

COMMUNITY VULNERABILITY, RESILIENCE STRATEGIES, AND GOVERNANCE CHALLENGES IN COASTAL BANGLADESH: A MIXED-METHODS STUDY OF TALALI UPAZILA, BARGUNA DISTRICT

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Abstract: Communities in the coastal region of southwestern Bangladesh are increasingly exposed to climate-induced challenges, including salinity intrusion, cyclones, freshwater scarcity, and the degradation of canal networks. While coastal vulnerability has been extensively documented, the role of local governance and power dynamics in shaping adaptation outcomes remains underexplored. This study investigates the interconnections among vulnerability, resilience, and governance in Taltali Upazila of Barguna District. Employing a mixed-methods approach, the research combines household surveys with Participatory Rural Appraisal (PRA), Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs) conducted in Barabagi, Nishanbaria, and Sonakata unions. Findings reveal that climate risks are amplified by institutional weaknesses, including unequal access to water resources, politically influenced support distribution, weak stakeholder coordination, and limited participation of marginalized groups in decision-making processes. These factors contribute to socioeconomic hardship and declining agricultural productivity. Despite these challenges, local communities demonstrate resilience through earthen embankment systems (badh), seasonal water management practices, salinity-tolerant crops, and diversified livelihoods. Drawing on Social-Ecological Systems, Pressure-and-Release, and Climate Justice frameworks, the study advocates inclusive governance, equitable resource management, canal restoration, and gender-responsive adaptation to strengthen long-term resilience.

Keywords: *Coastal Vulnerability; Community Resilience; Climate Justice; Power Dynamics; Salinity Intrusion; Water Governance;*

1. Introduction

Climate change is making life increasingly difficult for coastal communities in Bangladesh, with rising salinity, cyclones, and water scarcity threatening livelihoods and well-being. This study focuses on Taltali Upazila to examine how environmental challenges, local coping strategies, and governance systems shape community vulnerability and resilience in the face of a changing climate.

1.1. BACKGROUND

Bangladesh is one of the most vulnerable countries to natural disasters, largely due to its low-lying deltaic landscape. Millions of people regularly face the impacts of floods, cyclones, storm surges, and riverbank erosion, making environmental hazards a persistent challenge for communities across the country (Ahmed et al., 2016). Within this broader national context, the southwestern coastal region of Bangladesh faces some of the country's most pressing climate and environmental challenges. Taltali Upazila, located at the southern edge of Barguna District, is especially vulnerable due to its location near the Bay of Bengal, where several tidal rivers converge and continually expose local communities to coastal hazards (Alam et al., 2025). Surrounded by the Payra and Burishwar rivers to the west and the Andharmanik River to the east, Taltali is an ecologically diverse area

characterized by beaches, mangrove ecosystems, and char lands. However, its location also makes it highly vulnerable to climate-related pressures, placing livelihoods, housing, and freshwater resources at constant risk.

Among these challenges, salinity intrusion remains one of the most serious. During the dry season, salinity levels in surface water can rise significantly, reducing access to freshwater and affecting agriculture, fisheries, and everyday life for local communities (Alam et al., 2025). In highly saline areas, agricultural productivity is significantly reduced, with rice yields often falling by 30–40%. As a result, many farmers are unable to cultivate crops throughout the year and are typically limited to only one or two harvests annually (Ashrafuzzaman et al., 2022). The impacts of declining agricultural productivity extend far beyond the fields. Reduced income often pushes households into debt, increases reliance on seasonal migration for work, and forces families to adopt difficult coping strategies, such as reducing food consumption or selling valuable assets. These challenges are further intensified by recurring cyclones.

Cyclones such as Sidr in 2007, Aila in 2009, and Amphan in 2020 caused widespread damage to homes, embankments, and farmland across coastal Barguna. Looking ahead, rising sea levels are expected to place even greater pressure on the region, threatening both

settlements and livelihoods across the southwestern coastal zone. (Lam et al., 2022) Government estimates suggest Bangladesh will require approximately USD 3 billion for salinity control and coastal protection measures alone between 2015 and 2030.

1.2. PROBLEM STATEMENT

Despite significant policy efforts and numerous adaptation initiatives by government agencies and NGOs, the benefits of these interventions are often unevenly distributed in communities such as Taltali. This study suggests that persistent vulnerability is not simply the result of limited resources or a lack of technical solutions. Instead, it is closely linked to weaknesses in local governance, including unequal control over water resources, politically influenced distribution of support, the exclusion of marginalized groups from decision-making, and the limited recognition of local knowledge. Together, these challenges continue to undermine the ability of households and communities to adapt effectively to climate-related risks.

1.3. RESEARCH GAP

Scholarship on coastal vulnerability in Bangladesh has advanced considerably in recent years, with contributions across physical hazard assessment (Ashrafuzzaman et al., 2022; Salehin et al., 2018), livelihoods and migration, and general resilience frameworks (Choudhury et al., 2021; Hoque et al., 2019). However, significant gaps remain. First, the simultaneous operation of physical exposure, governance failure, and power asymmetries at hyper-local scales remains underexplored, with most studies addressing these dimensions in isolation. Second, the specific mechanisms through which local power structures mediate access to adaptation support and the climate justice implications thereof have received limited empirical attention in the Barguna district context. Third, methodologically, community-level participatory approaches remain underutilised relative to their demonstrated value for contextually grounded vulnerability analysis (Aalst et al., 2008). This study addresses these interrelated gaps.

