This concept focuses on operationalizing institutional measures to mainstream flood resilience across all layers of the education system—from planning and budgeting to curriculum and community engagement.

Figure 69: School Infrastructure in Pirojpur

2. Objectives

- Develop and enforce institutional frameworks that integrate flood resilience into school planning and construction regulations.
- Build the capacity of education authorities, facility managers, and school staff on flood preparedness, infrastructure maintenance, and risk response.
- Promote inter-ministerial collaboration to enable integrated education and disaster resilience planning.

- Strengthen school-community partnerships through local consultation and inclusive disaster response mechanisms.
- Incorporate climate education and flood awareness into school curricula to promote a culture of preparedness.

3. Justification for Selected Locations

Districts	Key Risk Factors	Strategic Importance
Khulna, Satkhira, Bagerhat, Patuakhali, Barguna, Barisal	Frequent monsoon flooding, cyclone exposure, poor school maintenance in rural and coastal areas	Disaster-prone regions with a dense rural school network
Sunamganj, Gopalganj, Pirojpur	Flash flood vulnerability, lack of elevated school buildings, limited teacher training	Education-service hubs in areas of high flood and social vulnerability
Chattogram	Urban flood risks, infrastructure congestion, growing school population	Major urban center with significant disaster exposure and infrastructure stress

These districts were selected due to high exposure to recurrent floods and the pivotal role of schools as both education centers and community disaster shelters. Institutional reforms in these areas will enhance preparedness, ensure safe learning environments, and protect critical infrastructure.

4. Key Climate Resilience Measures

- Policy Enforcement: Mandate national/local regulations requiring flood risk assessments in school planning and infrastructure investment.
- Capacity Building: Train education departments, school management committees, and facility operators on infrastructure maintenance and flood contingency planning.
- Teacher Training: Develop training modules on flood awareness, emergency drills, and child safety protocols for school personnel.
- Inter-Ministerial Coordination: Establish district-level coordination platforms involving education, disaster management, urban development, and WASH agencies.
- Community Engagement: Facilitate focus groups and consultations with parents, students, and teachers to co-design school emergency protocols.
- Curriculum Integration: Mainstream flood preparedness and climate education into science, geography, and social studies syllabi.
- School Committees: Form disaster response teams within schools involving students and parents for localized risk action plans.

5. Expected Outputs and Impacts

Expected Outputs	Expected Impacts
Institutional frameworks for flood-resilient education planning	Improved emergency preparedness and continuity in school operations
Trained education officials, school managers, and teachers	Enhanced flood safety and reduced student risk during disasters
School-specific emergency protocols and drills	Strengthened local response capacity and community awareness
Revised curriculam incorporating flood and climate risks	Informed future generations prepared for climate resilience

6. Gender and Social Considerations

- Ensure women's representation in education planning committees, school management, and disaster response teams.

- Address the safety and privacy needs of girls and women in flood shelters and school premises.
- Engage female students, teachers, and parents in curriculum development and awareness campaigns.
- Build leadership among women in the education sector to lead emergency preparedness efforts.
- Promote inclusive consultations with children, minorities, and differently abled individuals to address diverse vulnerabilities.

7. Linkage to National Adaptation Plan (NAP) Projects

This concept directly aligns with the following NAP thematic priorities:

- Climate-resilient housing and infrastructure, including educational institutions in flood-prone regions.
- Strengthening institutional capacity and regulatory frameworks for adaptive infrastructure development.

8. Potential Financing Options

Source	Potential Contributors	Advantages	Challenges
Government of Bangladesh	Ministry of Education, LGD, DPE	High alignment with education and resilience mandates	Competing budget priorities
Development Partners	UNICEF, UNESCO, World Bank, ADB	Proven record in school infrastructure and emergency education	Requires long-term coordination
Climate Finance	Green Climate Fund, Adaptation Fund	Climate-resilient education fits adaptation criteria	High competition and complex application
Private Sector/CSR	Local enterprises, EdTech firms	Opportunity for digital tools and local investment	Limited private focus on disaster-resilient education
NGOs and Foundations	Save the Children, BRAC, Aga Khan Foundation	Experience in school safety, teacher training, and local adaptation	Limited scalability without public systems integration

9. Critical Considerations and Future Outlook

- **Standardization:** Develop a national guideline for flood-resilient school planning and preparedness.
- **Monitoring:** Create indicators for tracking institutional resilience at school and district levels.
- **Localization:** Tailor risk assessments and response plans to school-specific vulnerabilities.
- **Innovation:** Promote digital training, early warning alerts, and student-led awareness tools.
- **Sustainability:** Embed resilience actions into school improvement plans and education budgets.

10. Estimated Investment Cost

The estimated cost will depend on the scale of institutional engagement and geographic coverage. Investment components include:

- Training and workshops for education stakeholders
- Development of regulatory and planning tools
- Curriculum revision and teaching aids for climate education
- Pilot school preparedness plans and coordination systems
- Community engagement and school-level drills

11. Economic and Financial Benefits

- Reduced learning disruptions and post-disaster reconstruction costs
- Lower child injury and trauma risks, contributing to long-term well-being
- Improved school service continuity, supporting education outcomes
- Enhanced trust in public institutions and disaster safety systems
- Increased community value of schools as multi-purpose flood response hubs

12. Stakeholder Consultations

Stakeholder consultations were held in **Pirojpur**, focusing on vulnerabilities of educational institutions to flooding and the institutional gaps in enabling school-level disaster resilience. Engagements included school management officials, education staff, and flood-exposed community members to gather perspectives on infrastructure, learning continuity, and inclusive planning.

Stakeholder Group	Role in the Project	Consultation Approach
Project Implementation Officer (PIO)	Oversight of school infrastructure and coordination with education authorities	Key Informant Interview (KII) – PIO
Male Community Members	Guardians, teachers, and laborers responsible for school access and safety	Focus Group Discussion (FGD) – Male
Female Community Members	Mothers, caregivers, and informal workers managing children's education during floods	Focus Group Discussion (FGD) – Female
School-Affected Households	Families experiencing school closure, damage, and accessibility issues due to flooding	Household Survey (n = 100)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Location: Flood-prone unions in Pirojpur

Key Observations:

- Participants reported that **school roads flood for days**, leaving children stranded at home or taking risky routes. Boys often miss class to help families with water clearance; girls stay home due to safety and sanitation challenges.
- Floodwaters routinely **damage floors, desks, latrines, and learning materials**. Temporary closures often stretch to weeks, especially after severe cyclones.
- Women raised concerns over **unsafe latrines, lack of lighting, and poor access to shelters**, which discourage continued attendance—especially for adolescent girls.
- **Recommendations**:
    - Raise school plinths and **build concrete access pathways**.
    - Ensure **functional toilets and gender-sensitive WASH facilities**.
    - Involve community and especially **mothers in disaster preparedness** training for schools.

Figure 70: FGD of Female Participants in Pirojpur

Figure 71: FGD of Female Participants in Pirojpur

13.2 Household Survey Outcomes

Profile: 100 households with school-age children across flood-prone Pirojpur unions

Key Findings:

- **Service Disruption**:
  - **87%** of households experienced **school closure during flooding**.
  - **59%** reported children missed more than **10 consecutive school days** last year due to floods.
- **Damage and Accessibility Issues**:
  - **73%** observed water entering school premises.
  - **48%** said children faced **difficulty walking to school** through submerged routes.
- **Community Priorities**:
  - **81%** prioritized **elevated school buildings and access roads**.
  - **66%** recommended **disaster response training** for teachers and school committees.
  - **78%** supported the inclusion of **nature-based solutions** (e.g., vegetative berms or buffer ponds) around school sites.

13.3 Key Informant Interview (KII) – PIO

Key Insights:

- **Flood Impacts on Operations**:
  - Local education offices lack dedicated funds or technical guidance for flood-proofing schools.
  - School closures impact exam schedules, curriculum delivery, and increase dropout risks.
- **Gaps in Coordination and Capacity**:
  - Disaster planning is **not embedded** in school management practices.
  - Existing education infrastructure plans do not **mandate elevation, drainage, or resilience audits**.
- **Recommendations**:

- Integrate flood risk assessments into **education infrastructure planning**.
- Strengthen **coordination between LGED, DPE, and disaster committees**.
- Establish **resilience standards** for school design, inclusive of gender and accessibility.

Figure 72: KII of PIO in Pirojpur

13.4 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Frequent school closures, long absences, and classroom damage due to seasonal flooding	Objective 1: Strengthen flood resilience of school infrastructure and learning continuity	FGDs, Household Survey
Children's mobility and learning disrupted, particularly in female-headed and low-income households	Objective 2: Reduce flood-induced educational disruption and promote inclusive school safety	Household Survey, FGDs
Gendered barriers in WASH access and safe mobility compromise girls' attendance	Objective 3: Enhance gender-responsive school infrastructure and emergency preparedness	FGDs – Female
Lack of coordination between education, disaster, and infrastructure authorities	Objective 4: Strengthen the enabling environment for resilient educational institutions	KII – PIO, FGDs
Supports SDG 4 (Education), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action)	Objective 5: Align outcomes with national education strategy, NAP, and SDGs	All Sources

14. Conclusion

Educational institutions must be central to climate resilience planning, particularly in flood-prone regions. This concept paper outlines a scalable, low-cost, and institutionally driven adaptation pathway focused on enabling policies, training, and curriculum reform. By integrating school flood preparedness into national education systems and aligning with adaptation strategies, Bangladesh can protect children, sustain learning outcomes, and cultivate a generation that is informed, prepared, and empowered to respond to climate risks.

4.7: IMPROVING RESILIENCE TO CYCLONE SHELTERS

1. Introduction

Bangladesh's coastal belt is frequently exposed to severe cyclones, tidal surges, and extreme weather events. Cyclone shelters are critical infrastructure in these regions, serving as safe havens for communities during emergencies. However, many shelters are structurally weak, poorly maintained, lack basic services, and are often inaccessible due to waterlogged or damaged roads during disasters.

Improving the resilience of cyclone shelters is vital to protect lives, reduce losses, and ensure the safety and dignity of vulnerable populations during emergencies. This concept focuses on strengthening existing shelters through structural upgrades, improving access and services, and institutionalizing inclusive management practices to enhance disaster preparedness and response in cyclone-prone areas.

2. Objectives

- Upgrade structural integrity of existing cyclone shelters to withstand high winds and storm surges.
- Ensure continuous access to shelters through flood-resilient roads and walkways.
- Improve utility services inside shelters, including water, sanitation, power, and lighting.
- Promote inclusive shelter management practices that consider gender, age, and disability needs.
- Strengthen local capacities for shelter maintenance, emergency operations, and coordination.

3. Justification for Selected Locations

Districts	Key Risk Factors	Strategic Importance
Barguna, Patuakhali, Bhola	Frequent cyclones, poor infrastructure, weak shelter networks	High-risk coastal zones with limited evacuation capacity
Satkhira, Khulna, Bagerhat	Storm surges, salinity intrusion, inaccessible shelters	Dense population and vulnerable embankment zones
Chattogram, Cox's Bazar	Urban flooding, limited land, poorly maintained shelters	Growing urban and peri-urban cyclone-prone settlements

These districts are consistently affected by major cyclonic events. Strengthening the cyclone shelter network in these areas is essential to safeguard vulnerable populations and ensure operational continuity of emergency response systems.

4. Key Climate Resilience Measures

- **Structural Rehabilitation:** Retrofit and reinforce cyclone shelters to meet disaster-resistant design standards.
- **Flood-Resilient Access:** Construct and maintain elevated or all-weather access roads and pathways to shelters.
- **Utility System Upgrade:** Install solar lighting, backup power systems, gender-sensitive sanitation, and clean water access.
- **Inclusive Planning:** Integrate gender-sensitive designs, child-friendly spaces, and accessible facilities for elderly and persons with disabilities.
- **Capacity Building:** Train community groups, local government officials, and school-based committees in shelter operation, maintenance, and emergency drills.
- **Institutional Coordination:** Strengthen coordination among LGED, DDM, CPP, and local Union Parishads for planning, implementation, and monitoring.

5. Expected Outputs and Impacts

- Structurally resilient cyclone shelters capable of withstanding high-intensity storms and tidal surges.

- Flood-free access routes ensuring timely and safe evacuation for all residents.
- Functional shelters with uninterrupted utility services during and after disasters.
- Community-based shelter management and maintenance protocols established.
- Reduced casualties and enhanced dignity and protection of women, children, and vulnerable groups during emergencies.

6. Gender and Social Considerations

- Ensure separate and secure spaces for women and girls within shelters.
- Design and maintain women-friendly WASH facilities with menstrual hygiene support.
- Train women as part of shelter management and emergency response teams.
- Engage marginalized groups including persons with disabilities and elderly in shelter design consultations.
- Promote leadership of local women's groups in disaster awareness and shelter coordination.

7. Linkage to National Adaptation Plan (NAP) Projects

This concept directly supports the following NAP thematic areas:

- Protection and management of vulnerable areas from cyclones and storm surges.
- Building resilience of critical public infrastructure including cyclone shelters and evacuation routes.

8. Potential Financing Options

Source	Potential Contributors	Advantages	Challenges
Government of Bangladesh	Ministry of Disaster Management and Relief (MoDMR), LGED	Aligned with national disaster risk priorities	Budget constraints and competing priorities
Climate Finance	Green Climate Fund (GCF), Adaptation Fund	High alignment with resilience-building objectives	Complex application and co-financing needs
Multilateral Partners	World Bank, ADB, UNDP	Technical and financial support for infrastructure upgrades	Requires strong institutional coordination
Bilateral Donors	Japan, Germany, UK	Interest in coastal adaptation and humanitarian support	Limited long-term funding horizon
NGOs and Foundations	BRAC, Red Crescent, Save the Children	Local presence and community trust	Limited scale and reliance on donor cycles

9. Critical Considerations and Future Outlook

- Standardization: Adopt national shelter design codes with climate resilience features.
- Monitoring: Develop digital inventory and tracking tools for shelter conditions and readiness.
- Localization: Decentralize maintenance funding and capacity to Union Parishads and community groups.
- Innovation: Explore use of solar microgrids, rainwater harvesting, and digital early warning systems.
- Sustainability: Integrate shelter maintenance in LGED and MoDMR operational budgets.

10. Estimated Investment Cost

Estimated investment will vary depending on the scale of coverage and condition of existing infrastructure. Key cost components include:

- Structural retrofitting and reinforcement
- Construction of elevated and flood-free access roads
- Installation of utility services (WASH, solar, lighting)
- Training programs for shelter management and emergency preparedness
- Stakeholder engagement and shelter design consultations

11. Economic and Financial Benefits

- Reduced disaster mortality and morbidity through effective shelter use
- Lower emergency response and recovery costs due to resilient infrastructure
- Increased efficiency of public investment in disaster preparedness
- Improved public confidence in disaster safety systems
- Enhanced value of cyclone shelters as multi-use community spaces

12. Stakeholder Consultations

Extensive community and stakeholder consultations were carried out in **Cox's Bazar**, one of Bangladesh's most cyclone-prone regions. The engagement aimed to understand challenges related to shelter access, structural resilience, utility services, and inclusive shelter management practices.

Stakeholder Group	Role in the Project	Consultation Approach
Local Key Person (Ward Member, Disaster Committee)	Responsible for local disaster response coordination and shelter activation	Key Informant Interview (KII)
Male Community Members	Shelter users and volunteers during cyclone seasons	Focus Group Discussion (FGD) – Male
Female Community Members	Mothers, caregivers, and persons responsible for managing vulnerable groups during disasters	Focus Group Discussion (FGD) – Female
Cyclone-affected Households	End users of shelters; families exposed to flooding and extreme winds	Household Survey (n=100)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Cyclone-prone community members, including frequent users of local cyclone shelters

Key Observations:

- Structural Risks:
    - Shelters were reported as physically weak, with broken windows, doors, and cracked foundations.
    - Some multi-purpose cyclone shelters also serve as schools, but are not flood-proofed or wind-resistant.

