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SHORELINE: A Nature-based Solution (NbS) Integrated Climate DSS Platform for Coastal Infrastructure in Bangladesh

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Abstract: Bangladesh's vulnerable coastline demands innovative approaches to infrastructure planning. The SHORELINE project addresses this by transforming climate data into actionable intelligence. The project involved the development of a Decision Support System (DSS) integrating validated historical meteorological records (1981–2024) with downscaled, bias-corrected CMIP6 future projections (2025–2100). Co-developed with local engineering and academic partners, the platform generates tailored, district-level risk assessments and planning advisories for short to long-term horizons. This replicable framework embeds climate intelligence and nature-based solutions into planning, shifting governance from reactive crisis response to proactive, risk-informed action for enhanced resilience.

Keywords: Climate Resilience; Nature-based solutions (NbS); Urban and Territorial Planning

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1. Introduction

While Bangladesh is recognized as a global leader in climate change adaptation and disaster risk preparedness, having established robust policies like the National Adaptation Plan (NAP) and the Bangladesh Delta Plan 2100, a critical gap persists at the operational level [1]. This gap is characterized by the challenge of translating vast quantities of available climate data into timely, localized, and actionable intelligence for infrastructure planning and management [2]. Consequently, infrastructure management often remains reactive, responding to damages after an event rather than proactively mitigating risks.

The Seasonal Hazard Observation and Resilience Enhancement for Local Infrastructure (SHORELINE) project addresses this challenge through a digital Climate Advisory Platform centered on an integrated Decision Support System (DSS). It combines a validated historical climatology (1981–2024) with ERA5 reanalysis [3] and multi-model SSP245 projections [4], [5] to drive a risk-prioritization workflow that integrates hazard, exposure, vulnerability, and nature-based solutions to inform resilient infrastructure investments.

2. Methodology

2.1. Backend Architecture

The scientific and technical foundation of the SHORELINE DSS combines historical observations, future climate model projections, and context-specific engineering knowledge to ensure that the platform's advisories are both scientifically credible and practically relevant. Figure 1 illustrates the framework and workflow used to build the platform's backend architecture.

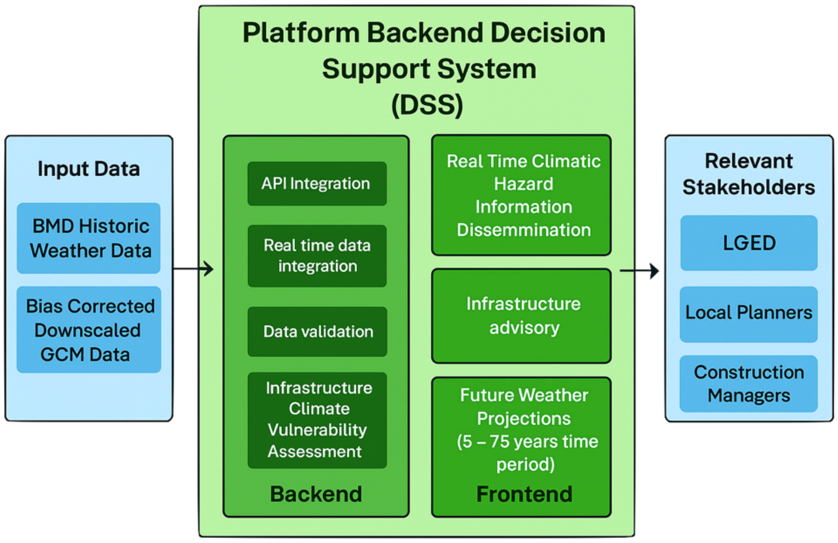


Figure 1. Methodological framework for developing the platform and its DSS backend.

2.2. Historical Climatology Baseline

SHORELINE covers 23 coastal districts of Bangladesh, integrating geospatial infrastructure inventories (LGED, BWDB) with cleaned and aggregated BMD temperature and precipitation records (1981–2024), cross-validated against ERA5 reanalysis to establish a robust historical climatology for the DSS [3].

2.3. Future Climate Trajectories

Future projections to 2100 were derived from 13 different CMIP6 GCMs under the SSP245 scenario. The ensemble projections indicate continued warming and intensification of heavy precipitation across South Asia, consistent with IPCC AR6 [6]. Model outputs were bias-corrected and statistically downscaled to district and upazila scales and validated against the 1981–2024 BMD baseline [7], ensuring locally calibrated future climate inputs for the DSS.