1.4. RESEARCH OBJECTIVES

- To analyse the nature and severity of biophysical and socio-economic vulnerabilities facing communities in Taltali Upazila.
- To examine how local governance structures and power dynamics mediate access to adaptation resources and water management infrastructure.
- To document and evaluate community-based coping and resilience strategies, with particular attention to their sustainability and equity dimensions.
- To assess the extent to which climate justice principles are reflected in institutional responses to coastal vulnerability in Taltali.

- To formulate evidence-based policy recommendations for inclusive, participatory, and climate-just adaptation governance.

1.5. RESEARCH QUESTIONS

- What are the primary biophysical and socio-economic vulnerabilities experienced by households in Taltali Upazila, and how do these intersect?
- What community-based resilience strategies have emerged in Taltali, and what are their strengths, limitations, and equity implications?

1.6. SIGNIFICANCE OF THE STUDY

This study contributes to three interrelated scholarly debates. Theoretically, it advances the application of Social-Ecological Systems (SES) theory and Climate Justice Frameworks to hyper-local coastal governance contexts in South Asia. Methodologically, it demonstrates the value of integrated participatory methods for generating community-specific vulnerability evidence that complements remote sensing and macro-level datasets. Practically, the study produces a granular, empirically grounded analysis of governance failures and resilience assets in Taltali that directly informs district-level planning, NGO programme design, and national climate adaptation policy in Bangladesh.

2. Literature Review

This section critically reviews the existing literature on coastal vulnerability, community resilience, climate justice, and adaptive governance in Bangladesh and beyond. The review identifies major theoretical perspectives, empirical findings, and unresolved knowledge gaps that inform the present study.

2.1. THEORETICAL FOUNDATION

2.1.1. *Social-Ecological Systems (SES) Theory*

The concept of the Social-Ecological Systems framework, initially conceived predominantly by DeCaro & Stokes (2013) and further refined through the contribution of Folke et al. (2010) envisions integrated dynamic systems of communities and their spatial contexts of diverse interaction between human and ecological components. This theory states that vulnerability is an outcome is an evolving outcome of complex Mutual influences among ecological conditions, institutional offerings, and social complexes rather than physical situations alone (Jozaei et al., 2022). Critically, SES theory acknowledges that these systems are non-stationary: baseline conditions shift over time, and governance structures that once enabled effective adaptation may become misaligned with evolving hazard profiles (Jozaei et al., 2022). In the Taltali context, the progressive silting of canal networks and the associated decline in freshwater availability represent precisely such a non-stationary ecological transition one that existing governance structures have failed to track.

SES theory further introduces the concept of panarchy: the idea that social-ecological systems exist in nested hierarchies of adaptive cycles, and that resilience at one scale may be undermined by conditions operating at another (Gunderson & Holling, 2003). For Taltali, this implies that community-level adaptive strategies, however innovative, may be systematically constrained by institutional failures at the Upazila, district, or national scale.

2.1.2. Pressure-Release Model

The Pressure-Release (or PAR) model (Wisner et al., 2004) situates disaster risk at the intersection of physical hazards and social vulnerability, and traces vulnerability to root causes embedded in political economy resource access, governance structures, and historical processes of marginalisation. Applied to Taltali, the model directs analytical attention to the 'unsafe conditions' (degraded housing, silted canals, contaminated water) produced by 'dynamic pressures' (rapid environmental change, inadequate institutional investment) rooted in 'root causes' (unequal power relations, governance failures, economic marginalisation). This model provides the structural logic for the governance analysis central to this study.

2.1.3. Climate Justice Framework

Climate justice frameworks affirm that maximized victims of climate change are the least responsible group for its damage, and that adaptation responses must not only be judged for their mechanical conclusiveness but also for their inferences (Balsiger, 2008). The climate justice lens in coastal Bangladesh portrays a completely different scenario. communities contribute negligibly to carbon emissions, such as those in Taltali, yet face the most dangerous effects of sea-level rise, water contamination, and intensified impacts of cyclonic activity (Sultana, 2021). To mitigate this situation, climate justice does not solely rely on improved adaptive outcomes, but rather a complete transformation of structures in governing bodies and in dividing adaptive benefits and burdens. Intersecting injustices of income group, gender, and spatial exclusion, a picture wholly relevant to the Taltali case. Sultana (2021) has specifically argued that water governance in Bangladesh embodies intersecting injustices of class, gender, and spatial marginalisation a framing directly applicable to the Taltali case.

2.2. CONCEPTUAL FRAMEWORK

The conceptual framework developed for this study (Ostrom, 2009; Sultana, 2021; Wisner et al., 2004) integrates the three theoretical pillars described above. Biophysical hazard exposure constitutes the environmental stressor acting on socially differentiated communities. The vulnerability of these communities is shaped by socio-economic conditions (income, housing, livelihood structure) and by the governance environment, the institutional rules, power relations, and resource

allocation mechanisms that determine who can access adaptation support and on what terms. Community adaptive strategies represent the agency side of the framework: the practices, knowledge systems, and collective actions through which communities respond to hazards. Resilience outcomes, the degree to which communities maintain livelihood continuity and social cohesion under stress, are the product of this multi-directional interaction. Climate justice serves as an overarching evaluative criterion throughout.