- Access Barriers:
    - Both groups highlighted the lack of raised roads or walkways, often forcing people to swim or walk through waist-high water.
- Utility Failures:

- Female participants emphasized the lack of lighting, separate toilets, drinking water, and designated areas for women and children.
- Overcrowding and sanitation issues were recurring themes.

- Inclusive Management:
  - Respondents demanded female shelter managers, separate spaces for elderly and disabled persons, and clearer announcements before evacuation.

Figure 73: FGD of Male Participants in Cox's Bazar

Figure 74: FGD of Female Participants in Cox's Bazar

13.2 Household Survey Outcomes

Profile: 100 households in cyclone-vulnerable wards of Cox's Bazar

Key Findings:

- Shelter Condition and Usage:
  - 64% had taken shelter during the most recent cyclone; however, 78% of them reported inadequate facilities.
  - 57% cited poor structural condition, including wall damage and non-functional doors.
- Access & Safety Issues:
  - 70% said they faced difficulty reaching shelters due to flooding and broken roads.
  - 39% of female-headed households felt unsafe due to inadequate lighting and crowding.
- Utility and Services:
  - 81% reported absence of basic services such as toilets, water, and power backup.
  - 63% requested solar panels and rainwater harvesting to make shelters functional post-disaster.
- Community Preferences:
  - 72% wanted cyclone shelters to also serve as community resource centers.
  - High demand for regular maintenance and youth-led evacuation drills.

13.3 Key Informant Interview (KII)

Interviewee: Local Key Person (Ward Disaster Committee Member)

Key Insights:

- Shelter Infrastructure Gaps:
    - Many shelters have not been upgraded in 10+ years.
    - No budget or designated team for routine repairs.
- Evacuation and Operations:
    - Warnings often come late, forcing rushed evacuations.
    - Suggested broadcasting through mosque mics, SMS alerts, and trained local responders.
- Recommendations:
    - Assign maintenance responsibility to local committees.
    - Allocate funds for yearly upkeep and disaster response training.
    - Build elevated access roads and introduce portable water and WASH kits.

13.4 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Cyclone shelters are physically degraded and structurally weak	Objective 1: Upgrade structural integrity of existing cyclone shelters to withstand storm events	FGDs, HH Survey, KII
Flooded, damaged roads prevent timely evacuation and shelter access	Objective 2: Ensure continuous access to shelters through flood-resilient roads and walkways	FGDs, HH Survey
Shelters lack toilets, lighting, water, and backup electricity systems	Objective 3: Improve utility services inside shelters	FGDs (Female), HH Survey
Women, elderly, and disabled persons are underserved during shelter use	Objective 4: Promote inclusive shelter management for all groups	FGDs (Female), KII
Local shelter management lacks resources, tools, and institutional backing	Objective 5: Strengthen local capacities for shelter maintenance and emergency coordination	KII – Ward Member, HH Survey

14. Conclusion

Cyclone shelters are a critical first line of defense in disaster-prone areas of Bangladesh. However, their current limitations in structural safety, accessibility, and functionality compromise their effectiveness. By upgrading existing infrastructure, strengthening institutional arrangements, and engaging communities—especially women and vulnerable populations—this concept presents a comprehensive, inclusive, and scalable solution for improving disaster resilience in coastal Bangladesh. It aligns directly with national adaptation goals and global frameworks for climate resilience and disaster risk reduction.

4.8: STRENGTHENING THE ENABLING ENVIRONMENT FOR CYCLONE SHELTER RESILIENCE IN COASTAL DISTRICTS

1. Introduction

Cyclone shelters are critical public infrastructure in Bangladesh's coastal belt, providing life-saving refuge for millions during disasters. However, the effectiveness of these facilities is frequently compromised by weak institutional arrangements, limited operational guidelines, and inadequate local ownership. With rising climate risks and increasing cyclone intensity, there is an urgent need to strengthen the enabling environment for cyclone shelter planning, operation, and maintenance.

This concept emphasizes the development of institutional frameworks, capacity building, and regulatory reforms that ensure cyclone shelters are functional, inclusive, and effectively managed. It proposes a systems approach—integrating national policy, local government leadership, and community participation—to enhance cyclone resilience and disaster readiness.

2. Objectives

- Develop and implement standardized operational and maintenance protocols for cyclone shelters across coastal districts.
- Strengthen the institutional capacity of local governments and shelter management committees.
- Integrate shelter planning and resilience into land use policy, zoning regulations, and urban planning.
- Promote community participation, especially of women and marginalized groups, in shelter governance.
- Establish long-term systems for monitoring, evaluation, and accountability in cyclone shelter operations.

3. Justification for Selected Locations

Districts	Key Risk Factors	Strategic Importance
Satkhira, Khulna, Bagerhat, Barguna	High cyclone frequency, inadequate shelter coverage, weak community coordination	Coastal frontline districts prone to storm surges and tidal waves
Patuakhali, Bhola, Noakhali	Shelter accessibility challenges, salinity intrusion, poor land use enforcement	Population-dense zones with repeated shelter failures
Chattogram, Cox's Bazar	Urban-rural shelter imbalance, unmanaged expansion, infrastructure overload	Regional growth centers with large displaced populations

These districts are selected for their exposure to cyclones and the operational challenges associated with their shelter infrastructure. Strengthening the enabling environment in these areas will improve the effectiveness of shelter-based climate resilience interventions.

4. Key Climate Resilience Measures

- **Policy Reform:** Formulate national-level guidelines for cyclone shelter operations, including disaster SOPs and local accountability systems.
- **Institutional Strengthening:** Build capacity of Union Parishads and municipalities to manage, monitor, and audit shelter facilities.
- **Planning Integration:** Ensure alignment of cyclone shelter development with national adaptation planning, disaster management frameworks, and local development plans.
- **Community Mobilization:** Establish local shelter committees with representation from vulnerable and marginalized groups, including women and persons with disabilities.
- **Data and Monitoring:** Introduce a digital shelter management system with geo-tagged shelter databases, maintenance status, and disaster readiness metrics.
- **Training and Simulation:** Conduct regular drills, planning exercises, and technical training for shelter managers and volunteers.

5. Expected Outputs and Impacts

- A harmonized framework for cyclone shelter operations across high-risk districts.
- Increased local ownership and community oversight through functional shelter committees.
- More responsive and accessible cyclone shelters due to improved planning and service delivery.
- Significant reduction in disaster fatalities, injuries, and service disruptions.
- Long-term resilience of cyclone shelters integrated into disaster risk management systems.

6. Gender and Social Considerations

- Establish gender-balanced shelter committees and prioritize leadership roles for women.
- Incorporate gender-sensitive design and privacy considerations in shelter use guidelines.
- Include women, elderly, and persons with disabilities in planning, feedback, and response exercises.
- Promote awareness campaigns that address safety, security, and dignity during emergency sheltering.
- Ensure that facilities like separate sanitation areas and maternal care spaces are part of shelter standards.

7. Linkage to National Adaptation Plan (NAP) Projects

This concept is aligned with the following thematic areas under Bangladesh's National Adaptation Plan:

- Protection and management of cyclone-vulnerable areas
- Institutional capacity building for disaster and climate resilience in critical infrastructure

8. Potential Financing Options

Source	Potential Contributors	Advantages	Challenges
Government of Bangladesh	Ministry of Disaster Management and Relief, LGED	National priority and local government linkage	Limited development budget allocation
Climate Finance	Green Climate Fund (GCF), Adaptation Fund	Resilience-aligned and impact-driven	High competition and long lead time for approval
Multilateral Partners	World Bank, ADB, UNDP	Infrastructure plus institutional reform support	Requires strong coordination and co-financing
Bilateral Donors	UK, Japan, Germany, Netherlands	Active in disaster risk reduction and social inclusion	Shorter-term cycles, may lack continuity
NGOs & Foundations	Red Crescent, BRAC, Oxfam	Trusted community partners with technical capacity	Limited scale without government co-implementation

9. Critical Considerations and Future Outlook

- **Standardization:** Define and adopt a national operating manual for cyclone shelters.
- **Digital Tools:** Scale up use of mobile-based early warning systems linked to shelter status and capacity.
- **Sustainability:** Embed shelter audits and maintenance budgets into Union and Municipal annual development programs.

- **Localization:** Promote co-ownership of shelter readiness by integrating committees with local disaster platforms.
- **Replication:** Document and replicate best practices from leading coastal districts nationally.

10. Estimated Investment Cost

The estimated cost will vary depending on the institutional maturity of local governments and the number of shelters targeted. Major cost components include:

- Development of guidelines and SOPs
- Capacity building programs for local governments and communities
- Shelter digitalization and monitoring tools
- Public campaigns, training, and community mobilization
- Design and implementation of a national shelter audit system

11. Economic and Financial Benefits

- Reduced loss of life and injury from timely, inclusive access to cyclone shelters
- Minimized economic disruptions from cyclone-induced displacement
- Reduced maintenance costs due to regular monitoring and upkeep
- Increased donor and government investment confidence due to structured systems
- Improved disaster response efficiency and coordination across administrative levels

12. Stakeholder Consultations

Stakeholder engagement was conducted in Cox's Bazar to assess the institutional, operational, and governance conditions of cyclone shelters. The consultations aimed to identify systemic gaps, governance challenges, and opportunities for inclusive, standardized shelter resilience practices.

Stakeholder Group	Role in the Project	Consultation Approach
Local Government Engineering Department (LGED)	Planning, design, construction, and maintenance of cyclone shelters	Key Informant Interview (KII)
Male Community Members	Shelter users and informal responders during cyclone events	Focus Group Discussion (FGD) – Male
Female Community Members	Primary caregivers and vulnerable shelter occupants (children, elderly, disabled)	Focus Group Discussion (FGD) – Female
Cyclone-Affected Households	End users of shelter services across various wards of Cox's Bazar	Household Survey (n=100)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Residents from cyclone-exposed unions in Cox's Bazar

Key Observations:

- **Operational Weaknesses:**
    - Participants described chaotic shelter operations with no designated shelter managers, unclear protocols, and inconsistent opening times.
    - Women pointed out the absence of female shelter coordinators and a lack of designated spaces for vulnerable individuals.
- **Governance and Inclusion Gaps:**
    - Community members reported that shelter planning happens without local input, especially from women and marginalized families.

- Respondents voiced a lack of trust in shelter managers and absence of grievance redress systems.

- Planning and Maintenance Issues:
  - No signage, maps, or local drills were in place.
  - Maintenance was irregular and typically reactionary, only triggered post-disaster.
- Community Proposals:
  - Introduce standardized training and management manuals.
  - Create ward-level shelter committees with women and youth representation.
  - Include shelters in local land use and disaster risk planning.

Figure 76: FGD of Male Participants in Cox's Bazar

Figure 75: FGD of Female Participants in Cox's Bazar

13.2 Household Survey Outcomes

Profile: 100 households from cyclone-prone wards in Cox's Bazar

Key Findings:

- Policy Awareness and Participation:
  - 68% were unaware of who operates the local shelter or how decisions are made.
  - 79% stated they had never been consulted about shelter construction or upgrades.
- Operational Deficiencies:
  - 57% experienced confusion during cyclone warnings due to lack of early announcements or proper instructions.
  - 62% felt shelter operations lacked transparency and preparedness.
- Inclusion & Management:
  - 39% said their local shelters did not accommodate women separately or lacked disability-accessible areas.
  - 53% supported the idea of formal committees with legal mandates and oversight.
- Long-Term Needs:
  - 88% supported the development of an online and public monitoring system.
  - 71% demanded that shelter location and investment be embedded in local development plans.

13.3 Key Informant Interview (KII)

Interviewee: LGED representative – Cox's Bazar

Key Findings:

- Institutional and Policy Gaps:
    - Shelter designs and implementation often follow ad-hoc budgeting and limited technical criteria.
    - LGED's role is typically construction-focused, with no mandate to ensure long-term operation or governance.

- Operational Framework Needs:
    - Called for standardized O&M (Operations & Maintenance) protocols across districts.
    - Recommended linking shelter management with Union Parishads and Upazila Disaster Committees.
- Capacity Building:
    - LGED endorsed training programs for shelter caretakers and committee leaders.
    - Proposed integrating shelter maintenance plans into annual development programming and performance tracking.

Figure 77: KII of LGED Representative in Cox's Bazar

13.4 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Absence of clear protocols and inconsistent management weakens shelter reliability	Objective 1: Develop and implement standardized operational and maintenance protocols	FGDs, KII, HH Survey
Local authorities lack clarity on their roles in long-term shelter operation	Objective 2: Strengthen the institutional capacity of local governments and shelter committees	KII, FGDs
Shelter development is disconnected from land use and urban planning strategies	Objective 3: Integrate shelter planning into zoning and urban development policies	HH Survey, KII
Women and vulnerable groups are excluded from shelter governance structures	Objective 4: Promote community participation in shelter governance	FGDs (Female), HH Survey
Monitoring, evaluation, and grievance redress are missing in most shelters	Objective 5: Establish long-term systems for monitoring, evaluation, and accountability	HH Survey, FGDs, KII

13. Conclusion

Cyclone shelters are central to disaster risk reduction in coastal Bangladesh, yet their functionality is only as strong as the systems managing them. Strengthening the enabling environment through governance reforms, inclusive planning, and local capacity building is essential to enhance resilience and reduce disaster losses. This concept provides a structured, scalable, and people-centered approach to cyclone shelter resilience aligned with national adaptation priorities and global climate goals.

5.1: MANAGING FLASH FLOODS IN NORTHEASTERN AND SOUTHEASTERN BANGLADESH

1. Introduction

The northeastern and southeastern regions of Bangladesh—particularly the Sylhet Haor area, Chattogram, and Cox's Bazar—face significant challenges due to flash floods. These low-lying and hydrologically active zones are increasingly vulnerable to intense rainfall events, upstream river surges, and siltation, all worsened by climate change. Flash floods not only disrupt transportation and agriculture but also lead to displacement, infrastructure damage, and public health crises. Communities in these regions, especially in haor basins and coastal lowlands, are among the most affected due to lack of drainage systems, poor flood forecasting capacity, and degraded natural buffers like wetlands and forests.

To address these challenges, an integrated adaptation response focused on urban and rural resilience is proposed, leveraging nature-based solutions, early warning systems, and flood-proof infrastructure. The approach emphasizes participatory planning, particularly inclusive of women and marginalized groups, to build sustainable local flood management systems.

2. Objectives

- Enhance structural and ecosystem-based flood resilience in flash flood-prone regions.
- Reduce flood-induced economic losses and livelihood disruption.
- Improve disaster preparedness and response capacity through inclusive early warning and planning systems.
- Promote nature-based flood management and ecological restoration.
- Align the project with SDGs, especially SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).

3. Justification for Selected Locations

Location	Key Vulnerability Factors	Strategic Importance
Sylhet Haor Region	Flash floods from upstream, lack of drainage, poor forecasting	Major rice-producing area, dense rural population, critical wetlands
Chattogram	Urban flash floods, deforestation, slope failure	Coastal port city, industrial hub, urban expansion
Cox's Bazar	Intense rainfall, refugee population pressure, river erosion	Coastal tourism zone, humanitarian hotspot

4. Key Climate Resilience Measures

- Flood-Resilient Infrastructure: Construct raised roads, embankments, and flood-resistant shelters in vulnerable zones using climate-resilient materials to withstand intense rainfall and surge impacts.
- Enhanced Drainage Systems: Rehabilitate and expand drainage channels, culverts, and urban stormwater systems in both urban and rural flash flood hotspots to ensure timely floodwater recession and reduce prolonged waterlogging.

- Nature-Based Solutions: Restore wetlands, reforest hill catchments, and develop green buffer zones to enhance natural absorption of runoff and mitigate peak flood volumes.
- Early Warning and Community Response: Establish inclusive flood management committees supported by mobile-based alerts and advanced weather forecasting to strengthen early response.
- Community-Led Maintenance and Monitoring: Train local residents to maintain minor infrastructure, clean drains, and monitor embankments to ensure sustainability and reduce response time.

