

**Livelihood Vulnerability to
Climate Change in Coastal South
Asia**

A Consolidated Livelihood Vulnerability Index Assessment for Bangladesh, India, Pakistan, and Sri Lanka

Executive Summary

Climate change poses a profound threat to the densely populated coastal regions of South Asia, where agriculture, aquaculture, and fisheries underpin household economies. This consolidated Livelihood Vulnerability Index (LVI) assessment integrates findings from Bangladesh, India, Pakistan, and Sri Lanka to present a regional perspective on vulnerability across coastal and deltaic systems.

The analysis followed the IPCC framework that defined vulnerability as a function of exposure, sensitivity, and adaptive capacity. Each national study applied the same methodology to ensure comparability. Results demonstrated that Bangladesh and India's Sundarban zones experienced the highest composite vulnerability, with LVI-IPCC scores of 0.92 and 0.90 respectively. The coastal belt of Pakistan recorded 0.79, while the Jaffna Peninsula in Sri Lanka scored 0.76. The consistent pattern across all four cases revealed water as the central axis of risk- scarcity, salinity, and contamination influence food systems, health conditions, and livelihood stability.

In Bangladesh, exposure to recurrent cyclones and saline flooding overwhelmed adaptation capacity. India faced similar pressures in the Sundarban, where embankment failures and saline intrusion threaten paddy cultivation and aquaculture. The coastal regions of Pakistan endured extreme aridity and declining freshwater inflow, producing widespread livelihood stress. In Sri Lanka, over-extraction of groundwater and saltwater intrusion had jeopardised the limestone aquifer upon which domestic and agricultural needs depend.

Common drivers of sensitivity included limited safe drinking water, declining soil fertility, high disease incidence, and inadequate food diversity. Adaptive capacity remained weak where poverty, gender inequities, and low institutional outreach persisted. Strengthening local institutions, expanding access to technology, and diversifying income sources were necessary to reduce vulnerability.

Collectively, the findings highlighted that building resilience in coastal South Asia demanded integrated water management, climate-smart agriculture, mangrove and aquifer restoration, and inclusive livelihood diversification. Addressing gender gaps in education and finance, alongside improving local governance and early warning systems, would be essential for sustainable adaptation.

1. Introduction

Coastal and deltaic areas across South Asia face rising exposure to climate-induced hazards. Sea-level rise, storm surges, saline intrusion, and erratic rainfall are altering ecosystems and undermining traditional livelihoods (IPCC, 2023; ADB, 2021; World Bank, 2020). These regions are densely settled, ecologically fragile, and socio-economically vulnerable, with agriculture, fisheries, and forest products forming the core of local income (FAO, 2022; OECD, 2021).

The present consolidated study synthesises four national assessments prepared under the broader objective of integrating climate-resilient agricultural policy into national development frameworks (UNDP, 2022). By applying a common methodology and comparable indicators, the report enables cross-country analysis of the structural and environmental factors shaping vulnerability (World Bank, 2021; UNESCAP, 2020). The findings aim to support evidence-based policymaking, guiding resource allocation and regional cooperation in adaptation planning (SACEP, 2023; FAO, 2023).

2. Study Areas

2.1 Bangladesh – South-western Coastal Sundarban Region

The south-western coastal districts of Khulna, Satkhira, and Bagerhat encompass low-lying land dissected by tidal rivers and creeks. Elevation seldom exceeds two metres above mean sea level. Agriculture and aquaculture dominate household livelihoods, supported by small-scale fisheries and forest-related activities such as crab and honey collection (ADB, 2021; Islam et al., 2022). The area experiences frequent cyclones, saline water intrusion, and embankment failures. Freshwater scarcity and poor drainage constrain productivity. Socio-economic challenges include high population density, seasonal migration, and a large proportion of female-headed households (World Bank, 2021). Health and education services are present but sparse in remote islands.

2.2 India – Sundarban of West Bengal

The Indian Sundarban, stretching across South and North Twenty-Four Parganas, is characterised by tidal channels, mudflats, and mangrove belts (Ghosh et al., 2021). Human settlements are densely packed near riverine routes and markets. The economy relies on rain-fed paddy, brackish aquaculture, and estuarine fisheries. Exposure to cyclones and saline inundation is frequent, while embankment degradation aggravates flooding (Chakraborty et al., 2022; IPCC, 2023). Freshwater scarcity and saline groundwater remain critical issues. Limited road connectivity and service delivery gaps heighten sensitivity. Social norms and limited livelihood diversification further restrict adaptive capacity (UNDP, 2022).

2.3 Pakistan – Coastal Sindh and Balochistan

The coastline of Pakistan includes the Indus Delta in Sindh and the arid Makran coast in Balochistan. In Sindh, reduced river flow has intensified seawater intrusion and mangrove loss (ADB, 2021; FAO, 2022). Communities rely on fishing and small-scale cropping where water permits. In Balochistan, extreme aridity and scarce freshwater limit livelihood opportunities (World Bank, 2020). Exposure to cyclones and heat extremes is recurrent. Infrastructure is weak and institutional presence minimal. Low literacy, especially among women, and pervasive poverty reduce the capacity to adapt (UNESCAP, 2020; SACEP, 2023).