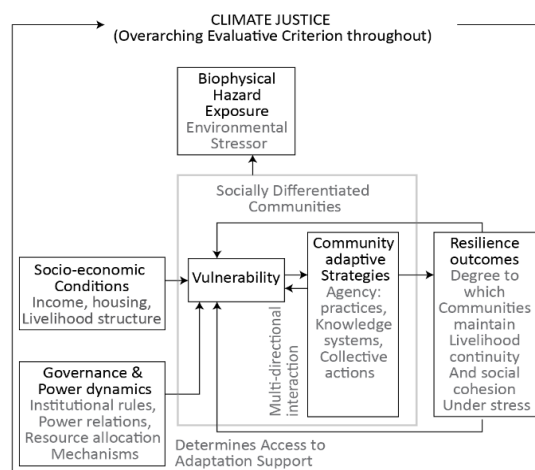


Figure 1: Conceptual Framework Diagram
(Source: Illustrated by the Author, based on Ostrom, 2009; Sultana, 2021; Wisner et al., 2004)

2.3. PREVIOUS STUDIES

2.3.1. Coastal Vulnerability in Bangladesh

The literature on coastal vulnerability in Bangladesh has documented, with considerable empirical richness, the interplay of physical and social processes driving household insecurity in the southwest. Ashrafuzzaman et al. (2022) provide a comprehensive analysis of salinity dynamics, demonstrating that surface water salinity has increased substantially over three decades with severe consequences for rice productivity, particularly in areas such as Barguna where multi-cycle cultivation is already marginal. Salehin et al. (2018) establish the mechanisms and drivers of soil salinity intrusion, identifying tidal dynamics, canal connectivity, and seasonal rainfall patterns as key determinants. Taken together, these studies establish that the biophysical dimensions of vulnerability in the southwestern coastal belt are well-characterised.

The livelihood and migration nexus document the acceleration of climate-induced displacement from coastal Bangladesh, while Ahmed et al. (2016) provide evidence on how cyclone exposure affects community resilience capacities in coastal Barguna, identifying social cohesion and institutional support as critical mediating factors. The importance of institutional support is further underlined by Islam & Nurse-Bray (2017), who demonstrate that formal institutional engagement significantly shapes agricultural adaptation outcomes across Bangladesh.

2.3.2. Community-Based Adaptation

The community-based adaptation (CBA) literature has established that locally-owned, participatory approaches are substantially more effective than top-down interventions in building contextually appropriate and sustainable resilience. Niu et al. (2023) reviewing CBA strategies in coastal regions globally, report that CBA approaches are associated with a 45% reduction in disaster-related economic losses, 75% community participation in decision-making, and the integration of traditional knowledge into 65% of adaptation projects. Critically, the study identifies good governance defined by transparency, equity, and genuine community participation as a necessary condition for CBA effectiveness.

Austin (2008) demonstrates the particular value of participatory community risk assessments (CRAs) as both a diagnostic tool and an empowerment mechanism, showing how PRA-based approaches can foster community engagement in climate risk reduction while simultaneously generating locally grounded evidence for policy. Their work directly informs the methodological design of the present study. Hoque et al. (2019) show that in coastal Bangladesh specifically, resilience is strongest where social cohesion intersects with effective governance and external institutional support, a finding that underlines the governance deficit at the heart of the Taltali case.

2.3.3. Governance, Power, and Climate Justice

Choudhury et al. (2021) examine adaptive governance and community resilience to cyclones in coastal Bangladesh, identifying institutional fit, social learning, and inter-organisational collaboration as key enablers and their absence as key constraints of effective adaptation. Their analysis highlights a recurring pattern of top-down governance that undermines community adaptive capacity, particularly in communities with strong power hierarchies and limited political voice. This pattern resonates directly with findings from Taltali. Sultana (2021) extends this analysis through an explicit climate justice lens, demonstrating that water governance in Bangladesh systematically disadvantages women, poor households, and politically marginalised communities, and arguing that addressing these injustices is a necessary precondition for meaningful adaptation. The social-ecological resilience perspective advanced by Jozaei et al. (2022) further contributes to this discussion by arguing that coastal governance must account for transformation not merely adaptation as a viable response to communities experiencing chronic, compounding vulnerability.

2.3.4. Synthesis of Literature and Knowledge Gaps

Despite this rich literature, three gaps remain. First, the interacting effects of physical hazard exposure, governance failure, and power asymmetry have not been empirically traced at the hyper-local scale in Taltali or similar Upazila-level contexts in Barguna District. Second,

the climate justice dimensions of water governance particularly as they manifest through NGO and government programme delivery have not been systematically analysed in this sub-regional context. Third, the integration of PRA, FGD, KII, and household survey data in a single mixed-methods study of Taltali offers a methodological contribution not yet present in the literature. This study fills these gaps.

3. Methodology

This section outlines the research design, study area, sampling strategy, data collection procedures, and analytical techniques employed in this study. The methodology was designed to ensure methodological rigor, triangulation of evidence, and a comprehensive understanding of vulnerability, resilience, and governance dynamics in the study area.