5. Expected Outputs and Impacts

Expected Impact	Key Benefits
Improved flood resilience of infrastructure	Reduced damage and disruption to critical services
Enhanced drainage and water recession capacity	Shorter duration of waterlogging and lower health risks
Restored ecosystem buffers	Increased runoff absorption and ecological stability
Aligned interventions with related flood projects	Avoidance of redundancy and more efficient resource use
Community empowerment and inclusion	Stronger ownership and maintenance of local infrastructure

6. Gender and Social Considerations

The project promotes inclusive resilience through participatory planning and decision-making. Key actions include:

- Inclusion of women in local flood committees and planning bodies.
- Leadership and capacity-building programs tailored for women.
- Gender-sensitive early warning dissemination and infrastructure design (e.g., lighting, access to shelters).
- Targeted consultations with marginalized and vulnerable populations.

7. Linkage to National Adaptation Plan (NAP) Projects

This project aligns directly with Bangladesh's National Adaptation Plan (NAP) under its key thematic area of "protection and management of potentially vulnerable areas due to tropical cyclones, flooding, and sea-level rise." The core linkages include:

- Strengthening climate-resilient infrastructure in flash flood-prone regions, particularly in the Sylhet Haor area, Chattogram, and Cox's Bazar.
- Enhancing stormwater drainage systems, embankments, and flood-protective structures to mitigate flash flood impacts.
- Improving disaster preparedness and emergency accessibility through early warning systems and community-based response mechanisms.
- Supporting sustainable, inclusive, and resilient rural and urban connectivity systems to ensure continuity during flood events.

This project contributes to achieving the national priority of reducing climate vulnerabilities and strengthening climate-resilient infrastructure systems for long-term disaster risk reduction.

8. Potential Financing Options

Financing Source	Potential Contributors	Key Advantages	Challenges

Government Funding	Ministry of Local Government (LGED), ADP funds	Ensures national ownership, supports local priorities	Budget limitations, competing sectoral demands
Multilateral Development Banks	World Bank, Asian Development Bank, AIIB	Access to concessional, large-scale climate-resilient infrastructure financing	Lengthy approval processes, strict compliance standards
Public-Private Partnerships (PPPs)	Private construction firms, transport operators	Encourages private sector innovation and cost-efficiency	Risk-sharing complexities, local PPP policy constraints
Blended Finance	Combination of public, private, and concessional funds	Leverages diverse financing sources and spreads risks	Coordination and regulatory alignment between multiple actors
International Climate Grants	Green Climate Fund (GCF), Adaptation Fund	Eases government financing burden, promotes international alignment	Highly competitive and time-consuming application processes

9. Critical Considerations and Future Outlook

- Sustainability: Emphasize low-maintenance designs and build community-led maintenance systems for long-term operation.
- Policy Integration: Mainstream flood resilience into local zoning laws, drainage codes, and urban planning tools.
- Community Engagement: Promote active participation by women, youth, and marginalized groups in both planning and monitoring.
- Innovation and Adaptation: Encourage use of local materials, data-driven planning, and adaptive technologies.
- Project Integration: Align and, where feasible, consolidate this initiative with similar ecosystem-based or drainage-focused projects to avoid overlap, ensure efficient implementation, and strengthen institutional adoption.

10. Estimated Investment Cost

The estimated investment cost will cover:

- Construction and reinforcement of flood-resilient infrastructure, including roads and embankments.
- Procurement of flood-resistant construction materials.
- Development of drainage systems, culverts, and protective barriers.
- Capacity building, community training, and emergency preparedness programs.
- Procurement of equipment for regular inspections and minor maintenance
- Integration of early warning systems and digital monitoring tools.

11. Economic and Financial Benefits

- Reduction in infrastructure flooding frequency and severity, securing uninterrupted access.
- Decreased maintenance and reconstruction costs due to more durable, flood-resilient infrastructure.
- Minimized economic losses from transport disruptions, safeguarding access to markets, services, and emergency routes.
- Boosted investor and public confidence in resilient infrastructure, fostering private sector participation.

- Creation of local employment opportunities during construction, maintenance, and operational phases.

12. Stakeholder Consultations

Stakeholder consultations were carried out in **Sunamganj**, a flash flood-prone district in northeastern Bangladesh. The engagement process included local administrative officials, ward-level leadership, and community members from flood-affected unions. The consultations focused on identifying root causes of flash flooding, challenges in flood response, infrastructure vulnerabilities, and the potential for nature-based and community-led flood management.

Stakeholder Group	Role in the Project	Consultation Approach
Assistant Commissioner (Land)	Local flood and land management authority overseeing resource allocation and hazard mitigation	Key Informant Interview (KII) – AC Land
Union Ward Member	Grassroots governance and community liaison for disaster planning	Key Informant Interview (KII) – Ward Member
Male Community Members	Farmers, transport workers, and daily wage laborers facing direct flood and mobility disruptions	Focus Group Discussion (FGD) – Male
Female Community Members	Caregivers and informal workers affected by health and safety risks during flash flood events	Focus Group Discussion (FGD) – Female
Flash Flood-Affected Households	End-users and primary beneficiaries experiencing economic losses and service failure due to floods	Household Survey (n = 100)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Male and female residents from flood-prone low-income areas, including day laborers, rickshaw pullers, homemakers, and small traders.

Key Findings:

- Waterlogging persists for 3–5 days after moderate rainfall; drains overflow and enter homes.
- Women reported physical risks when navigating flooded streets during emergencies or health needs.
- Several families created temporary bamboo walkways or stacked sandbags to access homes.
- Requests for RCC footpaths and drain covers to ensure safety, especially for children and the elderly.

Figure 78: FGD of Male Participants in Sunamganj

Figure 79: FGD of Female Participants in Sunamganj

13.2 Household Survey Outcomes

Profile: 100 households from low-lying, flash flood-prone wards in Sunamganj

Key Findings:

- **Impact on Income and Mobility**:
  - **71%** of households lost workdays or income due to flooding in the last year.
  - **64%** were unable to reach schools or health centers during at least one event in the previous 12 months.
- **Shelter and Housing Vulnerability**:
  - **59%** reported water entering homes, leading to damaged goods and sanitation challenges.
  - Only **26%** had access to any formal or informal shelter structure above flood levels.
- **Flood Adaptation Preferences**:
  - **83%** favored **planting flood-resistant vegetation** along embankments and roads.
  - **74%** supported use of **natural canal restoration** over concrete drains.
  - **69%** said they would participate in **community-based early warning training**.

13.3 Key Informant Interviews (KIIs)

Participants: AC Land (Sylhet Sadar), Ward Councilor of Ward 24, and community leaders.

Key Insights:

- The area lacks a formal stormwater drainage network and is heavily encroached by unregulated construction.
- Existing open drains are clogged due to poor solid waste management.
- The Ward Councilor emphasized the need for embankment protection near the canal adjacent to Kharpara, which frequently overflows.

- Local leaders called for a coordinated flood management master plan that includes land zoning, vertical infrastructure planning, and regular cleaning of existing drains.

Figure 80: KII of AC Land in Sunamganj

Figure 81: KII of Ward Member in Sunamganj

13.4 Integration of Findings and Project Relevance

Key Findings	Linked Project Objectives	Evidence Reference
Flash floods occur rapidly, overwhelming current evacuation and protection mechanisms	Objective 1: Enhance structural and ecosystem-based flood resilience	FGDs, KIIs, Household Survey
Crop and income losses, school and health access breakdowns are widespread during floods	Objective 2: Reduce economic losses and livelihood disruption caused by flooding	FGDs, Household Survey
No functioning early warning system; communities rely on visual cues or phone calls	Objective 3: Improve disaster preparedness and response through inclusive early warning systems	KIIs, FGDs, Household Survey
Strong community support for vegetated berms, canal restoration, and wetland protection	Objective 4: Promote nature-based flood management and ecological restoration	FGDs, Household Survey
Recommendations align with SDG 6 (water), 11 (urban resilience), and 13 (climate), as well as the NAP goals	Objective 5: Align intervention with SDGs and the National Adaptation Plan	KIIs, FGDs, Household Survey

14. Conclusion

Managing flash floods in the most vulnerable areas of Sylhet and coastal Bangladesh requires an integrated, community-anchored, and climate-smart approach. This concept combines infrastructure reinforcement, nature-based solutions, and institutional reforms to mitigate the devastating impacts of flash floods.

Its strong alignment with NAP priorities and SDGs makes it a scalable model for climate resilience. Through coordinated efforts across government, private sector, and communities, this initiative aims to protect lives, sustain livelihoods, and strengthen Bangladesh's long-term climate adaptation capacity.

5.2 REHABILITATING AND MANAGING COASTAL EMBANKMENTS

1. Introduction

The coastal districts of Bangladesh—particularly Satkhira, Patuakhali, and Hatiya—are increasingly affected by climate-induced hazards, including cyclonic storm surges, tidal flooding, and sea-level rise. Embankments and polders, once key barriers against these disasters, are now aging, degraded, or inadequately designed for intensified climate risks. The consequences include recurrent breaches, prolonged waterlogging, saltwater intrusion, and infrastructure failure—threatening agriculture, settlements, and transport routes.

To address these risks, this concept proposes a climate-resilient embankment rehabilitation program focused on modular construction, geosynthetic applications, and drainage enhancement. The project integrates local knowledge, advanced engineering, and inclusive governance to strengthen embankments for long-term resilience.

Figure 83: Road Infrastructure in Hatiya

Figure 82: Road Infrastructure in Hatiya

2. Objectives

- Rehabilitate and modernize coastal embankments to withstand sea-level rise and extreme storm surges.
- Improve drainage and sluice systems to minimize waterlogging within polders.
- Enhance the structural durability of embankments using advanced materials and modular designs.
- Promote community involvement, particularly women, in embankment monitoring and maintenance.
- Align the project with SDGs 5, 9, 11, and 13.

3. Justification for Selected Locations

Location	Climate Risk Profile	Strategic Importance
Satkhira District	Cyclonic storm surge, saline intrusion, tidal flood	Border district, shrimp and rice-producing zone
Patuakhali District	Sea-level rise, intense cyclones, embankment erosion	Gateway to Kuakata, key fisheries and tourism economy
Hatiya Upazila (Noakhali)	Island geography, storm surges, isolation, weak embankments	Disaster-prone, ferry routes, and highly vulnerable settlements

4. Key Climate Resilience Measures

The project will adopt a mix of engineered and nature-based measures to ensure durable, cost-effective, and inclusive flood protection:

- **Embankment Rehabilitation:** Strengthening vulnerable segments with geosynthetics, concrete revetments, and slope stabilization to reduce breach risk.
- **Modular Construction:** Deploying prefabricated RCC units for quick repairs and emergency response, reducing construction time and costs.
- **Drainage and Sluice Upgrades:** Expanding culverts, digitizing sluice gates, and improving outflows to address post-flood waterlogging and land use recovery.
- **Nature-Based Buffers:** Replanting mangroves and green belts alongside embankments to reduce wave energy and support biodiversity.
- **Digital Monitoring:** Introducing sensors, drones, and dashboards for real-time flood and infrastructure monitoring.
- **Environmental Safeguards:** Conducting EIAs to minimize ecological disruption and ensure compliance.
- **Inclusive Design:** Installing solar lighting and raised paths for safer access, especially for women, elderly, and children.

5. Expected Outputs and Impacts

Output	Impact
Rehabilitated embankments and polders	Reduced breach risk and salinity intrusion
Improved sluice and drainage systems	Lower waterlogging and improved land use
Community-based maintenance units	Faster repairs, localized monitoring
Gender-responsive infrastructure	Safer access for women, elderly, and children
Green buffers and modular designs piloted	Sustainable, scalable flood protection systems
Detailed cost-benefit estimate completed	Improved feasibility and financial planning for implementation
Environmental screening and EIA conducted	Higher regulatory compliance and reduced delays

6. Gender and Social Considerations

- Active involvement of women in consultations and local repair committees
- Safety features prioritized for women and elderly (lighting, raised paths)
- Gender-segregated FGDs ensured diverse perspectives
- Training programs for women in embankment inspection and emergency response

7. Linkage to National Adaptation Plan (NAP) Projects

This project supports the NAP thematic area: "Integrated management of coastal polders, sea dikes, and cyclone shelters."

- Strengthens infrastructure resilience to cyclones and sea-level rise
- Supports inclusive flood risk governance
- Enhances climate-proof transport and shelter access
- Incorporates nature-based adaptation through green buffer zones

8. Potential Financing Options

Financing Source	Contributors	Key Advantages	Challenges
Government Funding	LGED, Ministry of Water Resources	National ownership	Limited fiscal space
MDB Loans & Grants	ADB, WB, AIIB	Technical assistance, concessional finance	Complex appraisal & safeguard procedures

Climate Resilience Funds	GCF, Adaptation Fund	Low-cost capital for adaptation	Competitive, lengthy application cycle
Private Sector & CSR	Agro, transport, insurance sectors	Visibility, sustainability incentives	Limited scalability
Blended Finance	Multistakeholder consortia	Risk-sharing, alignment of public-private	Coordination and structuring

9. Critical Considerations and Future Outlook

- Engineering innovation: Test geosynthetics and modular RCC solutions
- Inclusive maintenance: Youth- and women-led monitoring teams
- Policy reform: Strengthen local land-use zoning and waterlogging maps
- Multi-sector integration: Link drainage planning to WASH, health, transport
- M&E integration: Drone, satellite, and community scorecards for progress tracking
- Consolidate overlapping initiatives from similar resilience projects into a **single integrated coastal protection framework**, reducing duplication and improving coordination across ministries and donors.

10. Estimated Investment Cost

Investment cost will cover:

- Rehabilitation of 60–80 km embankments
- Construction/upgrades of 40+ sluice gates
- Pilot of modular solutions and emergency barriers
- 300+ local people trained for inspection and response
- Digital monitoring tools and contingency supplies

11. Economic and Financial Benefits

- Reduced repair and recovery cost post-flood
- Secured agricultural productivity in polder zones
- Boosted value of coastal land and housing
- Improved logistics and transport reliability
- Encouragement of private investment in flood-adapted infrastructure

12. Stakeholder Consultations

Comprehensive consultations were undertaken in **Hatiya Upazila**, targeting key institutional stakeholders and local community members directly affected by coastal embankment degradation and tidal flooding. The consultation aimed to understand embankment vulnerability, assess existing structural gaps, and explore locally viable solutions.

Stakeholder Group	Role in the Project	Consultation Approach
Upazila Engineer, LGED	Coordination on embankment strengthening and design standards	Key Informant Interview (KII)
Union Parishad Representative	Local governance and community mobilization	Key Informant Interview (KII)
Community Members (men & women)	Direct beneficiaries, respondents on past flood experiences	Focus Group Discussions (FGDs)

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Conducted separately with adult male and female residents in flood-prone wards of Hatiya. Participants included farmers, fisherfolk, small traders, homemakers, and elderly members.

Key Observations:

- Structural Failures: Repeated breaches of embankments during high tides, especially in monsoon season. Men mentioned patching with sandbags and plastic sheets as an emergency response.
- Waterlogging and Access Issues: Participants described how waterlogging persists for days within the polder after a storm surge, cutting off access to schools, clinics, and markets.
- Safety for Women: Women participants stressed the dangers of walking on broken or slippery embankments at night due to the absence of streetlights and safe platforms.
- Community Knowledge: Several respondents highlighted traditional techniques—such as placing coconut husk mats or woven bamboo—to stabilize embankment edges temporarily.
- Evacuation Concerns: In cases of cyclone warnings, embankment pathways were flooded or too narrow for safe travel, particularly for elderly, pregnant women, or those with disabilities.

Figure 84: FGD of Male Participants in Hatiya

13.2 Household Survey Findings

Profile: 100 households surveyed across three unions, including female-headed households, subsistence farmers, and fishing families.

Findings:

- Embankment Breach Impacts:
    - 73% reported losing crops or household items due to embankment breaches in the past two years.
    - 64% said livestock had to be evacuated due to flooding within the polder after gate failure.
- Household Priorities:
    - 81% demanded **reinforced embankments** using concrete or geotextiles.
    - 69% requested more efficient **sluice gate operation and drainage systems** to prevent water stagnation.