2.4 Sri Lanka – Jaffna Peninsula

Jaffna lies within the semi-arid north of Sri Lanka, dependent on a fragile Miocene limestone aquifer (Gunaratne et al., 2021). Rainfall is seasonal, concentrated during the north-east monsoon. Agriculture focuses on paddy, red onion, and chilli cultivation, while coastal fisheries contribute significantly to income. Over-extraction of groundwater and saltwater intrusion have degraded the aquifer (Mathiventhan, 2022). Prolonged droughts exacerbate water stress and affect household health and nutrition. Post-conflict demographic changes have resulted in many female-headed households with limited assets. Social cohesion is strong, but formal institutions remain under-resourced (UNDP, 2022).

3. Methodology

The LVI–IPCC score was calculated through a four-step process (Hahn, Riederer, & Foster, 2009; Shah et al., 2013; Pandey et al., 2017).

- i. Standardization: Each sub-component is converted to a standardized 0–1 scale (Sullivan, Meigh, & Fediw, 2002).
- ii. Averaging: Sub-components are averaged to yield scores for each of the seven major components (Hahn et al., 2009).
- iii. IPCC Categorization: The major components are grouped as follows:
 - a) Exposure = Natural Disasters and Climate Variability (NDCV)
 - b) Sensitivity = Health (H) + Food (F) + Water (W)
 - c) Adaptive Capacity = Socio-Demographic Profile (SDP) + Livelihood Strategies (LS) + Social Networks (SN) (IPCC, 2014).
- iv. LVI–IPCC Score: The final index is calculated as:
- v. $LVI - IPCC = (Exposure - Adaptive Capacity) + Sensitivity$.

Scores range from –1 (least vulnerable) to +1 (most vulnerable) (Hahn et al., 2009; Pandey et al., 2017).

Table 1: Major components and indicators used in the LVI framework

| Major Component | Sub-components (Indicators) | Purpose |
|---|--|---|
| Socio-Demographic Profile (SDP) | Poverty rate; female literacy rate; dependency ratio; percentage of female-headed households | Captures demographic and structural determinants of resilience. |
| Livelihood Strategies (LS) | Share of households dependent on agriculture or fisheries; livelihood diversification index; access to credit; non-farm employment options | Evaluates reliance on climate-sensitive sectors and availability of alternatives. |
| Social Networks (SN) | Membership in community organisations; access to government or extension services; neighbour cooperation | Measures social capital and institutional connectivity. |
| Health (H) | Distance to nearest facility; prevalence of water-borne disease; child malnutrition; maternal healthcare access | Reflects public health conditions and service accessibility. |
| Food (F) | Months of food insecurity; dependence on single staple; crop loss frequency; dietary diversity | Gauges food availability and stability. |
| Water (W) | Households reporting scarcity or salinity; access to safe water; distance to source | Represents the most critical sensitivity factor in coastal regions. |
| Natural Disasters & Climate Variability (NDCV) | Frequency of cyclones, floods, or droughts; embankment failures; perceived rainfall and temperature changes | Quantifies exposure to climatic hazards. |

4. Results

4.1. Bangladesh

Table 2: LVI Calculation for the selected study area in Bangladesh

| Contributing Factor | Major Component | Score (0–1) | Interpretation |
|--------------------------|--|-------------|---|
| Exposure | Natural Disasters & Climate Variability (NDCV) | 0.83 | Intense cyclone activity and saline flooding generate extreme exposure. |
| Sensitivity | Health (H) | 0.76 | Limited health services and recurrent disease elevate sensitivity. |
| | Food (F) | 0.81 | Seasonal shortages and saline-affected crops increase food insecurity. |
| | Water (W) | 0.90 | Freshwater scarcity and contamination produce critical stress. |
| Adaptive Capacity | Socio-Demographic Profile (SDP) | 0.77 | High poverty and low literacy reduce resilience. |
| | Livelihood Strategies (LS) | 0.83 | Dependence on agriculture and fisheries with minimal diversification. |
| | Social Networks (SN) | 0.58 | Informal cooperation present but institutional support inadequate. |
| LVI-IPCC | | 0.92 | Overall vulnerability extremely high. |

4.2 India

Table 3: LVI Calculation for the selected study area in India

| Contributing Factor | Major Component | Score (0–1) | Interpretation |
|--------------------------|-----------------|-------------|---|
| Exposure | NDCV | 0.81 | Frequent cyclones and embankment breaches sustain high exposure. |
| Sensitivity | Health (H) | 0.74 | Disease prevalence and weak services heighten risk. |
| | Food (F) | 0.79 | Yield losses from salinity and drought lead to persistent insecurity. |
| | Water (W) | 0.88 | Saline groundwater and limited safe supply cause acute sensitivity. |
| Adaptive Capacity | SDP | 0.75 | Poverty and low education restrict adaptation. |
| | LS | 0.81 | Primary-sector dependence constrains diversification. |
| | SN | 0.56 | Community cohesion exists but institutional channels remain weak. |
| LVI-IPCC | | 0.90 | Overall vulnerability extremely high. |