3.1. RESEARCH DESIGN

A mixed-methods research design integrating both qualitative and quantitative approaches was adopted to provide a comprehensive assessment of community vulnerability, resilience, and governance in Taltali Upazila. The mixed-methods approach was selected due to the complex and multidimensional nature of the research problem, which requires the integration of diverse sources of evidence. Quantitative data were collected on biophysical and socioeconomic conditions, including salinity levels, cyclone and flood impacts, housing conditions, cropping patterns, and demographic characteristics. Qualitative data were gathered through participatory research methods, key informant interviews, and in-depth interviews to capture local experiences, perceptions, and adaptive responses to climate-related hazards. Secondary data, map and literature analysis the biophysical and institutional context.

3.2. STUDY AREA

Taltali Upazila is the southernmost Upazila of Barguna District in the Barisal Division of southern Bangladesh. It is bounded to the west by the Payra river and Barguna Sadar Upazila, to the east by the Andharmanik River and Kalapara Upazila, to the south by the Bay of Bengal, and to the north by Amtali Upazila. The Upazila encompasses diverse coastal landscapes, including beach corridors (Fatrar Char, Shuvo Shanda, Nidrar Char), mangrove areas, and agricultural lowlands.

Fieldwork was conducted in three unions: Barabagi, NishanBaria, and Shonakata, selected to represent the spatial diversity of vulnerability conditions within the Upazila, including variation in canal access, distance from the coast, and degree of governance engagement.

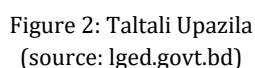
3.4. DATA COLLECTION

PRA sessions were conducted in all three study unions, engaging farmers, fisherfolk, women, and community leaders. Tools employed included: (i) social and resource mapping to document spatial dimensions of water access and vulnerability; (ii) hazard/problem ranking to identify and prioritise community-perceived risks; (iii) seasonal calendars to trace temporal patterns of hazard exposure, livelihood activity, and coping responses; and (iv) historical timelines to document changes in the canal system and governance arrangements over time. PRA data were validated through key informant interviews and direct field observations (Austin, 2008).

Three FGD sessions were conducted, stratified by livelihood group: (i) farmers and agricultural labourers; (ii) fisherfolk; and (iii) women. Each session addressed water management practices, canal maintenance, governance experiences, NGO and government programme delivery, and community perceptions of equity and climate justice. Sessions lasted approximately 90–120 minutes and were conducted in Bengali. Audio recordings were made with participant consent, and field notes were maintained by a co-investigator.

Semi-structured KIIs were conducted with union parishad chairmen, NGO field officers, local government officials (Upazila agricultural officer, fisheries officer), and community leaders. The interview protocol addressed: institutional mandates for water governance and adaptation, programme delivery processes and targeting criteria, coordination between government and NGO actors, and perceptions of community participation and power dynamics.

A structured household questionnaire consisting of 46 items was administered through face-to-face interviews with household representatives in the selected unions of Taltali Upazila. The questionnaire covered six thematic domains: (i) demographic characteristics, (ii) livelihood and economic conditions, (iii) hazard exposure and vulnerability, (iv) water access and management, (v) coping and adaptation strategies, and (vi) governance, institutional support, and climate justice perceptions. Most questions were closed-ended with predefined response categories, while a limited number allowed respondents to provide additional qualitative information. Interviews were conducted in Bangla and required approximately 20–30 minutes to complete. A total of 20 completed questionnaires were included in the analysis.



Method	Location/ unit	No.	Date
Participatory Rural Appraisal (PRA)	Barabagi, NishanBaria, Shonakata unions	1 session	03/11 /2025
Focus Group Discussion (FGD)	Taltali Upazila (2 groups)	2 groups	04/11 /2025
Key Informant Interview (KII)	chairmen, NGO staff, leaders	3	04/11 /2025
Household Survey	3 unions across Taltali Upazila	20	03/11 /2025
Secondary Data Review	PKCP, Govt. reports, NGO docs, literature	N/A	N/A

Secondary data were compiled from government baseline surveys and maps, historical cyclone and rainfall records obtained from the Bangladesh Meteorological Department, reports from the Ministry of Environment, Forest and Climate Change, and planning documents prepared under the Payra–Kuakata Comprehensive Plan (PKCP) initiative.

3.4.5. Secondary Data

The PKCP documents provided supplementary spatial information, maps, and contextual planning data that were accessible through government sources during the study period but are currently unavailable through the public government portal. INDC documentation; (Ashrafuzzaman et al., 2022) salinity datasets; and published peer-reviewed literature. Secondary data served both to contextualise primary findings and as a source of triangulation.

3.5. DATA ANALYSIS

Qualitative data from PRA, FGD, and KII were analysed using thematic analysis following the six-phase protocol. Themes were identified inductively from the data and subsequently organised according to the study's conceptual framework, including vulnerability, governance, power dynamics, resilience, and climate justice. PRA hazard ranking scores were aggregated across groups to produce community-weighted priority scores (Table 4). Household survey data were analysed using descriptive statistical techniques, including frequencies, percentages, and mean values. Qualitative interview transcripts and field notes were manually coded and categorised through an iterative coding process. A codebook was developed and refined throughout the analysis to ensure consistency in theme identification and interpretation.

3.6. RELIABILITY AND VALIDITY

Reliability and validity were ensured through methodological triangulation by cross-checking findings from PRA, FGDs, KIIs, household surveys, and secondary sources. Member checking was also used to enhance the credibility of the findings.