- 56% of women emphasized the need for raised walking paths and well-lit emergency routes along embankments.

- Traditional Practices:
  - Families used makeshift bamboo walkways over breached sections or relied on dugout boats during emergencies.
  - Men described pooling funds to repair small embankment segments post-cyclone in the absence of formal support.

13.3 Key Informant Interviews (KIIs)

Interviewees: Upazila LGED Engineers, Union Parishad Members

Insights:

- LGED Observations:
  - Many embankment segments lack proper slope protection and foundation reinforcement, making them prone to breaching.
  - Suggested piloting layered geosynthetics and prefabricated RCC panel reinforcement in critical stretches.
- Union Parishad Feedback:
  - Called for establishing shared emergency embankment maintenance funds and community-led "embankment watch" teams.
  - Emphasized the need for training on sluice gate management for local operators.

Figure 85: KII of LKP in Hatiya

13.4 Integration of Findings and Alignment with Project Objectives

The integrated insights from FGDs, household surveys, and KIIs reflect both the technical vulnerabilities and lived realities of embankment users in Hatiya. The following synthesis links field evidence with the project's strategic goals:

Key Findings	Linked Project Objectives	Evidence Source
Frequent embankment breaches during monsoon or tidal surges	Obj 1: Rehabilitate and strengthen embankment structures	FGDs, KIIs, Household Survey
Waterlogging within polders due to poor drainage/silted gates	Obj 2: Upgrade drainage and sluice systems	Household Survey, FGDs
Women's restricted mobility due to unsafe, broken pathways	Obj 4: Design inclusive, gender-sensitive embankment access	FGDs (women), Household Survey
High use of informal repair methods and local community actions	Obj 4: Promote traditional knowledge and community ownership	FGDs, KIIs
Institutional support exists but is constrained by budget gaps	Obj 3 & 5: Improve governance and institutional coordination	KIIs (LGED, UP)

14. Conclusion

Rehabilitating coastal embankments is not just an infrastructure task—it is a lifeline for millions living in Bangladesh's vulnerable coastal belt. This project offers a climate-smart, community-inclusive, and technically sound approach to transform failing embankments into resilient structures. By combining modular construction, improved drainage, and social equity, this initiative will significantly reduce disaster losses and improve adaptive capacity. Future iterations of this proposal may include **detailed cost assessments, integrated timelines, and consolidated project scopes**, ensuring that embankment rehabilitation efforts are feasible, fundable, and attractive for cross-ministerial adoption.

The project's alignment with NAP and the SDGs makes it a strategic investment in Bangladesh's fight against climate change impacts.

5.3 REHABILITATING DRAINAGE CHANNELS WITHIN THE POLDERS

1. Introduction

In the low-lying coastal districts of Satkhira, Patuakhali, and Hatiya, aging and poorly maintained drainage infrastructure within polders has led to prolonged waterlogging, agricultural losses, and transport disruption. Drainage channels are heavily silted, and obsolete sluice gates no longer regulate water effectively. With climate change exacerbating rainfall variability and sea-level rise, restoring the drainage systems within these areas is critical to community resilience and economic recovery.

This project aims to rehabilitate and desilt drainage channels and sluice gates within the polders to restore water flow, improve agricultural productivity, and reduce household vulnerability to waterborne health risks and flooding.

Figure 86: Infrastructure in Hatiya

2. Objectives

- Rehabilitate internal drainage systems through excavation of silted canals and repair of sluice gates.
- Alleviate chronic waterlogging in polder communities by improving drainage efficiency.
- Enhance agricultural productivity and protect road and utility infrastructure from flood damage.
- Empower local communities, especially women and vulnerable groups, to participate in drainage monitoring and maintenance.
- Contribute to SDG 9 (Infrastructure), SDG 11 (Sustainable Communities), and SDG 13 (Climate Action).

3. Justification for Selected Locations

Location	Climate Risk Profile	Strategic Importance
Satkhira District	Tidal flooding, saline intrusion, clogged drainage	Major polder zone for rice, shrimp, and homesteads
Patuakhali District	Sluice failure, sedimentation, poor flow discharge	Dense canal network supporting agriculture and fisheries
Hatiya Upazila	Island setting, poor drainage outflow, high rainfall	Isolated but high-risk community with frequent flooding

4. Key Climate Resilience Measures

- Excavation of Silted Khals: Manual or mechanical cleaning of blocked drainage canals.
- Sluice Gate Repair: Functional rehabilitation of rusted or broken gates, including possible automation.
- Sediment Management Plans: Introduce scheduled desilting cycles with community involvement.
- Drainage-Road Coordination: Improve cross-drainage under roads to prevent infrastructure damage.
- Community Maintenance Teams: Establish volunteer or paid local teams for routine monitoring.

5. Expected Outputs and Impacts

Output	Anticipated Impact
Rehabilitated drainage channels	Improved water flow and reduced stagnant water
Operational sluice gates	Controlled water discharge during tides and monsoons
Reduced waterlogging inside polders	Increased agricultural productivity and reduced health risks
Local community involvement in upkeep	Improved ownership and sustainability of drainage systems

6. Gender and Social Considerations

- Women from vulnerable households participated in community consultations.
- FGDs revealed that women face mobility and health challenges due to standing water around homes, clinics, and markets.
- Drainage interventions will prioritize safe pathways, latrine access, and female employment in maintenance.
- Community training will include women-led households and local youth to monitor khals and gate conditions.

7. Linkage to National Adaptation Plan (NAP) Projects

This project directly supports the following NAP interventions:

- Integrated management of polders, sea dikes, and cyclone shelters
- Drainage management of economic/industrial zones and rural infrastructure
  By reducing internal waterlogging and strengthening sluice operations, the project aligns with national flood risk mitigation and sustainable land use goals.

8. Potential Financing Options

Source	Contributors	Key Benefits	Challenges
Government Budget	Ministry of Water Resources, LGED	Institutional support and rural priority	Competing sectoral demands, budget shortfalls
Development Partners	ADB, World Bank, GCF, Adaptation Fund	Technical expertise and climate finance	Slow disbursement and complex approval cycles
Private Sector & CSR	Fertilizer, agro-processing firms	Community engagement and sustainability	Voluntary, may lack scale or continuity
Community-Based Funding	Water user groups, labor contributions	Strengthens local ownership and sustainability	Financial constraints of vulnerable communities

9. Critical Considerations and Future Outlook

- Establish pre-monsoon desilting calendars to avoid disruptions during cropping cycles.
- Improve coordination between BWDB, LGED, and Union Parishads to streamline responsibilities.
- Pilot drone-based mapping and community scorecards for canal maintenance tracking.
- Explore nature-based solutions where feasible, including vegetation buffers along canal edges.
- Design a replication model for other flood-prone polders in Barisal, Khulna, and Bhola.

10. Estimated Investment Cost

Preliminary cost estimates for the intervention range between USD 20–30 million, which will cover:

- Excavation of 80–100 km of internal drainage canals (khals)
- Repair or replacement of 25–30 sluice gates with modern mechanisms
- Capacity building and training of local maintenance teams (targeting at least 300 community members)
- Establishment of digital monitoring tools and performance reporting
- Community workshops and gender-sensitive design upgrades

11. Economic and Financial Benefits

- Restoration of arable land and homesteads previously lost to prolonged flooding
- Increased yield and reduced crop damage due to timely water evacuation
- Improved household and public health through decreased exposure to stagnant water
- Protection of critical transport links during the rainy season
- Empowerment of local labor markets through engagement in excavation and gate repair

12. Stakeholder Consultations

Comprehensive consultations were carried out in **Hatiya Upazila, Noakhali District**, a climate-vulnerable coastal region of Bangladesh. These consultations aimed to assess local drainage conditions, community vulnerabilities, and resilience preferences, involving both institutional and community stakeholders.

Stakeholder Group	Role in the Project	Consultation Approach
Local Government Engineering Department (LGED)	Responsible for design, construction, and maintenance of embankments and drainage systems	Key Informant Interview (KII) with Upazila Engineer
Male and Female Community Members	End users of drainage and embankment infrastructure	Separate Focus Group Discussions (FGDs)
Affected Households in Hatiya	Residents affected by flooding, drainage blockages, and erosion	Household surveys covering diverse groups

13. Field Data and Observations

Field assessments revealed critical insights into the physical conditions of drainage systems, community coping strategies, and recommendations for improved climate resilience. These findings are categorized below:

13.1 Focus Group Discussions (FGDs)

Participants: Adult women and men from flood-affected unions in Hatiya.
Key Observations:

- **Drainage System Dysfunction**: Both male and female groups reported that drainage canals (khals) remain blocked most of the year, leading to prolonged waterlogging.
- **Informal Adaptation**: Local residents used bamboo, sandbags, or temporary cuts to restore water flow, but these were short-lived.
- **Mobility Constraints**: Women described difficulties accessing healthcare and markets during waterlogging. Students missed school, and pregnant women faced major risks.
- **Gender-Specific Needs**: Female participants highlighted the lack of raised walkways, poor lighting near embankments, and safety concerns at night.
- **Community-led Solutions**: Men proposed setting up "local maintenance groups" and requested tools and training to undertake khal cleaning before monsoon season.

Figure 87: FGD of Male Participants in Hatiya

13.2 Household Survey Outcomes

Profile: 100 households including farmers, fisherfolk, daily wage earners, and women-led families.
Key Findings:

- Economic Disruption:
  - 72% reported reduced agricultural yields due to water stagnation on croplands.
  - 58% said fish farms overflowed and stock escaped during tidal surges.
  - 65% mentioned persistent waterlogging after even moderate rainfall.
- Drainage Preferences:
  - 85% supported concrete-covered drains over open channels.
  - 70% demanded a seasonal maintenance plan with local labor involvement.
  - 53% highlighted the need for embankment repair at canal outfall points.
- Emergency Response Gaps:
  - 33% of households were unable to access cyclone shelters during emergencies due to blocked or submerged routes.
  - Informal wooden walkways were widely used during floods, despite safety risks.

13.3 Key Informant Interview (KII)

Interviewee: LGED Upazila Engineer in Hatiya

Key Insights:

- Technical Condition: Most khals lack proper maintenance; vegetation and sedimentation are blocking water flow.
- Manpower Deficiency: LGED lacks dedicated staff or resources for routine cleaning of rural drainage systems.
- Suggested Solutions:
  - Use of manual desilting before monsoon.
  - Deploying local labor groups under LGED supervision.
  - Urged community-based maintenance schemes, with basic training and monitoring tools.

Figure 88: KII of LGED Upazila Engineer

13.4 Integration of Findings and Alignment with Project Objectives

The following table consolidates qualitative insights from FGDs and KIIs with quantitative results from household surveys. This integration highlights the alignment between field realities and the proposed project objectives:

Key Findings	Linked Project Objectives	Evidence Source
Blocked drainage canals causing prolonged waterlogging and crop/fishery losses	Objective 1: Rehabilitate internal drainage channels and restore flow	FGDs, Household Survey
Informal adaptation practices indicate urgent need for formalized maintenance	Objective 3: Establish local maintenance programs and build community capacity	FGDs, KIIs
Economic disruptions from stagnant water affecting agriculture and aquaculture	Objective 2: Minimize income loss through timely water evacuation	Household Survey
Women face restricted mobility and safety risks due to waterlogged walkways	Objective 4: Integrate gender-sensitive design and improve household resilience	FGDs (Women)
Inadequate institutional capacity for drainage upkeep at the local level	Objective 5: Improve inter-agency coordination and embed community-based systems	KII – LGED Engineer
Demand for seasonal desilting using local labor to improve cost-effectiveness	Objective 3 & 5: Local employment and decentralized O&M frameworks	FGDs, Household Survey, KII

14. Conclusion

Drainage system failures within the polders of southwestern Bangladesh are a critical but under-addressed barrier to climate resilience, agriculture, and public health. This project proposes a well-structured intervention to modernize drainage infrastructure, improve sluice performance, and engage communities in sustaining long-term outcomes.

The design is grounded in local observations, inclusive planning, and alignment with national adaptation priorities. As such, it offers a scalable, adaptive model for restoring Bangladesh's climate-vulnerable lowlands.

5.4: DREDGING MAJOR AND MEDIUM RIVERS IN SOUTHERN BANGLADESH

1. Introduction

Southern Bangladesh, especially its southwest and south-central polders, faces a growing crisis from river sedimentation, reduced navigability, and increasing flood risk. Over time, major and medium rivers in this region have become heavily silted due to upstream erosion, tidal interactions, and inadequate sediment management. This has led to chronic waterlogging, embankment breaches, disruptions in transport, and declining agricultural productivity.

Dredging has become a vital climate adaptation and infrastructure recovery strategy in these areas. However, past dredging efforts have been limited in scope, lacked scientific prioritization, and were often implemented without community engagement or environmental safeguards. This project proposes a strategic, inclusive, and environmentally informed dredging program targeting key river segments to improve flood resilience, restore navigation, and protect critical polder infrastructure.

2. Objectives

- Conduct scientific assessments to guide strategic river dredging in southwest and south-central polders.
- Reduce flood-induced waterlogging in polder systems by restoring river flow and discharge capacity.
- Enhance river navigation and connect economic zones, facilitating transport and market access.
- Build institutional capacity for sustainable dredging operations with community participation.
- Align the initiative with Bangladesh's National Adaptation Plan (NAP) and SDGs 5, 9, 11, and 13.

3. Justification for Selected Locations

Region	Key Risk Factors	Strategic Importance
Southwest Polders	Silted rivers, tidal surges, floodwater retention	Dense with agriculture and fisheries, connected to major economic corridors
South-Central Polders	Poor river-drainage linkage, seasonal floods, sedimentation	Critical to food systems, cyclone evacuation, and regional transport flow

These regions represent both physical vulnerability and high economic value. Dredging key river routes will safeguard livelihoods, infrastructure, and ecological stability.

4. Key Climate Resilience Measures

- Hydrological and Sediment Flow Assessments: Mapping river sections with critical silt buildup, backwater effects, and embankment vulnerability.
- Targeted Dredging Plans: Prioritize river stretches near polder outfalls, urban zones, and flood-prone agricultural belts.
- Monitoring and Evaluation (M&E) Framework: Establish real-time systems for water level, sedimentation, river depth, and ecological impact monitoring.
- Riverbank Stabilization: Use eco-engineering techniques to prevent post-dredging erosion and ensure long-term structural stability.
- Community and Stakeholder Engagement: Develop local advisory groups to ensure transparency, address grievances, and monitor dredging impacts.

5. Expected Outputs and Impacts

Output	Impact
Dredging of priority river segments	Improved river discharge, reduced waterlogging and inland flood damage
Revived navigation channels	Increased movement of goods and people, reducing transport burden on roads

Reduced water retention near polder systems	Enhanced productivity and minimized crop loss
Improved cross-agency coordination	Integrated and timely infrastructure response to climate-induced disasters

6. Gender and Social Considerations

- Include women, fishers, and river-dependent communities in planning, identifying impact zones, and deciding dredging schedules.
- Conduct FGDs to understand gender-specific risks, especially for women living along unstable or flood-prone riverbanks.
- Prioritize gender-responsive relocation support where dredging might disrupt riverbank households.
- Promote women's involvement in river monitoring committees and sediment reuse planning.

7. Linkage to National Adaptation Plan (NAP) Projects

This project supports the following thematic areas:

- WRM6: Dredging of major and medium rivers to enable flood discharge under extreme climate conditions.
- WRM8: Drainage and water management for economic zones, cities, and critical infrastructure.

It provides critical infrastructure adaptation in line with Bangladesh's long-term climate resilience strategy.