4.3 Pakistan

Table 3: LVI Calculation for the selected study area in Pakistan

| Contributing Factor | Major Component | Score (0–1) | Interpretation |
|---------------------|-----------------|-------------|--|
| Exposure | NDCV | 0.72 | Heat extremes, sea-level rise, and coastal hazards yield very high exposure. |
| Sensitivity | Health (H) | 0.68 | Poor service access and malnutrition sustain health risk. |
| | Food (F) | 0.75 | Declining fish stocks and crop failures intensify food stress. |
| | Water (W) | 0.85 | Chronic scarcity and saline intrusion create severe sensitivity. |
| Adaptive Capacity | SDP | 0.70 | Poverty and low literacy hinder adaptation. |
| | LS | 0.78 | Reliance on fisheries and marginal farming restricts alternatives. |
| | SN | 0.60 | Informal networks active yet formal support minimal. |
| LVI-IPCC | | 0.79 | Overall vulnerability very high. |

4.4 Sri Lanka

Table 3: LVI Calculation for the selected study area in Sri Lanka

| Contributing Factor | Major Component | Score (0–1) | Interpretation |
|---------------------|-----------------|-------------|---|
| Exposure | NDCV | 0.68 | Droughts and floods produce substantial exposure. |
| Sensitivity | Health (H) | 0.45 | Moderate health sensitivity due to climate-linked diseases. |
| | Food (F) | 0.62 | Water-intensive crops amplify food system risk. |
| | Water (W) | 0.75 | Aquifer salinity and over-extraction are major stressors. |
| Adaptive Capacity | SDP | 0.55 | High dependency ratios and female-headed households limit adaptation. |
| | LS | 0.65 | Agricultural focus with limited diversification lowers resilience. |
| | SN | 0.40 | Community solidarity strong but institutions under-resourced. |
| LVI-IPCC | | 0.76 | Overall vulnerability high. |

5. Discussion

5.1 Bangladesh

The coastal zone of Bangladesh endured recurrent cyclones, tidal surges, and saline inundation. Exposure was the highest among the four countries. Water scarcity and contamination remained chronic, producing interlinked impacts on health and food. Adaptive capacity was constrained by poverty, limited education, and weak institutional support. Priorities should include mangrove rehabilitation, improved embankment maintenance, managed aquifer recharge, and non-farm livelihood promotion targeted at women and youth.

5.2 India

The Indian Sundarban mirrored Bangladesh in hazard frequency but differed in institutional structure. High exposure stemmed from cyclones and saline breaches. Water sensitivity was acute due to saline groundwater and inadequate infrastructure. Adaptive capacity was limited by dependence on primary sectors and insufficient credit or insurance access. Policies should strengthen integrated coastal zone management, invest in salinity-resistant crops, and expand rural enterprise development.

5.3 Pakistan

Pakistan's coastal vulnerability reflected chronic water scarcity, loss of freshwater inflows, and degradation of coastal ecosystems. Dependence on fisheries left households exposed to fluctuating catches and environmental degradation. Adaptive capacity remained low due to weak governance and widespread poverty. Introducing biosaline agriculture, enforcing sustainable fishing regulations, and supporting vocational diversification could mitigate livelihood risk.

5.4 Sri Lanka

Jaffna's vulnerability was less about sudden disasters and more about slow-onset stresses. The limestone aquifer would face irreversible salinity changes if unmanaged. Agricultural dependence on water-intensive crops sustained sensitivity, while demographic imbalances restricted adaptation. An Integrated Water Resource Management plan, promotion of drought- and saline-tolerant crops, and strengthening farmer organisations for collective action would have to be prioritised.

6. Comparative Synthesis

Across all four countries, water emerged as the most significant determinant of vulnerability. Exposure varied in form from cyclones and surges in the Sundarban to drought and salinity in Pakistan and Sri Lanka. Sensitivity was shaped by intertwined factors of water, food, and health. Adaptive capacity lagged behind exposure in every region, reflecting entrenched socio-economic constraints.

Bangladesh and India exhibited near-identical risk structures, with extreme exposure and limited adaptive potential. Pakistan's coastal belt ranked slightly lower but faced deep structural scarcity. Jaffna in Sri Lanka recorded the lowest composite score but still displayed critical aquifer fragility. The comparative evidence highlighted that technical measures alone were insufficient, and institutional reform, social inclusion, and economic diversification were equally vital.

7. Conclusion

The consolidated Livelihood Vulnerability Index analysis revealed that the resilience deficit of coastal South Asia was rooted in water stress and socio-economic inequality. To reduce vulnerability, adaptation policies should integrate hydrological management with social development. Investments in freshwater infrastructure, mangrove and aquifer restoration, and climate-smart agriculture should coincide with programmes that strengthen education, women's participation, and local governance. Cross-border collaboration on early warning systems and resource sharing would further reinforce resilience.

Long-term climate resilience in coastal South Asia would depend on transforming vulnerability from a condition of survival into a pathway of sustainable security, where communities possess both the means and the agency to adapt to a changing environment.

8. References

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