3.7. ETHICAL CONSIDERATIONS

This study was conducted for academic and research purposes and received no external funding. Participants provided verbal informed consent, and all responses were anonymized to ensure confidentiality. Participation was voluntary, and respondents could withdraw at any time. As the study did not involve medical interventions or sensitive personal data, formal IRB approval was not required. The authors declare no conflicts of interest.

4. Results

4.1. DEMOGRAPHIC AND SOCIO-ECONOMIC PROFILE OF RESPONDENTS

The study engaged a broadly representative cross-section of Taltali's household population. Respondents included both male (approximately 60%) and female (approximately 40%) participants, reflecting deliberate efforts to ensure gender-inclusive representation. The mean age of respondents was approximately 35 years, with the majority having experience in agriculture and/or fishing. Annual household income for most respondents ranged between BDT 100,000 and BDT 200,000, indicating a low-income rural economy characterised by strong dependence on environmental and seasonal productivity. Table 2 presents the socio-economic characteristics of the study population in full.

Table 2: Socio-Economic Characteristics of Survey (Source: Authors' household survey, 2025 (n = 20).)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	12	60%
	Female	8	40%
Age Group	18–30	6	30%
	31–50	10	50%
	51+	4	20%
Primary Livelihood	Agriculture	6	~30%
	Fishing	4	~22%
	Livestock	3	~16%
	Day Labour	1	~6%
	Home maker	2	~10%
	Other	4	~16%
Annual Income (BDT)	<100,000	5	25%
	100,000–200,000	9	45%
	>200,000	6	30%
Education Level	No formal education	4	20%
	Primary	8	40%
	Secondary+	8	40%

4.2. BIOPHYSICAL VULNERABILITY: HAZARD EXPOSURE AND ITS COMMUNITY IMPACT

PRA problem-ranking exercises conducted across all three study unions produced a consistent ordering of perceived hazards, with salinity intrusion ranked as the primary concern across all groups (Table 4). Salinity levels during the dry season (January–May) range from 5 to 20 ppt in surface waters, rendering most canals and shallow tube wells unsuitable for both irrigation and domestic use (Alam et al., 2025; Haq et al., 2024).

The majority of farming households reported cultivating (Figure 3) their land no more than once or twice per year as a direct consequence of salinity and associated water scarcity, a finding consistent with regional salinity data indicating up to a 30–40% reduction in rice productivity in high-salinity areas (Ashrafuzzaman et al., 2022).

Table 3: Cropping Pattern

(Source: Payra-Kuakata Comprehensive Plan Focusing on EcoTourism Structure Plan: 2021-2041, 2023)

Cropping pattern	Area (acre)	%
Single crop	20399.83	58
Double crop	12948.28	37
Triple crop	1744.11	5

Cyclonic events represent a second layer of physical vulnerability. Respondents reported that housing stock across all three unions remains predominantly semi-permanent or temporary in construction, leaving households acutely exposed to cyclonic surges.

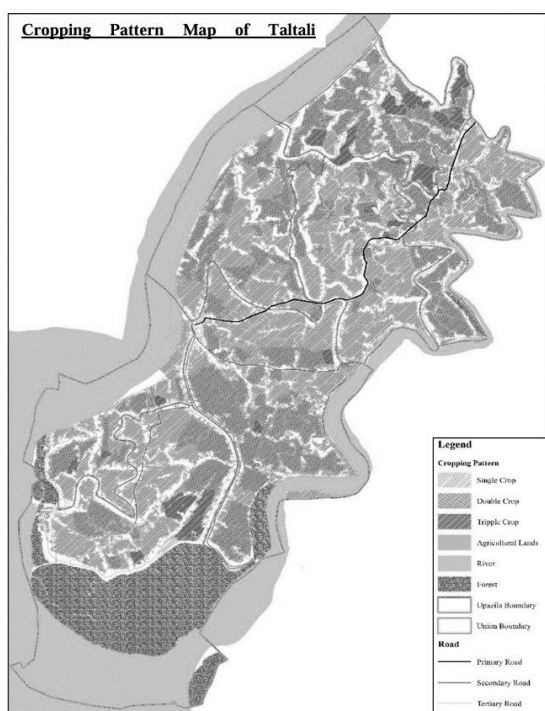


Figure 3: Cropping Pattern Map

(Source: Payra-Kuakata Comprehensive Plan Focusing on EcoTourism Structure Plan: 2021-2041, 2023)

Table 4: Community-Weighted Hazard Ranking: PRA

Rank	Hazard/ Problem	PRA Score	Most Affected Group	Key Impact
1	Salinity Intrusion	1	Farmers / All HHs	Crop failure, water scarcity
2	Cyclone / Tidal Surge	5	Farmers, Fisherfolk	House destruction, livelihood loss
3	Canal Siltation / Degradation	3	Farmers	Irrigation failure, waterlogging
4	Fresh water Scarcity	2	Women, Households	Health, domestic burden

	(dry season)			
5	Pest Outbreak	6	Farmers	Crop damage, income loss
6	Social Conflicts (power/access)	4	Marginal Households	Elite capture, unequal access

The canal network of Taltali constructed 30–40 years ago and central to both irrigation and drainage has progressively degraded through siltation, lack of maintenance, and, as documented in FGDs, deliberate manipulation by powerful landowners who block canal segments to retain water for private agricultural benefit. The Barabagi union was specifically identified in secondary data as lacking a primary canal outlet for agricultural land creating a structural deficit in freshwater access that no household-level coping strategy can overcome.