8. Potential Financing Options

Financing Source	Key Contributors	Advantages	Limitations
Public Infrastructure Budget	BWDB, LGED, MoWR	Strong institutional base and ownership	Competing priorities in ADP allocations
Multilateral Development Banks	ADB, World Bank, JICA	Technical support and concessional finance	Long approval and procurement cycles
International Climate Funds	Green Climate Fund, Adaptation Fund	Emphasis on resilience and nature-based integration	Application complexity and extensive M&E requirements
PPPs with Dredging Firms	Port operators, logistics companies	Cost-sharing, innovation, rapid mobilization	Need for clear contract frameworks and risk management
Local Stakeholder Contributions	Boat unions, riverbank communities	Increases accountability and project ownership	Small-scale, requires strong facilitation and trust

9. Critical Considerations and Future Outlook

- Seasonal Timing: Avoid peak monsoon and fish-breeding seasons to minimize ecological disruption.
- Sediment Disposal: Develop a sediment management plan for reuse in embankment strengthening or land restoration.
- Ecosystem Sensitivity: Use dredging techniques that preserve aquatic biodiversity and limit turbidity.
- Institutional Reform: Strengthen BWDB's capacity for multi-year dredging strategies with geospatial tools and community partnerships.

- **Replication**: Apply this model to other critical rivers such as the Bishkhali, Kacha, and Tentulia in future phases.

10. Estimated Investment Cost

Covering:

- River mapping, hydrological modeling, and EIAs
- Deployment of dredgers and support vessels in identified zones
- Riverbank erosion control and sediment trap infrastructure
- Community liaison teams and grievance redress systems
- Monitoring devices and digital dashboards for water and sediment tracking
- Training programs for BWDB and local authorities on sustainable dredging management

11. Economic and Financial Benefits

- **Flood Risk Reduction**: Lower damage to crops, roads, embankments, and homes during heavy rainfall events
- **Restored Navigation**: Enables cost-efficient waterborne transport for goods, boosting trade and commerce
- **Employment Creation**: Direct jobs in dredging, monitoring, riverbank protection, and logistics
- **Agricultural Recovery**: Increased yield and cropping intensity through reduced water stagnation
- **Public-Private Synergy**: Opportunities for port operators and local enterprises to invest in climate-proof infrastructure

12. Stakeholder Consultations

Stakeholder consultations were held in **Jashore District** with separate male and female community groups directly impacted by river siltation, waterlogging, and recurring floods. These discussions captured lived experiences, infrastructure needs, and community-driven solutions.

Stakeholder Group	Role in the Project	Consultation Approach
Male Community Members	End users of rivers for fishing, agriculture, and transport	Focus Group Discussion (FGD) – Male
Female Community Members	Households affected by flooding, waterlogging, and mobility loss	Focus Group Discussion (FGD) – Female

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Participants: Adult men and women from flood-affected riverbank communities in Jashore
Key Observations:

- **River Dependency and Siltation Effects**:
  - The community historically depended on the river for irrigation, fishing, and bathing.
  - Due to siltation and reduced river depth, benefits have declined significantly.
  - Shrimp farming and river ghats (like Hajir Ghat) have become defunct.
- **Climate Hazards and Infrastructure Gaps**:
  - Both groups cited frequent flooding, waterlogging, and cyclone impacts (e.g., Amphan).
  - Heavy rains have led to crop damage, pond fish loss, and flooded homes.

- Gender-Specific Issues:
    - Women highlighted restricted access to clean water, latrines, and safe mobility.
    - Men emphasized irrigation and loss of fishery-based income.
- Community Recommendations:
    - Dredging must be paired with embankment construction and culvert placement.
    - Suggest use of “roads on embankments” for multipurpose use.
    - Demand for regular maintenance, tree plantation, and community engagement in planning.

Figure 90: FGD of Male Participants in Jashore

Figure 89: FGD Female Participants in Jashore

14. Conclusion

Dredging major and medium rivers in Bangladesh's southern region is not just a hydraulic intervention—it's a climate resilience imperative. With sedimentation choking critical river systems and increasing inland flood risks, this project takes a holistic approach to restore river functionality, protect infrastructure, and strengthen adaptive capacities.

By combining scientific assessment, targeted engineering, stakeholder participation, and environmental stewardship, the proposed dredging initiative ensures long-term benefits for riverine communities and national resilience goals. Its alignment with SDGs and the National Adaptation Plan makes it a strategic and scalable model for safeguarding deltaic Bangladesh in the era of climate change.

5.5: IMPLEMENTING TIDAL RIVER MANAGEMENT IN LOW-LYING EMBANKED AREAS

1. Introduction

Low-lying polders in Bangladesh's southwest and south-central regions, especially in Satkhira and Khulna, are increasingly vulnerable to tidal flooding, waterlogging, and sedimentation due to climate change and anthropogenic interventions. Traditional embankments have often disrupted natural siltation and water flow, leading to long-term drainage congestion and land subsidence.

Tidal River Management (TRM) offers a nature-based, community-driven solution that restores tidal connectivity between rivers and beels (natural lowlands), allowing sediment deposition, improved drainage, and long-term land elevation. This concept paper outlines a comprehensive plan to implement TRM in priority areas by integrating local knowledge, technical planning, and climate-resilient infrastructure measures.

2. Objectives

- Enhance flood resilience and reduce prolonged waterlogging in polders.
- Improve water quality, siltation management, and agricultural productivity.
- Support economic growth through restored livelihoods and transport infrastructure.
- Foster inclusive and gender-sensitive planning and implementation of TRM.
- Align with SDG targets and Bangladesh's National Adaptation Plan (NAP).

3. Justification for Selected Locations

Location	Key Risk Factors	Strategic Importance
Satkhira District	Severe waterlogging due to silted riverbeds and obstructed drainage flow	Longstanding TRM pilot sites; large low-lying beels suitable for natural sediment capture
Khulna District	Land subsidence, embankment breaches, saline water intrusion	Rich in agriculture and aquaculture; potential to restore land elevation through TRM
South-Central Polders	Frequent tidal flooding and declining river-beel connectivity	Hosts dense population centers and vital roads affected by drainage congestion

These areas are physically vulnerable, ecologically significant, and socio-economically dependent on water-based infrastructure. Reintroducing tidal dynamics through TRM will help mitigate flooding, restore land productivity, and reduce long-term adaptation costs.

4. Key Climate Resilience Measures

- TRM Site Identification: Select beels with high waterlogging and low elevation.
- Design and Engineering: Construct inlets/outlets, embankment breaches, and compartments for controlled siltation.
- Community Co-Management: Establish local water committees to manage operation, maintenance, and conflict resolution.
- Water Quality Monitoring: Introduce low-cost systems for tracking turbidity, salinity, and flow velocity.
- Gender Integration: Design access paths, toilets, and safe community areas around TRM sites with women's participation.

5. Expected Outputs and Impacts

Impact Area	Key Outcomes
Flood and Water Management	Reduced tidal flooding and waterlogging inside polders
Water Quality and Agriculture	Improved water availability and reduced salinity for farming

Transport and Infrastructure Resilience	Enhanced road stability and connectivity due to better drainage
Economic Growth	Boosted productivity in farming and aquaculture; new employment opportunities
Social and Environmental Benefits	Strengthened community cohesion and ecosystem restoration

6. Gender and Social Considerations

- Organize dedicated FGDs for women and marginalized communities.
- Develop gender-sensitive indicators for TRM outcomes (mobility, health, income).
- Ensure women's roles in beel monitoring, committee leadership, and benefit-sharing.
- Regularly assess impacts of TRM on access to water, sanitation, and livelihoods for vulnerable groups.

7. Linkage to National Adaptation Plan (NAP) Projects

This TRM initiative contributes directly to:

- Accommodating excess floods through improved drainage of major and medium rivers.
- Managing industrial and critical infrastructure zones with risk-informed resilience.

8. Potential Financing Options

Financing Source	Contributors	Benefits	Challenges
Government Funding	BWDB, LGED, Ministry of Water Resources	Ownership, alignment with national priorities	Limited budget, competing allocations
Multilateral Funds	GCF, ADB, World Bank	Climate adaptation relevance, concessional loans	Technical documentation and delays
Community-Based Cost Sharing	Local TRM Committees	Local accountability, sustainable O&M	May be limited in poorer polders
PPP and Blended Finance	NGOs, private dredging firms, donors	Innovation, financial leverage	Complex negotiation and legal clarity needed

9. Critical Considerations and Future Outlook

- Sustainability: Long-term TRM success depends on continued community management and sediment flow monitoring.
- Legal and Land Issues: TRM implementation must resolve disputes related to land ownership post-siltation.
- Ecological Monitoring: A biodiversity assessment should accompany TRM to avoid harm to fisheries and vegetation.
- Scalability: This pilot model can be expanded across the coastal delta with improved guidelines and state support.

10. Estimated Investment Cost

The estimated investment includes:

- Canal excavation and dredging:
- Construction of sluice gates, inlets/outlets
- Beel compartmentalization and embankment breach/reinforcement
- Community training and equipment for monitoring
- Administrative, land compensation, and technical oversight

11. Economic and Financial Benefits

- Enhanced agricultural productivity in reclaimed lands post-siltation.
- Lower expenditure on embankment repairs due to natural sediment reinforcement.
- Job creation in dredging, embankment works, and TRM management.
- Boost to fishery and transportation sectors due to improved drainage.

12. Stakeholder Consultations

Stakeholder consultations were conducted in **Jashore**, a critical site for tidal river management (TRM) interventions. Communities in embanked, low-lying areas contributed through gender-segregated FGDs and a household survey. These interactions focused on sedimentation, waterlogging, TRM perceptions, and local roles in governance.

Stakeholder Group	Role in the Project	Consultation Approach
Male Community Members	Farmers, landowners, and fishermen impacted by tidal inflows and sedimentation	Focus Group Discussion (FGD) – Male
Female Community Members	Caregivers and agricultural workers dependent on drainage and safety of embankments	Focus Group Discussion (FGD) – Female
Affected Households (n = 100)	Residents living within polder zones facing chronic waterlogging and flood damage	Household Survey

13. Field Data and Observations

13.1 Focus Group Discussions (FGDs)

Location: Waterlogged unions near beel areas in Jashore

Key Observations:

- Participants explained that **inadequate silt removal** and blocked tidal flow have caused long-term water stagnation in polders.
- Male participants reported that farmland is frequently unusable due to standing water, impacting **crop yield, labor demand**, and local food prices.
- Women emphasized that **waterlogging prevents school attendance**, worsens sanitation, and increases their **time burden** for caregiving and food preparation.
- **Community Recommendations**:
    - Regularly open selected sluice gates to restore tidal flushing.
    - **Involve local farmers in TRM operation and monitoring**.
    - Integrate **vegetation-based embankment protection** to stabilize banks.

Figure 92: FGD of Male Participants in Jashore

Figure 91: FGD of Female Participants in Jashore

13.2 Household Survey Outcomes

Profile: 100 households in embanked lowland areas of Jashore

Key Findings:

- Flooding and Inundation:
  - 88% of respondents experienced severe waterlogging lasting more than two weeks annually.
  - 65% reported repeated damage to homes, crops, or roads during tidal surges.
- TRM Awareness and Support:
  - 81% were familiar with the concept of TRM.
  - 74% believed TRM could restore local drainage and agriculture if properly managed.
  - Major concerns included lack of transparency, inequitable sediment benefits, and political interference.
- Adaptive Preferences:
  - 76% preferred rotational TRM systems to avoid prolonged beel occupation.
  - 69% supported embankment strengthening with vegetated slope protection.
  - 83% demanded inclusion in decision-making through community TRM councils.

13.3 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Prolonged waterlogging and sedimentation disrupts agriculture and mobility	Objective 1: Improve drainage and flood resilience in low-lying embanked areas	FGDs, Household Survey
Households report frequent losses of crops, food insecurity, and reduced income	Objective 2: Reduce flood-related economic and livelihood disruptions	FGDs, Household Survey
TRM is known but suffers from weak transparency, equity, and inclusion	Objective 3: Promote participatory, inclusive, and equitable TRM governance	Household Survey, FGDs
Broad support for nature-based flood control, bank stabilization, and rotational beel management	Objective 4: Integrate ecosystem-based adaptation into TRM planning	FGDs, Household Survey
Project contributes to SDG 6 (Water), SDG 11 (Resilience), and SDG 13 (Climate Action)	Objective 5: Align with national adaptation goals and sustainable development targets	All Data Sources

14. Conclusion

Implementing Tidal River Management (TRM) in Bangladesh's low-lying embanked areas offers a sustainable and transformative solution to the entrenched problems of waterlogging, sedimentation, and declining agricultural productivity. Through the strategic reconnection of rivers and beels, TRM can restore natural siltation cycles, elevate land levels, and improve water flow in polders that are otherwise trapped in recurring flood vulnerability.

This concept builds on decades of community experience, ecological science, and policy dialogue. With integrated planning, strong stakeholder engagement, gender-sensitive programming, and robust financing strategies, this TRM initiative has the potential to become a model for nature-based climate adaptation in deltaic regions.

Aligned with key SDGs and Bangladesh's NAP priorities, the project will not only enhance climate resilience but also stimulate local economies, reduce poverty, and safeguard vital infrastructure for future generations.

5.6: UTILIZING ECO-ENGINEERING SOLUTIONS FOR FLOOD AND DRAINAGE SYSTEM MANAGEMENT

1. Introduction

Major urban centers across Bangladesh, including Dhaka, Chattogram, Sylhet, and Rajshahi, are experiencing an increase in localized flooding and stormwater management challenges due to rapid urbanization, climate variability, and inadequate drainage infrastructure. These floods, often short-duration but intense (pluvial floods), disrupt mobility, damage infrastructure, pollute water bodies, and disproportionately affect marginalized communities.

Eco-engineering solutions offer an innovative, sustainable, and cost-effective approach to urban flood management. By integrating green roofs, permeable pavements, and urban wetlands into urban planning, these interventions help reduce runoff, enhance water storage, improve biodiversity, and build long-term climate resilience.

2. Objectives

- Mitigate urban pluvial flooding through green infrastructure and eco-engineering interventions.
- Improve water quality, stormwater retention, and urban biodiversity.
- Enhance urban liveability and climate resilience using nature-based solutions.
- Promote inclusive planning with gender and community-sensitive designs.
- Align the intervention with SDGs 6, 11, 13, and 15 and the National Adaptation Plan (NAP).

3. Justification for Selected Locations

Location	Key Risk Factors	Strategic Importance
Chattogram	Hilly runoff, tidal flooding, poor stormwater capacity	Largest port city with vulnerable informal settlements
Sylhet	Flash floods from upstream, blocked urban drainage	Prone to both pluvial and fluvial flooding, high-density residential zones
Rajshahi	Seasonal storms, low urban permeability, minimal green infrastructure	Secondary city with opportunity to pilot low-cost green solutions

These cities are urban economic engines with chronic waterlogging, aging infrastructure, and growing climate vulnerabilities—making them ideal candidates for eco-engineering-based flood management interventions.

4. Key Climate Resilience Measures

- Green Roofs: Vegetative roofing systems to capture and store rainwater, reduce runoff, and lower urban heat island effects.
- Permeable Pavements: Pavements that enable water infiltration to reduce surface runoff and recharge groundwater.
- Urban Wetlands: Restored or newly created wetlands to retain stormwater, treat runoff, and provide habitat.
- Rain Gardens and Bioswales: Vegetated, shallow depressions that slow and filter stormwater near roads or buildings.
- Riparian Buffers and Pocket Parks: Vegetated zones near canals or drains to prevent erosion and offer urban green spaces.
- Digital Monitoring Platforms: Deploy IoT-enabled rainfall and drainage sensors, integrated with GIS-based dashboards, to monitor flood levels, drainage flow, and eco-engineering system performance in real-time. Data will inform proactive maintenance and community alerts.

5. Expected Outputs and Impacts

Output	Impact
Reduced surface runoff	Decreased waterlogging and pluvial flooding
Improved stormwater management	Enhanced drainage performance and reduced peak discharge volumes
Enhanced water quality	Filtering of pollutants through wetlands and bioswales
Urban green space development	Increased recreational areas, improved mental health, and biodiversity
Infrastructure cost savings	Lower long-term repair and maintenance costs due to flood damage reduction
Real-time flood and drainage monitoring system established	Improved response time, reduced infrastructure downtime, and better data for future planning
Shifted project focus to high-vulnerability rural/riverine zones	Greater relevance, improved flood resilience in underserved and high-risk communities

6. Gender and Social Considerations

- Ensure women, youth, and marginalized groups participate in stakeholder consultations, design workshops, and benefit-sharing mechanisms.
- Conduct gender-sensitive assessments on access to flood-prone zones, sanitation facilities, and green spaces.
- Design safe, accessible green infrastructure (e.g., well-lit rain gardens or wetlands) with community feedback.
- Track gender-specific outcomes in the project's Monitoring and Evaluation (M&E) framework.