2.4. Infrastructure Vulnerability Assessment

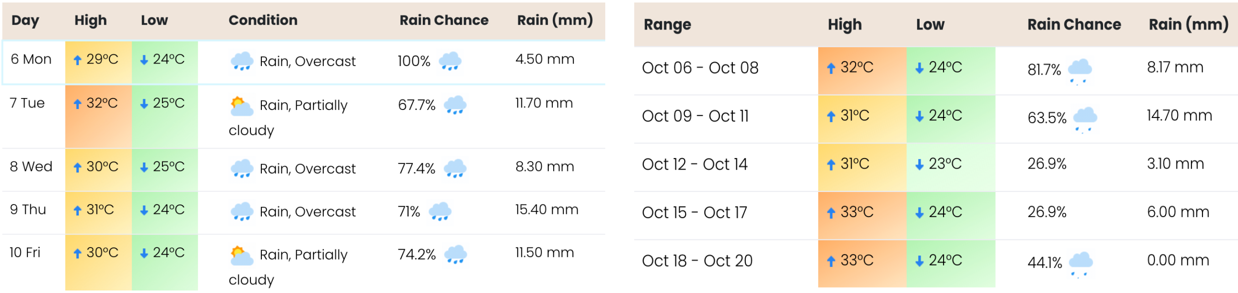
Infrastructure vulnerability was defined through a co-production process with LGED engineers. The resulting dataset classifies critical assets (e.g., rural roads, bridges, culverts, public buildings, cyclone shelters) and specifies hazard-specific failure thresholds for rainfall, flooding, heatwaves, and cyclones [2], enabling systematic translation of climate hazards into infrastructure risk and advisory outputs.

3. Results: The SHORELINE Climate Advisory Platform Modules

The SHORELINE DSS translates its integrated data foundation into a suite of three user-facing modules, each designed to support a different aspect of the infrastructure planning and management cycle.

3.1. Real-Time Hazard Monitoring and Forecasting

The Risk Dashboard and Weather Forecast Panel support near-term operational planning by integrating real-time data with 3–5 day and ≈2-week forecasts. District- and upazila-level risks are displayed through an interactive map and color-coded matrix (high–low) for hazards such as heatwaves, heavy rainfall, and windstorms, enabling rapid assessment and response. These multi-horizon alerts help planners anticipate impacts and prioritize timely interventions. Figure 2 illustrates the forecast horizons.



Day	High	Low	Condition	Rain Chance	Rain (mm)
6 Mon	29°C	24°C	Rain, Overcast	100%	4.50 mm
7 Tue	32°C	25°C	Rain, Partially cloudy	67.7%	11.70 mm
8 Wed	30°C	25°C	Rain, Overcast	77.4%	8.30 mm
9 Thu	31°C	24°C	Rain, Overcast	71%	15.40 mm
10 Fri	30°C	24°C	Rain, Partially cloudy	74.2%	11.50 mm

Range	High	Low	Rain Chance	Rain (mm)
Oct 06 - Oct 08	32°C	24°C	81.7%	8.17 mm
Oct 09 - Oct 11	31°C	24°C	63.5%	14.70 mm
Oct 12 - Oct 14	31°C	23°C	26.9%	3.10 mm
Oct 15 - Oct 17	33°C	24°C	26.9%	6.00 mm
Oct 18 - Oct 20	33°C	24°C	44.1%	0.00 mm

(**a**) (**b**)

Figure 2. Platform forecast views: (a) short- to medium-term (daily) outlook showing maximum/minimum temperature, sky condition, probability of precipitation, and expected rainfall; (b) sub-seasonal to seasonal (S2S) outlook summarized in multi-day ranges for the coming weeks, with the same variables.

3.2. Automated Infrastructure Advisory System

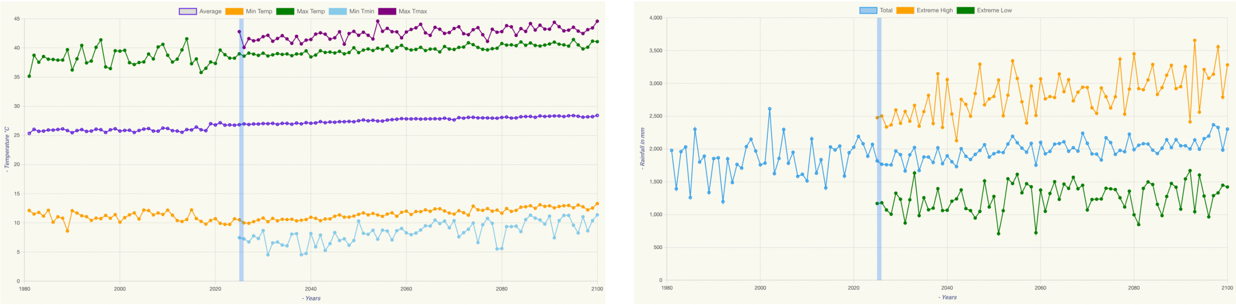
The Infrastructure Advisory System converts forecast data into location- and asset-specific advisories by applying predefined vulnerability thresholds. When climate triggers are exceeded, the system automatically generates time-sensitive guidance tailored to the affected infrastructure type. Table 1 illustrates this logic for rural roads.