“The canal was excavated during my father’s time. Since then, it has not been re-excavated for many years. The canal has become silted up, so water can no longer flow properly.” - Participant, FGD-1, male Farmer, 40 years old. A significant proportion of households affected by Cyclone Sidr in 2007 have not yet fully recovered their pre-disaster livelihood status (Figure), a finding that illustrates the compounding, non-linear nature of climate impacts in this context and its climate justice implications. The Ashrayan government housing programme has provided some households with more durable structures; however, community members noted that Ashrayan units are frequently situated on outer sites ('bahir pash') that remain exposed to future climatic events and lack adequate sanitation facilities.



Figure 4: House Condition
(Source: by Author)

4.3. SOCIO-ECONOMIC VULNERABILITY AND COPING STRATEGIES

Financial vulnerability is particularly acute during disaster periods. Approximately 90% of survey respondents reported reducing their household food consumption and basic needs expenditure during climate crisis events (Figure 5).

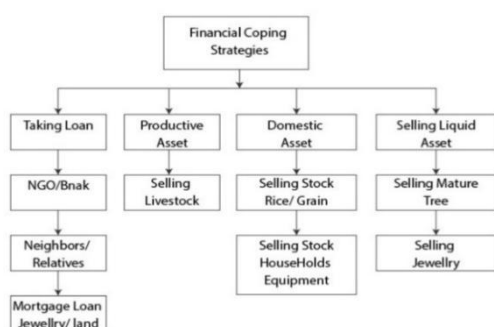


Figure 5: Financial Coping Strategies
(Source: Authors' synthesis from primary data (PRA, FGD, KII, household survey))

Table 5: Multi-Dimensional Vulnerability Assessment Matrix: Taltali Upazila
(Source: Authors' synthesis from primary data and secondary data)

Dimension	Indicator	Current Status	Severity (H/M/L)	Data Source
Physical	Housing quality	Semi-permanent / temporary	High	Field survey / PKCP
	Cyclone exposure	High – Bay of Bengal proximity	High	PKCP, 2023
	Canal functionality	Severely silted, degraded	High	PRA / FGD
Environmental	Salinity levels (dry season)	5–20 ppt	High	PKCP, 2023
	Cropping cycles/year	1–2 cycles (majority)	High	PKCP, 2023
Social	NGO support equity	Uneven; politically biased	High	FGD / KII
	Early marriage rate	After SSC exam	High	FGD
Economic	Annual HH income	BDT 100,000–200,000 (majority)	High	HH Survey
	Food reduction in crises	~90% of HHs reduce intake	Very High	Field Survey
Governance	Inclusive decision-making	Weak; elite-dominated	High	KII / FGD
	Coordination (Govt–NGO)	Poor; overlapping mandates	High	KII

Social consequences of this vulnerability cycle include increased rates of early marriage and school dropout, which particularly summarise the multi-dimensional vulnerability profile identified through the integrated analysis of primary and secondary data, a finding consistent with research on climate-social conflict interactions in coastal Bangladesh (Sultana, 2021).

Table 6: Community Coping and Resilience Strategies Documentation and Assessment

Strategy Type	Specific Strategy	Actor	Limitations
Agricultural Adaptation	Saline-tolerant crop cultivation	Farmers	Limited seed availability; unequal distribution
	Modified cropping calendar	Farmers	Restricted to 1–2 cycles/yr
Water Management	'Badh' (earthen barriers)	Community groups	Temporary; individual only
	Rainwater harvesting tanks	NGOs / HHs	Inequitable distribution
	Seasonal water calendars (PRA)	Community	No formal institutionalization
	Social Conflicts (power/access)		Marginal Households
Financial Coping	Borrowing / informal loans	Households	High-interest debt cycle
	Asset sale / mortgage	Households	Irreversible loss of assets
	Reduced food consumption	Households (~90%)	Nutritional and health consequences
Livelihood Diversification	Seasonal migration (fishing/labour)	Adults, mainly male	Family separation; social costs
Structural	canal repair	Community groups	No institutional support; short-lived
	Ashrayan Govt. housing	Government	Outer sites still climate-exposed

4.3.1. Community Water Management: The 'Badh' System

Among the most significant community-based adaptive practices documented is the construction and maintenance of 'badh' earthen barriers erected across narrow canal segments by groups of neighbouring farmers to block saline water intrusion and store monsoon rainfall for irrigation and domestic use. Badh construction and management is governed by informal community agreements, typically organised through collective decision-making processes term consumption smoothing (reducing food intake, that determine optimal timing for opening and closing canal access based on seasonal salinity patterns and crop calendars.