7. Linkage to National Adaptation Plan (NAP) Projects

NAP Reference	Project Linkage
WRM7	Construction and rehabilitation of flood and drainage management measures with eco-engineering solutions

8. Potential Financing Options

Source	Potential Contributors	Advantages	Challenges
Government Budget	City Corporations, LGED, MoLGRD	Institutional ownership and sustainability	Budget constraints; competing urban priorities
Green Climate Fund / GEF	GCF, GEF, LDCF	Climate adaptation relevance, low-cost finance	Competitive proposals; rigorous reporting
Development Banks	ADB, World Bank (PROVATi3/SMART)	Technical assistance and long-term concessional lending	Procurement timelines and fund release delays
Private Sector (CSR, PPPs)	Real estate, IT parks, banks	Green branding, innovation, tech partnerships	Requires incentives and regulatory alignment
Community Contributions	Resident associations, youth groups	Enhances local ownership, especially for rain gardens/roofs	Limited funding potential and organizational support

9. Critical Considerations and Future Outlook

- Maintenance Models: Establish community co-maintenance mechanisms for rain gardens and permeable pavements.
- Land Use Integration: Embed eco-engineering principles into DAP, municipal masterplans, and zoning regulations.

- **Data and Monitoring**: Develop digital dashboards for rainfall, runoff, and system performance tracking.
- **Awareness and Capacity Building**: Conduct city-wide campaigns on the benefits and use of green infrastructure.
- **Scalability**: Pilot eco-engineering in ward-level zones, with a roadmap for citywide rollout.
- **Location Refinement**: Project scope will prioritize flood-prone rural and peri-urban regions (e.g., river basins in Gaibandha, Kurigram) over cities with lower vulnerability like Rajshahi.

- **Digital Data Systems**: Implement performance tracking tools—such as mobile apps and sensor-linked dashboards—to measure effectiveness of green infrastructure in managing stormwater.
  Evidence-Based Selection: Future expansion will rely on flood vulnerability indexing and stakeholder-driven prioritization.

10. Estimated Investment Cost

Component
Green roof installation (pilot, 10 bldgs)
Permeable pavement (5 km sidewalks/alleys)
Urban wetland restoration (2 sites)
Rain gardens and bioswales (20 small units)
Awareness, M&E, community co-design

11. Economic and Financial Benefits

- **Property value increases** in well-drained, green neighborhoods.
- **Lower municipal maintenance costs** due to improved water infiltration and pollutant reduction.
- **Tourism and recreation** potential from wetland parks and green corridors.
- **Urban job creation** in green construction, maintenance, and landscaping sectors.
- **Reduced health costs** through improved water quality and reduced flood-related disease exposure.

12. Stakeholder Consultations

Stakeholder consultations were conducted in **Rajshahi City**, focusing on urban flood and drainage challenges linked to poor runoff management, encroachment of water bodies, and limited integration of nature-based solutions. Consultations included government agencies and households exposed to frequent urban flooding and drainage congestion.

Stakeholder Group	Role in the Project	Consultation Approach
Barind Multipurpose Development Authority (BMDA)	Key urban water resource and infrastructure management agency	Key Informant Interview (KII) – BMDA
Urban Households in Rajshahi	Residents affected by drainage overflow, pluvial flooding, and service disruption	Household Survey (100)

13. Field Data and Observation

13.1 Household Survey Outcomes

Profile: 100 urban households surveyed in Rajshahi neighborhoods vulnerable to intense rainfall and poor stormwater drainage, covering socio-economically diverse groups.

Key Findings:

- **Flooding Frequency and Severity**:

- 78% of households reported experiencing urban flooding at least once a year, even during moderate rainfall.
- 65% indicated that the flooding typically lasts 2–3 hours, while 18% reported standing water for over 12 hours.

- Infrastructure and Waterlogging Triggers:
  - 67% cited blocked or undersized drainage systems as the main reason for flooding.
  - 41% pointed to encroachment and landfilling of canals and ponds that previously absorbed rainwater.
- Health, Mobility, and Safety Impacts:
  - 49% of households experienced disease outbreaks (e.g., skin rashes, diarrhea) during flood seasons.
  - 36% reported that school children or elderly family members had trouble moving during flood hours.
  - Open drains and exposed electric wiring during storms were cited as safety hazards by 52%.
- Adaptation and Community Preferences:
  - 84% favored green solutions like rooftop gardens, tree planting, or wetland restoration in urban layouts.
  - 71% requested eco-drainage solutions, such as bio-swales and vegetated retention ponds.
  - 63% supported including women and marginalized groups in planning public green spaces or water projects.

Figure 94: FGD of Male Participants in Rajshahi

Figure 93: FGD Female Participants in Rajshahi

13.2 Key Informant Interview (KII) – BMDA

Interviewee: Senior Engineer, Barind Multipurpose Development Authority (BMDA), Rajshahi

Key Insights:

- Institutional Gaps:

- Urban expansion has outpaced planning controls, with drainage lines laid decades ago still in use today.
- Municipal and water authorities operate in silos, with little integration of nature-based engineering into formal projects.

- Flood Drivers:
  - Urban compaction and sealed surfaces (e.g., concrete yards, roads) prevent infiltration and escalate surface runoff.
  - Natural retention areas (e.g., ponds, fields) have been degraded or filled in.
- Strategic Recommendations:
  - Develop a citywide **green infrastructure strategy** with designated retention corridors and biofiltration zones.
  - Include **women and local committees** in maintenance of community drainage and plantation efforts.
  - Introduce performance standards for eco-engineered drainage channels as part of Rajshahi's master plan.

Figure 95: KII of BMDA Representative

13.3 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Frequent urban flooding due to undersized and blocked drainage	Objective 1: Mitigate urban pluvial flooding through green and eco-engineered solutions	Household Survey, KII – BMDA
Water bodies degraded and runoff unmanaged, contributing to waterlogging and pollution	Objective 2: Improve water quality, stormwater retention, and urban biodiversity	Household Survey, KII – BMDA
Public support for urban greening, retention areas, and bioswale integration	Objective 3: Enhance urban liveability and resilience using nature-based solutions	Household Survey
Women and vulnerable groups lack voice in drainage or infrastructure planning	Objective 4: Promote inclusive planning with gender and community-sensitive designs	Household Survey
Institutional endorsement for eco-engineering standards and alignment with NAP and SDGs 6, 11, 13, 15	Objective 5: Align with national and global climate and biodiversity frameworks	KII – BMDA

14. Conclusion

Eco-engineering approaches represent a vital shift in how Bangladesh's urban centers manage flooding, climate change, and sustainability. By combining technical innovation with nature-based solutions, cities like Dhaka, Chattogram, Sylhet, and Rajshahi can mitigate waterlogging, enhance liveability, and reduce future disaster risk. This concept prioritizes community ownership, gender inclusion, and environmental co-benefits—making it a replicable model for climate-resilient urban growth. With the right support, this initiative can redefine Bangladesh's urban landscape for a greener, safer, and more adaptive future.

5.7 WATER MANAGEMENT IN POLDERS

1. Introduction

Southwest and south-central Bangladesh are home to complex polder systems that play a critical role in agriculture, aquaculture, and rural livelihoods. However, climate-induced stress, inadequate drainage management, and weakened institutional coordination have led to frequent waterlogging, poor crop productivity, and infrastructure deterioration.

Effective water management in polders requires locally led and community-driven governance. Strengthening Water Management Committees (WMCs), composed of farmers, women, and local leaders, is key to operating and maintaining infrastructure like drainage sluices, flushing inlets, and regulators. This concept aims to build an enabling environment where empowered WMCs facilitate inclusive, resilient, and technically sound water management.

Figure 97: Water Infrastructure in Satkhira

Figure 96: Water Infrastructure in Satkhira

2. Objectives

- Strengthen and institutionalize WMCs for sustainable operation and maintenance (O&M) of water control structures.
- Foster inclusive decision-making by ensuring gender-balanced representation in WMCs.
- Improve water resource use efficiency to support agriculture, aquaculture, and transport infrastructure.
- Reduce flood risk and waterlogging through improved drainage planning and community monitoring.
- Align with SDG targets (5, 6, 11, 13) and Bangladesh's National Adaptation Plan (NAP).

3. Justification for Selected Locations

Location	Key Risk Factors	Strategic Importance
Southwest Polders (e.g., Satkhira, Khulna)	Poor maintenance of sluice gates, unmanaged drainage congestion	High agricultural output zones and flood-vulnerable regions
South-Central Polders (e.g., Barisal, Patuakhali)	Weak WMCs and institutional gaps in drainage operation	Potential for high-impact agricultural intensification with better water control

These locations represent vulnerable regions where WMCs can play a transformative role in managing water, reducing disaster risk, and improving rural productivity.

4. Key Climate Resilience Measures

- **Capacity Building of WMCs**: Provide technical, financial, and organizational training for efficient O&M.
- **Community-Based O&M Protocols**: Develop standardized procedures and tools for flushing gates, canal cleaning, and inlet/outlet monitoring.
- **Digital Mapping and Monitoring**: Introduce mobile-based apps or dashboard systems to track water levels and infrastructure conditions.
- **Farmer-WMC Collaboration**: Strengthen seasonal planning between farmers and WMCs to align irrigation and drainage cycles.
- **Gender Equity in WMCs**: Ensure at least 40% representation of women, with dedicated leadership and training roles.
- Ensure that **flood risk is systematically assessed and integrated** across all polder rehabilitation, drainage, and governance activities, recognizing that flood exposure is a shared threat across sectors and must be addressed through multi-infrastructure coordination.

5. Expected Outputs and Impacts

Output	Impact
Functional and gender-balanced WMCs	Improved decision-making and equitable management of water resources
Reduced waterlogging and drainage delays	Increased agricultural yield and minimized road infrastructure damage
Strengthened infrastructure operation	Lower maintenance backlog and improved flood resilience
Integrated community-farmer coordination	Synchronized water use for agriculture, aquaculture, and rural access

6. Gender and Social Considerations

- Mandate gender quotas for WMC formation to promote inclusive leadership and representation.
- Organize separate training and consultation sessions for women, especially in socially conservative areas.
- Integrate gender-sensitive indicators in M&E: e.g., women-led decision outcomes, satisfaction scores, accessibility feedback.
- Document and promote best practices of women-led WMCs to scale nationally.

7. Linkage to National Adaptation Plan (NAP) Projects

NAP Reference	Project Linkage
WRM5, WRM6	Integrated management of coastal polders, sea dikes, and cyclone shelters, including participatory O&M

8. Potential Financing Options

Financing Source	Potential Contributors	Strengths	Challenges
Government Budget (LGED, BWDB)	Ministry of Water Resources	Strong local presence and policy alignment	Resource constraints and fund continuity
Community Contributions	Farmer cooperatives, aquaculture groups	Local ownership and sustainability of O&M	Need facilitation, uneven contributions
Donor Grants	IFAD, GCF, World Bank (CRIMP, PROVATi3)	Alignment with resilience and community governance goals	Conditionality on structure, reporting requirements

Local NGO Partnerships	Uttaran, BRAC, WaterAid	Experience in training and community mobilization	Limited in scaling infrastructure investment

9. Critical Considerations and Future Outlook

- Institutional Reform: WMCs need legal recognition, SOPs, and regulatory frameworks.
- Data and Decision Support: Introduce GIS-based water maps for real-time planning and accountability.
- Climate Variability Readiness: Align water management planning with changing rainfall and tidal patterns.
- Scalability: Establish a pilot in 3–5 unions and gradually scale through policy incorporation in BWDB manuals.
- Cross-Sector Flood Risk Integration: This project will coordinate with other infrastructure sectors—such as transport, health, and energy—to ensure that flood risk considerations are embedded across all related investments in polder zone

10. Estimated Investment Cost

The estimated total cost of implementing this initiative is USD 1.8–2 million, which will include:

- Capacity building and training for Water Management Committees (WMCs), including technical and leadership development.
- Procurement of O&M equipment such as sluice gate tools, water level monitoring kits, and basic repair materials.
- Facilitation of participatory planning activities, including stakeholder workshops and seasonal water planning sessions.
- Monitoring and evaluation tools to track WMC performance, infrastructure condition, and community feedback.
- Gender mainstreaming interventions, including outreach campaigns, training for women leaders, and inclusive planning support.
- Community engagement and mobilization costs, covering field facilitation, logistics, and communication materials.

11. Economic and Financial Benefits

- Reduced public spending on frequent repairs due to proactive O&M by trained WMCs.
- Increased productivity from timely drainage in crop fields and aquaculture ponds.
- Enhanced road durability in polder zones due to controlled water levels.
- Employment opportunities for local youth in inspection, repair, and monitoring.

12. Stakeholder Consultations

Stakeholder consultations were carried out in **Shyamnagar Upazila, Satkhira District**, a highly vulnerable coastal polder region. These consultations included institutional interviews, community-level FGDs, and structured household surveys to understand drainage, embankment, and water governance challenges.

Stakeholder Group	Role in the Project	Consultation Approach
NGF (Local NGO Representative, Gabura)	Oversight and monitoring of embankment condition and disaster resilience coordination	Key Informant Interview (KII)
Male Community Members	Direct users of polder infrastructure for agriculture, mobility, and safety	Focus Group Discussion (FGD) – Male
Female Community Members	Households facing waterlogging, loss of access, and flood impacts	Focus Group Discussion (FGD) – Female
Rural Households in Satkhira	Residents exposed to tidal surge, saline intrusion, and drainage failure	Household Survey (n=100)

13. Field Data and Observations

Consultations revealed chronic drainage problems, community-driven coping strategies, and local support for embankment repair and sustainable water management.

13.1 Focus Group Discussions (FGDs)

Participants: Adult men and women from polder-dependent villages in Shyamnagar
Key Observations:

- **Polder Failure and Tidal Intrusion**:
  - Communities reported that breaches in embankments frequently allow saline water to enter cropland and homes.
  - Women highlighted increased waterborne diseases and poor sanitation due to stagnant water.
- **Local Resilience**:
  - Residents constructed temporary barriers using sandbags, bamboo, and earthen walls.
  - Women suggested the need for separate cyclone shelters and raised walkways to reach markets and schools.
- **Infrastructure Demands**:
  - Calls for embankment elevation, repair of broken sluice gates, and community-based water management committees.
  - Strong demand for installing culverts and regular de-silting of canals and khals.

Figure 98: FGD of Male Participants in Satkhira

Figure 99: FGD of Female Participants in Satkhira

13.2 Household Survey Outcomes

Profile: 100 households in Satkhira polder areas, with a mix of agricultural, wage-labor, and fisherfolk livelihoods

Key Findings:

- Infrastructure Impact:
    - 61% reported loss of agricultural productivity due to saline water intrusion.
    - 48% suffered long-term waterlogging after cyclone events.
    - 70% experienced structural damage to household or nearby embankments.
- Risk and Vulnerability:
    - Over 60% of respondents indicated they cannot access shelters due to impassable roads.
    - 26% of female-headed households reported reduced food security during floods.
- Community Preferences:
    - 77% support reinforced embankments with integrated culverts.
    - 64% endorse forming union-level water management groups.
    - 89% favored inclusion of local labor in embankment maintenance and khal re-excavation.

13.3 Key Informant Interviews (KIIs)

Stakeholder: Local Knowledgeable person (Ward Member)

Key Insights:

- Root Causes:
    - Breaches in polder embankments were due to poor maintenance, illegal encroachments, and inadequate drainage planning.
    - Lack of enforcement on sluice gate operations has caused salinity backflow.
- Recommended Measures:
    - Decentralized committees for sluice operation and embankment inspections.
    - Mobilizing local volunteers for early warning dissemination and barrier reinforcement during storms.
    - Joint planning between Union Parishads and LGED to align embankment work with community needs.