Table 1. Example of Hazard-Specific Advisory Logic for Rural Road Infrastructure.

Climate Hazard & Threshold	Potential Effect on Asset	Preventive Measures	Managerial Preparedness	Nature-based Solutions (NbS)	Post-Event Response
Heavy Rainfall (>50mm in 24 hours)	Surface erosion, potholes, waterlogging, weakened subgrade	Ensure proper drainage; use high-quality, water-resistant asphalt.	Adjust work schedules to avoid pouring/curing; protect stored materials.	Permeable pavements, rain gardens, bioretention swales; protect riparian vegetation; soil moisture monitoring; re-establish vegetation.	Patch potholes; recompact subgrade; clear drainage channels.
Floods (Submersion >48 hours)	Road washout, pavement damage, increased sedimentation	Construct elevated embankments; use flood-resistant surfacing materials.	Monitor flood forecasts; reinforce embankments; develop emergency detour plans.	Restore floodplains, wetlands, riparian buffers; artificial wetlands; natural flood defense assessment; replant flood-tolerant vegetation.	Stabilize with sandbags; reconstruct damaged sections; clear debris.
Cyclones (Wind >120 km/h)	Uprooted trees, shoulder erosion, debris blockage	Implement wind-resistant road alignment; reinforce road edges and shoulders.	Secure equipment and signage; schedule tasks before peak impact; clear evacuation routes.	Plant wind-resistant trees as windbreaks; restore mangroves/dunes; prune for resilience; replant resilient species; bioengineering for erosion.	Clear debris; repair shoulders and damaged pavement.

3.3. Strategic Long-Term Resilience Planning

The Planning Management Interface equips users with tools for long-term strategic analysis. Within this module, planners can select a location, an infrastructure type, and a planning horizon (e.g., 5, 25, 50, or 75 years) to visualize future climate trends based on the integrated CMIP6 projections. Interactive graphs display projected changes in key variables like average and extreme temperature and precipitation patterns from 1981 to 2100. Based on these projections, the module generates downloadable reports in PDF format that provide both quantitative climate data and qualitative design guidance. For example, a report for a 25-year road project might recommend specific design adjustments to account for a projected 20% increase in extreme rainfall events, thereby directly informing climate-resilient investment decisions. Figure 3 illustrates the ensemble mean and model-extreme bounds.



(**a**) (**b**)

Figure 3. District-level climate projections from a 13-member CMIP6 ensemble (SSP245): (a) temperature trajectories showing the ensemble mean and model-extreme bounds for Tmax and Tmin; (b) precipitation trajectories showing the ensemble mean annual total with model-extreme high/low bounds. The blue vertical markers indicate the transition from the observed baseline (1981–2024) to the projection period (2025–2100).

4. Discussion and Conclusion

SHORELINE delivers a climate-informed DSS that translates multi-timescale climate data into actionable infrastructure advisories, enabling a shift from reactive response to proactive, risk-informed planning in coastal Bangladesh. Co-developed with IWFM-BUET and LGED, the platform aligns scientific rigor with operational needs, securing institutional adoption and scalability. The framework is replicable for national application and for other climate-vulnerable deltaic regions in line with the NAP and Delta Plan 2100.

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Conflicts of Interest: The authors declare no conflict of interest.

References

[1] A. Parven, I. Pal, and C. Wuthisakkaroon, “Climate Smart Disaster Risk Management for a Resilient Community in Satkhira, Bangladesh,” 2020, pp. 477–496. doi: 10.1007/978-981-32-9527-8_26.

[2] Md. Z. Hossain and N. Huq, “Institutions Matter for Urban Resilience: The Institutional Challenges in Mainstreaming Climate Smart Disaster Risk Management in Bangladesh,” 2013, pp. 169–191. doi: 10.1007/978-3-642-31110-9_11.

[3] H. Hersbach *et al.*, “The ERA5 global reanalysis,” *Quarterly Journal of the Royal Meteorological Society*, vol. 146, no. 730, pp. 1999–2049, Jul. 2020, doi: 10.1002/qj.3803.

[4] B. C. O’Neill *et al.*, “The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6,” *Geosci Model Dev*, vol. 9, no. 9, pp. 3461–3482, Sep. 2016, doi: 10.5194/gmd-9-3461-2016.

[5] V. Eyring *et al.*, “Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization,” *Geosci Model Dev*, vol. 9, no. 5, pp. 1937–1958, May 2016, doi: 10.5194/gmd-9-1937-2016.

[6] Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2022 – Impacts, Adaptation and Vulnerability*. Cambridge University Press, 2023. doi: 10.1017/9781009325844.

[7] V. Mishra, U. Bhatia, and A. D. Tiwari, “Bias-corrected climate projections for South Asia from Coupled Model Intercomparison Project-6,” *Sci Data*, vol. 7, no. 1, p. 338, Oct. 2020, doi: 10.1038/s41597-020-00681-1.