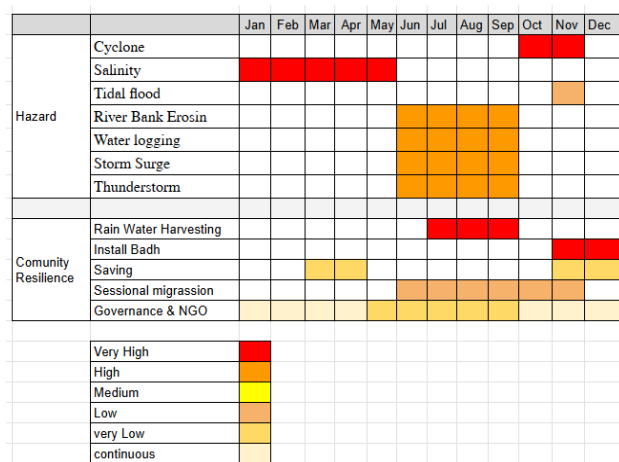


Figure 4: Disaster & Resilience calendar
(Source: Authors' PRA, FGD, KII, and household survey)

"When saline water starts entering, we build earthen embankments by collecting contributions and working together ourselves. When freshwater arrives, we open the embankment to allow water flow."
— Male Farmer, FGD -2.

"Farmers with land adjacent to canals sometimes block freshwater for their own fields, reducing water flow to inland areas and creating unequal water distribution."
— Male Farmer, FGD -2.



Figure 5: Canal sluice System & local coping Badh
(Source: Authors' field survey)

While the badh system demonstrates the sophistication of local ecological knowledge and community self-organisation, its effectiveness is constrained by several structural limitations. As the embankments are temporary, they must be reconstructed each season, and in the absence of formal water-control infrastructure in most canals, farmers have to manage water flows themselves through the seasonal construction and removal of badhs.

Community members noted that only one major canal is equipped with a sluice gate, while water management in the remaining canals depends largely on farmer-led interventions. In addition, influential landowners may at times manipulate water flows for private benefit, and farmers with land adjacent to canals can retain freshwater for their own fields, reducing water availability in more distant areas. Consequently, community members emphasised that additional sluice gates and canal re-excavation are necessary for more equitable and sustainable water management.

4.4. FRESHWATER ACCESS, GENDER, AND SOCIAL BURDEN

The water crisis of Taltali's dry season bears a gendered burden. During periods of peak salinity (January–May), most ponds and canals are unsuitable for domestic use, compelling primarily women and children to travel significant distances to reach functioning deep tube wells. Field survey reveal that these journeys frequently traverse structurally vulnerable terrain (embankments, canal crossings), increasing both the physical burden and safety risks for women.



Figure 6: Way to Reach Drinking Water
(Source: Authors' field survey)

"In the dry season, we often have to cross canals on bamboo walkways or broken bridges to collect water from deep tube wells. This is especially risky for pregnant women and young children, yet water collection remains the responsibility of women and children."
— FGD-1, Woman Participant, Female.



Figure 7: Pond and water tank
(Source: Authors' field survey)

NGO-distributed rainwater harvesting tanks (Figure 9) with capacity: 1,500 litres, represent a significant and valued intervention, providing cooking-quality freshwater during the dry season. However, FGD and KII data reveal a pattern of inequitable distribution: some households paid for tanks while others received them without charge, and allocation did not consistently follow poverty or vulnerability criteria. Multiple respondents reported that distribution was influenced by political connections and social relationships with local elites, a finding that directly illustrates the governance dimensions of climate vulnerability in this context.

4.5. GOVERNANCE, POWER DYNAMICS, AND CLIMATE JUSTICE

The governance analysis synthesized from KII and FGD data identified five interconnected mechanisms through which governance failures compound physical vulnerability in Taltali (Table 7).

Table 7: Governance Failure Mechanisms and Their Consequences for Community Resilience
(Source: Authors' synthesis from KII and FGD data, HH = household.)

Governance Issue	Manifestation in Taltali	Impact on Community	Source
Elite Capture	Canal blockage for private benefit; biased NGO distribution	Reduced freshwater access for marginal HHs	FGD, KII
Top-Down Aid Delivery	Rainwater tanks are distributed unevenly; some pay, some receive free	Social tension; inequity	FGD
Poor Govt-NGO	Overlapping / delayed programs	Duplication; gaps in coverage	KII

Coordination			
Exclusion from Decision-Making	No community water committee; women excluded	Maladaptation; unsustainable strategies	PRA, KII
Climate Justice Deficit	Poorest HHs still recovering from Cyclone Sidr (2007)	Perpetual vulnerability cycle	Field Survey, FGD

"I do not know the exact criteria used to select households for NGO-supported water tanks. It would have been better if the tanks had been distributed based on need. Nevertheless, the tanks have been beneficial, as they allow households to collect and store rainwater. The government has also made efforts to provide some tanks in the area." — Union Chairman, KII Participant of particular significance from a climate justice perspective. The findings reveal that the most economically and socially marginalised households, those facing compound vulnerabilities of landlessness, disability, female-headedness, or chronic debt were least likely to have received government or NGO adaptation support, and least represented in any formal decision-making process. This mirrors the structural injustice documented by (Sultana, 2021) in water governance contexts across Bangladesh, where the formal language of community participation frequently masks the de facto exclusion of the most vulnerable.

5. Discussion

The findings of this study illuminate a consistent and theoretically coherent pattern: the physical exposure of Taltali's communities to salinity, cyclones, and canal degradation is real and severe, but the translation of physical hazard into chronic household vulnerability is driven, to a significant degree, by structural failures in governance and the reproduction of power asymmetries that limit access to adaptation resources.