Figure 100: KII of Ward Member in Satkhira

14. Conclusion

Strengthening Water Management Committees (WMCs) in Bangladesh's polders offers a low-cost, high-impact solution for improving rural resilience against flooding, salinity intrusion, and infrastructure decay. This initiative promotes a bottom-up, gender-balanced approach to climate adaptation that puts water users at the center of decision-making. By aligning technical interventions with local governance, the proposed concept ensures both efficiency and equity in polder water management. With policy, institutional, and financial support, this can evolve into a scalable national model under Bangladesh's broader climate resilience and adaptation framework.

5.8: STRATEGIC ASSESSMENT OF CLIMATE RISKS AND DEVELOPMENT PLANNING INFORMED BY CLIMATE RISKS

1. Introduction

Bangladesh's coastal districts face growing threats from sea-level rise, storm surges, flooding, and extreme weather events caused by climate change. These hazards endanger lives, infrastructure, and the long-term sustainability of socio-economic development. Yet, planning and development processes often proceed without fully considering climate risk assessments or projected climate trends.

Integrating strategic climate risk assessments into development planning is essential for reducing vulnerability and enhancing adaptive capacity. This approach enables planners and policymakers to identify exposure hotspots, understand potential sectoral impacts, and formulate proactive, risk-informed interventions. Climate-informed development frameworks are critical for achieving resilience, safeguarding investments, and ensuring sustainable growth in Bangladesh's high-risk zones.

2. Objectives

- Conduct comprehensive climate risk assessments to identify vulnerabilities across sectors, geographies, and populations.
- Develop and mainstream climate risk-informed planning frameworks at national and subnational levels.
- Improve adaptive capacity of infrastructure, services, and local economies through risk-responsive policies.
- Strengthen institutional mechanisms to integrate climate data into planning, monitoring, and evaluation systems.
- Contribute to achieving SDG 5 (Gender Equality), SDG 6 (Water), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action).

3. Justification for Selected Locations

Districts	Key Risk Factors	Strategic Importance
Coastal Districts (e.g., Satkhira, Khulna, Patuakhali, Barguna)	High exposure to sea-level rise, tidal surges, and salinity intrusion	Vulnerable regions critical for agriculture, fisheries, and disaster preparedness
Urbanizing Coastal Centers	Unplanned expansion into risk-prone areas	High population density, essential urban services, and future growth centers

These locations are characterized by both climate vulnerability and rapid development. Without integrating risk assessments, new investments in these zones may face recurring losses, inefficiencies, and adverse social impacts.

4. Key Climate Resilience Measures

- Strategic Risk Assessments: Conduct detailed analyses of climate exposure, sensitivity, and adaptive capacity across sectors.
- Risk-Informed Development Planning: Integrate climate data and modeling into land use plans, investment decisions, and zoning regulations.
- Sectoral Impact Studies: Assess climate risks to infrastructure, agriculture, housing, health, and water systems.
- Digital Risk Mapping: Develop GIS-based tools and climate vulnerability atlases to inform real-time planning.
- Policy and Regulatory Reforms: Update planning codes, construction standards, and sectoral guidelines to incorporate climate risk management.

- **Institutional Capacity Building:** Launch structured training programs for national and subnational agencies (e.g., planning commissions, LGED, DoE) to systematically incorporate climate risk in development planning processes.
- **Real-Time Climate Risk Tools:** Integrate live data systems and regional climate monitoring platforms that reflect dynamic and location-specific risks, enabling planners to respond to emerging threats more accurately.

5. Expected Outputs and Impacts

Expected Outputs	Expected Impacts
Improved resilience of communities, infrastructure, and economies	Reduced vulnerability to climate-related risks (e.g., sea-level rise, flooding, storm surges)
Development planning processes informed by climate risk assessments	Infrastructure and public investments are better adapted to climate change impacts
Strengthened institutional capacity for climate risk integration	Government agencies, planners, and local authorities equipped to implement risk-informed development
Availability of climate risk data and decision-support tools (e.g., maps, models)	Enhanced ability of stakeholders to make informed, evidence-based decisions
Inclusion of marginalized groups in risk-informed planning	Equitable adaptation outcomes that prioritize the most vulnerable

6. Gender and Social Considerations

- Ensure inclusive participation of women, youth, persons with disabilities, and marginalized groups in climate risk consultations and scenario planning.
- Conduct gender-sensitive vulnerability assessments to identify differentiated impacts.
- Incorporate social protection and gender equity indicators into risk frameworks.
- Facilitate women's leadership roles in planning, monitoring, and implementation of resilience strategies.

7. Linkage to National Adaptation Plan (NAP) Projects

This project is directly linked to NAP priority themes focused on integrated coastal resilience and climate-informed decision-making:

- Strengthening national and local planning institutions to adopt climate risk data.
- Integrating climate risk into land use and zoning frameworks.
- Enhancing cross-sectoral coordination in climate-resilient development.

8. Potential Financing Options

Source	Potential Contributors	Advantages	Challenges
Government Budget	Ministry of Planning, MoEFCC	Policy alignment, ease of integration with planning systems	Competing priorities and limited climate allocations
Development Partners	GIZ, World Bank, UNDP, ADB	Technical expertise, experience with mainstreaming approaches	Project timelines and fiduciary conditions
Climate Finance	Green Climate Fund, Adaptation Fund	Climate relevance, co-benefits for adaptation and mitigation	Requires strong M&E and proposal quality

9. Critical Considerations and Future Outlook

- **Data Standardization**: National guidelines must be developed for uniform risk assessment methods.

- Capacity Development: Targeted training is essential for government planners, data analysts, and local governments.
- Policy Coherence: Align with Five Year Plans, Delta Plan 2100, and National Resilience Programs.
- Sustainability: Institutionalize processes within BBS, DoE, and LGED to ensure continuity.
- Technology Integration: Invest in remote sensing, cloud-based mapping, and AI tools for predictive risk analytics.
- Mainstreaming Climate Risk in Project Approval: Establish mandatory climate risk screening criteria for all development projects at national and local levels, ensuring that investment decisions reflect exposure and resilience needs.
- Regionalized Risk Assessment: Develop and apply real-time, geospatially disaggregated climate risk models to capture regional variation and improve precision in planning and zoning decisions.

10. Estimated Investment Cost

The estimated cost will depend on geographic scope and technical depth. The budget will cover:

- Climate modeling and hazard risk studies
- Stakeholder consultation and policy development
- Digital platform development and data infrastructure
- Capacity-building programs
- Community outreach and gender integration

11. Economic and Financial Benefits

- Reduced future loss and damage to public infrastructure, agriculture, and housing.
- Improved efficiency of infrastructure investment and service delivery.
- Increased investor confidence in climate-informed development.
- Strengthened disaster preparedness and reduced emergency response costs.
- Enhanced community resilience, enabling long-term savings and socio-economic stability.

12. Stakeholder Consultations:

Stakeholder insights were derived from an extensive household survey conducted in Chittagong, Cox's Bazar, Noakhali, Patuakhali, Pirojpur, Jessore, and Satkhira. While no KIIs or FGDs were conducted, the household data offers robust evidence on public exposure to climate hazards, perceptions of infrastructure risk, and planning-related challenges at the community level. The survey captured voices across socioeconomic, gender, and geographic lines, forming a credible base for strategic, risk-informed development planning.

Stakeholder Group	Role in the Project	Consultation Approach
Coastal Households	Directly affected by climate-related hazards and infrastructure planning decisions	Household Survey
Development and planning institutions	Indirectly represented via gaps in service access, spatial equity, and policy effectiveness	Inferred from household responses

13. Field Data and Observations

13.1 Household Survey Outcomes

Profile: 2,200 households across seven high-risk coastal districts.

Key Findings:

- Exposure to Hazards:
    - Major hazards include storm surges, tidal flooding, waterlogging, and saline intrusion.
    - Many households face multiple hazards annually, which are increasing in frequency and intensity.
- Planning Gaps:
    - 71% of respondents reported that local development projects (e.g., roads, health centers) are not climate-resilient.
    - Infrastructure often deteriorates after a single season, suggesting a lack of risk-informed design.

- Impact on Services and Livelihoods:
    - Disruptions to education, markets, and WASH systems are common during floods and surges.
    - Agricultural livelihoods suffer significantly from waterlogging and salinity, with no coordinated planning relief.
- Perceptions on Governance and Inclusion:
    - Households see limited transparency or public participation in infrastructure or adaptation decision-making.
    - Women-headed households reported higher vulnerability and less access to disaster-prepared services.
- Community Priorities:
    - Strong support for risk screening of public investments, spatial hazard mapping, and nature-based infrastructure.
    - High demand for resilience planning training at the union and upazila levels.

14. Conclusion

As climate threats accelerate, Bangladesh must shift from reactive to proactive development planning. Integrating strategic climate risk assessments into mainstream planning will help mitigate exposure, protect infrastructure, and ensure equitable growth. This approach supports the national vision for climate-resilient development under the Delta Plan 2100, Perspective Plan, and SDG commitments.

This concept emphasizes institutional strengthening, cross-sector alignment, digital innovation, and inclusive governance. By equipping planners, policymakers, and communities with the tools to understand and act on climate risks, the project will lay the foundation for a more secure, sustainable, and climate-informed future for Bangladesh's most vulnerable districts.

5.9: MAINSTREAMING SPATIAL HAZARD ANALYSIS INTO POLICY

1. Introduction

Bangladesh's coastal districts are among the most vulnerable regions globally to climate-induced hazards such as storm surges, sea-level rise, and flooding. Despite this, development planning and adaptation investments often rely on generalized data and outdated risk assessments. There is a critical need to incorporate high-resolution spatial hazard analysis into policy and decision-making processes to better understand exposure, guide infrastructure investments, and reduce community vulnerability.

Mainstreaming spatial hazard analysis into policy frameworks allows decision-makers to anticipate future climate risks, optimize resource allocation, and implement context-specific adaptation strategies. This approach aligns with national strategies like the Bangladesh Delta Plan 2100 and Mujib Climate Prosperity Plan and supports international adaptation commitments.

2. Objectives

- Promote data-driven, spatially informed decision-making at local and national levels.
- Integrate spatial hazard mapping into key planning documents and sectoral policies.
- Strengthen institutional capacities to utilize high-resolution geospatial and climate data.
- Ensure inclusive participation and gender equity in spatial data collection and use.
- Enhance climate risk governance through mainstreamed spatial analysis.

3. Justification for Selected Locations

Districts	Key Risk Factors	Strategic Importance
Coastal Districts (e.g., Satkhira, Khulna, Patuakhali, Barguna)	Exposure to coastal flooding, storm surges, and sea-level rise	Areas prioritized in national climate and development plans
Urbanizing Secondary Coastal Towns	Unregulated expansion into hazard-prone zones	Targets for future climate-resilient urban and economic infrastructure growth

These regions face high levels of both climatic risk and development pressure. Mainstreaming spatial hazard data will allow for evidence-based zoning, infrastructure resilience planning, and community safety improvements.

4. Key Climate Resilience Measures

- Data-Driven Decision-Making: Apply geospatial analytics and climate modeling to inform land use and infrastructure planning.
- Emerging Data Sources: Use satellite imagery, LiDAR, UAV (drone) mapping, and crowdsourced household data.
- Policy Integration: Mainstream hazard maps and vulnerability layers into development plans, DRM frameworks, and sectoral investments.
- Training and Institutional Support: Build capacities of planning bodies, local governments, and data managers.
- Cross-Agency Coordination: Align hazard data and analysis processes between MoDMR, Planning Commission, LGED, BWDB, and City Corporations.

5. Expected Outputs and Impacts

Expected Outputs	Expected Impacts
Enhanced local and national planning using spatial data	Improved planning accuracy and alignment with hazard-prone zones
Risk-informed infrastructure and service investments	Reduced vulnerability to climate hazards and financial loss
Strengthened community and infrastructure resilience	More sustainable and adaptive development pathways in coastal districts

6. Gender and Social Considerations

- Ensure spatial data collection processes are **inclusive**, capturing needs of women, elderly, and marginalized populations.
- Conduct **gender-sensitive analysis** to understand how spatial vulnerabilities differ across groups.
- Promote women's participation in **data collection, mapping exercises**, and decision-making committees.
- Track gender-disaggregated outcomes of spatial hazard-informed policies to improve future planning.

7. Linkage to National Adaptation Plan (NAP) Projects

This concept aligns with:

- **WRM3** – Protection and management of potentially vulnerable areas due to tropical cyclones, sea-level rise, extreme storm surges, and flooding.

It directly supports the national goal of embedding climate risk in spatial development frameworks to minimize long-term vulnerability.

8. Potential Financing Options

Source	Potential Contributors	Advantages	Challenges
Government of Bangladesh	MoEFCC, GED, Planning Commission	Strategic policy alignment	Requires inter-agency coordination
Development Agencies	UNDP, GIZ, ADB	Proven experience with spatial data integration	Requires strong reporting, time-intensive validation
Climate Finance	Adaptation Fund, Green Climate Fund	Emphasis on spatial planning and digital adaptation tools	Competitive and complex funding process
Research and Academic Partners	Universities, data labs	Access to innovation, open data, and capacity development	May need upscaling and quality assurance mechanisms

9. Critical Considerations and Future Outlook

- **Standardization**: Develop a national spatial hazard analysis framework, with guidance for scale, format, and use.
- **Interoperability**: Ensure data-sharing platforms work across ministries and are compatible with national dashboards.
- **Localization**: Tailor data to union- and ward-level decision-making needs.
- **Sustainability**: Embed hazard analysis in the planning cycle through mandates, budget allocations, and SOPs.
- **Youth and Innovation**: Encourage partnerships with startups and youth-led geospatial innovators.

10. Estimated Investment Cost

The estimated cost for implementing will depend on scale and coverage. It includes:

- Procurement of high-resolution spatial data and remote sensing services
- Development of user-friendly data platforms and dashboards
- Technical training for planners and administrators
- Policy development and dissemination
- Outreach and community-based spatial risk awareness

11. Economic and Financial Benefits

- Optimized public infrastructure investments due to reduced exposure to known hazards
- Cost savings in future disaster response and reconstruction efforts
- Boosted investor confidence in safe and resilient development zones
- Strengthened risk governance through improved data transparency and accountability

12. Stakeholder Consultations

Comprehensive consultations will be conducted with relevant national, sub-national, and local actors to

Stakeholder input was captured through a large-scale **household survey covering 2,200 households** across seven hazard-prone coastal districts: **Chittagong, Cox's Bazar, Noakhali, Patuakhali, Pirojpur, Jessore, and Satkhira**.

Stakeholder Group	Role in the Project	Consultation Approach
Households in coastal regions	Primary recipients of planning outcomes, directly affected by climate and infrastructure risks	Household Survey (n = 2,200)
Planning and infrastructure stakeholders	Represented indirectly through service access gaps and adaptation barriers	Inferred from household response data

The consultation findings underscore a pressing need for spatially targeted planning that reflects localized hazard exposure and vulnerability patterns.

13. Field Data and Observations

13.1 Household Survey Outcomes

A total of 2,200 households were surveyed across seven coastal districts, capturing demographic diversity, disaster exposure, and infrastructure service gaps.

Key Findings:

- **Hazard Exposure**:
  - Households reported repeated exposure to **storm surges, flooding, salinity intrusion, and cyclonic winds**.
  - Many respondents lacked access to **hazard maps or early warning systems** tailored to their local area.
- **Service Disruption and Risk Visibility**:
  - Infrastructure systems such as roads, schools, and WASH services were often **placed without risk screening**, leading to repeat damage during disasters.
  - **Environmental degradation**, particularly through loss of wetlands and natural barriers, was a recurring concern.
- **Planning Gaps**:
  - Respondents indicated that **local development rarely reflects spatial hazard data**.
  - **Disaster-prone zones still receive unregulated construction**, increasing future exposure.
- **Community Adaptation Responses**:
  - Households rely on informal coping strategies like **elevating homes, planting vegetation, or using sandbags**, often without technical or financial support.
  - A large share favored **community mapping, climate-resilient zoning, and better access to planning data**.

14. Conclusion

Mainstreaming spatial hazard analysis into national and sub-national policy is essential for effective climate adaptation in Bangladesh. By enabling data-driven decisions, it ensures that infrastructure, land use, and social programs are informed by the realities of climate risk on the ground. The initiative strengthens long-term resilience and improves institutional capacity to respond to an increasingly volatile climate future.

Integrating this spatial approach will enhance planning precision, safeguard investments, and improve disaster preparedness across sectors. By embedding gender-sensitive, inclusive, and locally validated spatial hazard analysis into policy, Bangladesh can set a global example for how digital tools and participatory governance can converge for transformational climate resilience.

5.10: RISK-BASED URBAN AND REGIONAL PLANNING FOR RESILIENT COASTAL INFRASTRUCTURE

1. Introduction

Bangladesh's 19 coastal districts face recurring threats from cyclones, storm surges, sea-level rise, and tidal flooding. These hazards put immense pressure on critical infrastructure systems, including energy grids, transportation corridors, water networks, and social facilities such as schools and hospitals. Rapid urbanization without climate-resilient planning exacerbates these risks, particularly in vulnerable and low-lying areas.

This concept promotes the integration of risk-based urban and regional planning strategies to ensure that public infrastructure can withstand climate shocks. By combining updated climate risk data, nature-based solutions, and institutional capacity-building, the project aims to mainstream resilience into long-term development frameworks and infrastructure investments.

2. Objectives

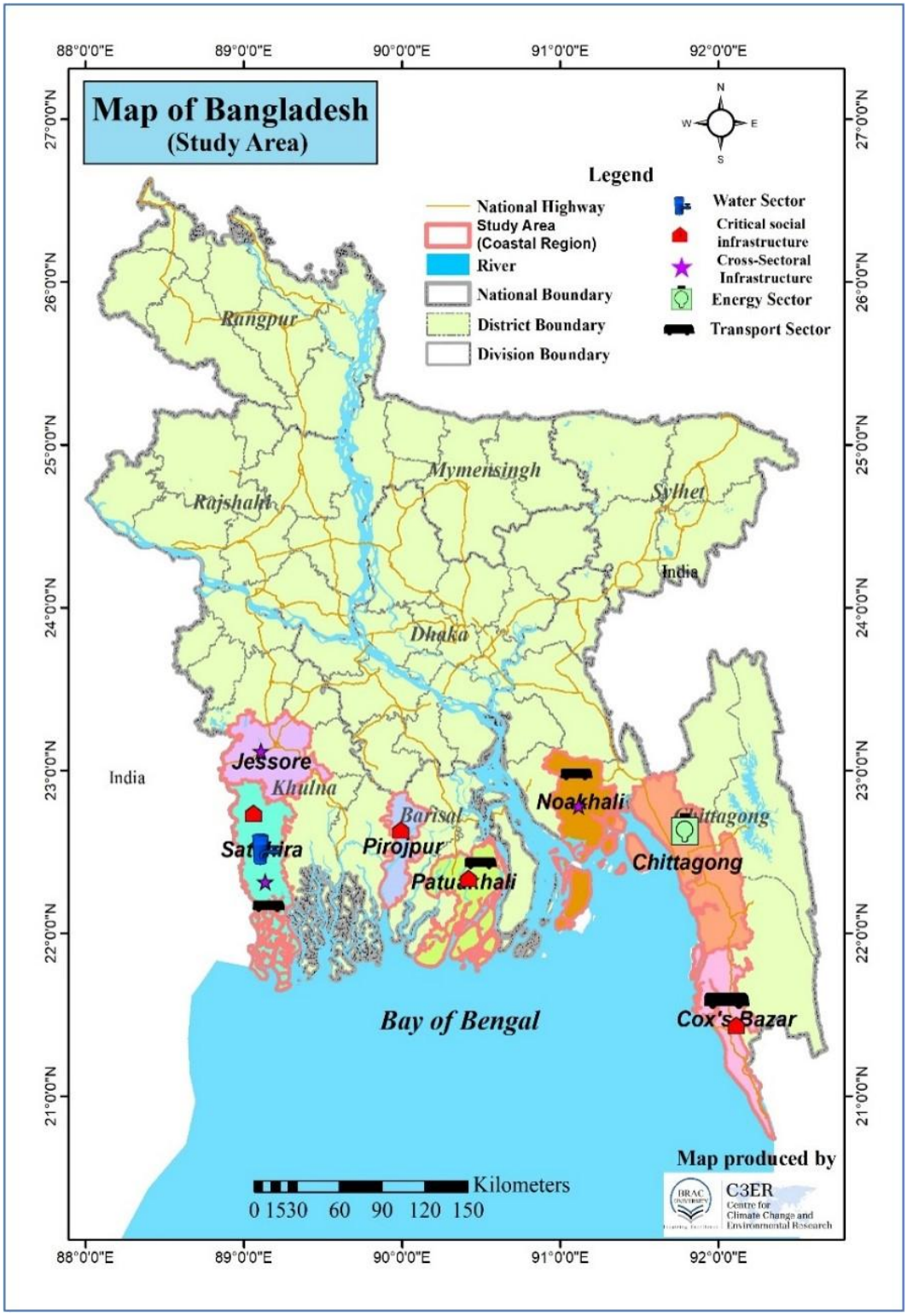
- Integrate updated climate, flood, and hazard data into urban and regional planning systems.
- Establish multi-sectoral data systems to track risk exposure of energy, water, transport, and social infrastructure.
- Promote both nature-based and engineered solutions to reduce climate vulnerability.
- Develop and implement planning standards and policies aligned with climate risk.
- Enhance institutional and technical capacities at national and sub-national levels.
- Improve gender-inclusive infrastructure planning and ensure equitable service access during extreme events.

3. Justification for Selected Locations

The 19 coastal districts of Bangladesh are marked by dense urban settlements, low-lying topography, poor drainage systems, and frequent exposure to climate hazards. These areas regularly face waterlogging, embankment failures, and road disruptions, especially during storms and tidal events. As development intensifies in these regions, the absence of climate-resilient infrastructure planning poses long-term economic and social risks.

District	Key Vulnerability Factors	Strategic Importance
Chattogram, Khulna, Barisal	Coastal exposure, urban density, flood-prone areas	Economic hubs, administrative centers, port logistics
Satkhira, Bagerhat, Patuakhali	Tidal flooding, embankment weakness, saline intrusion	Municipalities requiring resilient connectivity to health and trade services
Noakhali, Bhola, Barguna	Storm surges, poor drainage, limited evacuation infrastructure	Populated yet under-resourced districts with recurring transport issues
Cox's Bazar, Laxmipur, Feni	Erosion, urban expansion, tourism dependency	High-growth towns with sensitive infrastructure
Patuakhali	Recurrent flooding, low road elevation	Key deltaic link for rural-urban access and logistics

Investments in these districts are crucial to secure disaster resilience, maintain economic activities, and safeguard human lives.



4. Key Climate Resilience Measures

- Risk Mapping and Indexing: Utilize updated flood models, hazard maps, and projections for sea-level rise and cyclones to identify high-risk zones. Develop a parameter-driven risk index to quantify vulnerabilities at the local level. This index will include metrics such as land loss, population displacement, service disruption duration, crop damage, infrastructure downtime, and

human exposure to hazards. The index will support targeted planning and resource allocation for the most affected regions.

- Sectoral Infrastructure Database: Establish a GIS-enabled, multi-sectoral data system that captures vulnerabilities across energy, water, transport, and social infrastructure. Link this database to the risk index to enable spatial visualization and priority ranking of infrastructure needs.
- Nature-Based + Engineered Solutions: Integrate mangroves, dunes, wetlands, and urban green buffers with hard engineering measures such as levees, elevated roads, and cyclone-resilient buildings, creating a layered protection strategy.
- Integrated Policy Planning: Embed climate risk thresholds and risk index scores into urban master plans, zoning codes, and building regulations to guide resilient urban expansion.
- Task Force Creation: Establish cross-sectoral task forces to manage risk-informed planning, combining expertise from energy, water, transport, housing, agriculture, and disaster management agencies.
- Training and Capacity Building: Train urban planners, engineers, municipal staff, and technical institutions on the application of the risk index, use of integrated data systems, and design of resilient infrastructure solutions.

5. Expected Outputs and Impacts

Expected Outputs	Expected Impacts
Development and application of a climate risk index	Prioritized investment and efficient resource allocation to high-risk areas
Resilient energy, water, and transport infrastructure	Minimized service disruption and faster recovery post-disaster
Nature-based and engineered defenses integrated	Improved coastal stability and ecosystem services alongside infrastructure protection
Risk-informed urban and regional planning guidelines	Safer city expansion, reduced exposure to hazard-prone zones
Elevated transport and evacuation routes	Increased community safety and reduced fatalities during cyclones/floods

6. Gender and Social Considerations

- Ensure gender-balanced decision-making through inclusive planning committees.
- Conduct community consultations with women, children, the elderly, and people with disabilities.
- Design infrastructure for universal accessibility, including transport and evacuation systems.
- Support training and employment opportunities for women in climate-resilient construction, maintenance, and disaster preparedness.
- Use gender-disaggregated data to inform resilience investments that serve the most vulnerable.

7. Linkage to National Adaptation Plan (NAP) Projects

This initiative aligns with:

- WRM3 – Protection and management of potentially vulnerable areas due to tropical cyclone, sea-level rise, storm surges, and flooding.

It supports national goals under the Bangladesh Delta Plan 2100, Mujib Climate Prosperity Plan, and Sustainable Development Goals (SDGs 5, 7, 9, 11, 13, and 15).

8. Potential Financing Options

Source	Potential Contributors	Advantages	Challenges

Government Budget	LGED, Ministry of Planning, MoEFCC	Alignment with national planning and development mandates	Limited fiscal space and competing priorities
Multilateral Development Banks	ADB, World Bank, AIIB	Large-scale, concessional financing with technical support	Time-consuming procurement and compliance requirements
Climate Funds	GCF, Adaptation Fund	Climate resilience-focused investment aligned with NDCs and NAP	Competitive and highly technical proposal process
Blended Finance	PPPs, CSR funds, development bonds	Shared risk and capital mobilization	Regulatory complexity, limited track record in resilience
Development Partners	UNDP, GIZ, JICA	Proven experience with capacity-building and infrastructure reform	Needs strong government coordination

9. Critical Considerations and Future Outlook

- Institutionalize risk-based infrastructure planning through updates to building codes, zoning laws, and development control frameworks.
- Mainstream the risk index as a tool for screening, prioritizing, and budgeting infrastructure investments in vulnerable districts.
- Prioritize nature-based solutions through co-financing incentives and policy mandates in coastal development projects.
- Integrate hazard exposure parameters (e.g., salinity intrusion, population density, land-use change) into planning algorithms and geospatial tools.
- Promote innovation via digital infrastructure monitoring, IoT-based early warning, and GIS-linked dashboards.
- Enhance resilience audits and climate screening in all pre-investment infrastructure pipelines.

10. Estimated Investment Cost

The estimated investment will depend on project phasing and geographic coverage. This includes:

- Development and implementation of a **parameter-driven coastal climate risk index**, including baseline data collection, tool development, piloting, and institutional adoption.
- Risk assessments, modeling, and planning toolkits
- Elevation and flood-proofing of roads and transport systems
- Nature-based buffer infrastructure (mangroves, dunes, wetlands)
- Upgrading vulnerable water, energy, and social infrastructure assets
- Institutional capacity development, training, and policy reform

11. Economic and Financial Benefits

- **Reduced post-disaster recovery costs** due to better protected assets and uninterrupted services
- **Increased investor confidence** in coastal infrastructure investment zones
- **Job creation** in resilient infrastructure sectors, especially for youth and women
- **Protected tourism and industrial zones** in coastal towns and cities
- **Avoided economic losses** from flood and cyclone disruptions to trade and public services

12. Stakeholder Consultations

Stakeholder consultations were designed around household-level insights and institutional planning gaps across climate-exposed urban and peri-urban areas in **all coastal districts** Although no formal KIIs or FGDs were conducted, comprehensive **household survey analysis** served as a proxy for capturing public sentiment, service disruption experiences, and infrastructure planning priorities.

Stakeholder Group	Role in the Project	Consultation Approach
Households in high-risk areas	Direct beneficiaries of urban and regional infrastructure systems	Household Data Analysis (n = 100)
Planning and infrastructure agencies	Reflected through policy review and inferred from service delivery outcomes	Secondary analysis of planning and service gaps

These consultations highlight the disconnection between planning institutions and community realities, especially in relation to service access, climate resilience, and gender-inclusiveness. They also reveal broad support for participatory, risk-informed planning and adaptive infrastructure policies.

13. Field Data and Observations

13.1 Household Survey Outcomes

Profile: A total of 100 households across flood-prone zones in Satkhira, Khulna, and Cox's Bazar were surveyed to assess infrastructure resilience, access to services during disasters, and inclusion in local development processes.

Key Findings and Insights:

A. Planning Awareness and Participation

- Only **21%** of households were aware of any local or regional planning process.
- **74%** had never been consulted in infrastructure or resilience planning.
- Among female-headed households, over **60%** reported never participating in any community decision-making forum.

B. Service Disruption and Risk Exposure

- **68%** of households faced prolonged service breakdowns (>3 days) during recent cyclone/flood events.
- **42%** experienced **educational disruption** due to flooding and poor access to schools.
- **19%** had been **displaced multiple times** in the past five years due to tidal surges, erosion, or service failure.

C. Gender Equity and Access

- Only **23%** of female respondents felt that local shelters or health services were accessible during floods.
- **76%** recommended institutional inclusion of women, youth, and marginalized groups in planning processes.

D. Community Priorities

Infrastructure Priority	% Support
Climate-informed zoning and building regulation	83%
Flood-proofing essential services	89%
Joint planning across utilities and infrastructure	72%
Risk dashboards or SMS-based alert systems	64%

E. District-Level Risk Profiles

District Cluster	Vulnerability Factors	Strategic Importance
Khulna, Barisal, Chattogram	Coastal flooding, high urban density	Major economic and administrative hubs
Satkhira, Bagerhat, Patuakhali	Embankment failure, saline intrusion	Health networks, rural transport
Cox's Bazar, Laxmipur, Feni	Erosion, tourism stress, unregulated urban expansion	Growth corridors, migrant populations

F. Institutional Expectations

- **81%** expected future infrastructure development to be aligned with updated flood and erosion maps.
- **72%** emphasized coordination across sectors (transport, water, housing).
- **64%** requested digital platforms for infrastructure maintenance and community monitoring.

13.2 Integration of Total Findings and Alignment with Project Objectives

Key Findings	Linked Project Objectives	Evidence Reference
Households unaware of or excluded from formal planning and zoning processes	Objective 1: Integrate updated climate, flood, and hazard data into urban and regional planning systems	Household Survey
Lack of integrated risk registers across energy, water, transport, and health sectors	Objective 2: Establish multi-sectoral data systems to track risk exposure	Household Survey
Infrastructure consistently fails during disaster events due to lack of elevation, drainage, and redundancy	Objective 3: Promote both nature-based and engineered solutions to reduce climate vulnerability	Household Survey
Zoning codes and building standards are outdated, inaccessible, or unenforced	Objective 4: Develop and implement planning standards and policies aligned with climate risk	Household Survey
Local governments lack tools, training, and inter-agency coordination capacity	Objective 5: Enhance institutional and technical capacities at national and sub-national levels	Household Survey (inferred)
Women, youth, and vulnerable groups excluded from infrastructure design and emergency access	Objective 6: Improve gender-inclusive infrastructure planning and equitable service access during extreme events	Household Survey – Female Respondents

14. Conclusion

This concept proposes a transformative shift in how infrastructure is planned and built in Bangladesh's most climate-exposed regions. By embedding risk-based approaches into regional and urban planning, the initiative will prevent future damage, enable safe and inclusive development, and promote long-term resilience.

Through collaboration across government, development partners, and communities, this project can serve as a model for climate-proofing national infrastructure. It is a necessary step to achieving sustainable urbanization and regional growth amid intensifying climate pressures.

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