From an SES perspective (Jozaei et al., 2022), Taltali presents a system in which the social and ecological subsystems have become de-coupled: the biophysical crisis of canal siltation and salinity escalation has outpaced institutional responses, creating a widening gap between ecological conditions and the governance capacities available to manage them. The 'non-stationarity' concept is particularly apt here. Governance frameworks designed for a previous hydrological regime (when canals were functional and salinity manageable) are now structurally misaligned with current environmental realities.

The Pressure-Release model (Wisner et al., 2004) provides a complementary analytical lens. The 'unsafe conditions'

documented in this study degraded housing, silted canals, contaminated water sources are not the product of inevitable natural processes but are sustained by the 'dynamic pressures' of inadequate institutional investment and the 'root causes' of unequal power relations. Elite capture of canal infrastructure, politically biased programme delivery, and the systematic exclusion of marginalised communities from decision-making are not accidental governance failures; they reflect the translation of broader socio-economic inequalities into the domain of climate adaptation.

The climate justice implications are substantial. Bangladesh contributes approximately 0.47% of global greenhouse gas emissions while bearing disproportionate impacts from climate change. Within Bangladesh, communities such as those in Taltali are already among the most economically marginalised, who bear the greatest costs. The findings that 90% of surveyed households reduce food consumption during crisis periods, and that many affected by Cyclone Sidr in 2007 have not fully recovered nearly two decades later, illustrate the cumulative, compounding nature of climate injustice at the household level.

Despite these structural constraints, the study also documents genuine and significant adaptive capacity. The badh system, seasonal calendars, and collective embankment maintenance represent sophisticated, community-driven adaptations grounded in deep local ecological knowledge. These practices align with the community-based adaptation (CBA) principles identified by Niu et al. (2023) as central to building durable resilience: local ownership, integration of traditional knowledge, and governance arrangements that are genuinely participatory. The critical finding is that these community capacities are being systematically undermined rather than supported by the prevailing governance environment conclusions consistent with Choudhury et al.'s (2021) analysis of adaptive governance failures in coastal Bangladesh and Hoque et al.'s (2019) identification of governance quality as a primary determinant of resilience outcomes.

The gendered dimensions of vulnerability documented in this study further enrich this analysis. Women's disproportionate burden in water collection, their exclusion from formal decision-making processes, and their heightened social vulnerability during crises (evidenced by increased early marriage rates) are not peripheral findings but central to understanding how governance failures compound physical vulnerability in gendered ways. This finding resonates with Sultana's (2021) broader argument that water governance in Bangladesh embodies intersecting injustices of class, gender, and spatial marginalisation.

6. Policy and Practical Implications

The findings generate six interconnected policy recommendations, grounded in the empirical evidence and theoretical frameworks of this study.

6.1. ESTABLISH PARTICIPATORY WATER USER COMMITTEES

The most urgent institutional reform identified by community members across all three study unions is the establishment of formally recognised, representative water user committees with genuine authority over canal management, sluice gate operation, and maintenance scheduling. Such committees should be established at the union level, with mandatory representation of marginal groups (women, landless households, small farmers) and clear legal protection against elite capture. This recommendation is grounded in the CBA literature's consistent finding that governance arrangements that are genuinely inclusive produce substantially better adaptation outcomes (Choudhury et al., 2021; Niu et al., 2023).

6.2. PRIORITISE CANAL RE-EXCAVATION AND SLUICE GATE INSTALLATION

Community members across all three unions identified canal re-excavation and sluice gate installation as the most transformative infrastructure investment available. Functional sluice gates at critical canal junctions would allow communities to retain freshwater during monsoon and exclude saline intrusion during dry season, potentially enabling two or more cropping cycles per year where currently only one is possible. The economic and food security benefits of this single infrastructure investment would be substantial. Investment should be prioritised based on hydrological mapping and community-identified priority sites.

6.3. REFORM ADAPTATION SUPPORT DISTRIBUTION

The systematic inequities in NGO and government programme distribution documented in this study where politically connected households receive support while the most vulnerable are excluded represent a fundamental climate justice failure. All adaptation support programmes operating in Taltali should be required to: (i) use transparent, needs-based eligibility criteria; (ii) establish independent community monitoring committees; (iii) publish beneficiary lists at the union level; and (iv) conduct gender-disaggregated targeting to ensure women-headed and marginalised households receive proportionate access.

6.4. INTEGRATE LOCAL KNOWLEDGE INTO FORMAL ADAPTATION PLANNING

The badh system, seasonal calendars, and community-based water management practices documented in this study represent valuable adaptive knowledge that is currently invisible to formal governance processes. A systematic effort to document, validate, and integrate this local knowledge into upazila-level adaptation planning would strengthen both the technical quality of interventions and community ownership of outcomes. This aligns with the CBA principle of building on existing community knowledge rather than displacing it with external expertise (Austin, 2008; Niu et al., 2023).

6.5. IMPLEMENT GENDER-RESPONSIVE ADAPTATION

Women's disproportionate burden in water collection, and their systematic exclusion from formal decision-making, require targeted policy responses. Recommendations include: (i) prioritising rainwater harvesting tank distribution to women-headed and female-majority households; (ii) siting water infrastructure to minimise travel distances and safety risks for women; (iii) mandating at least 40% female representation in water user committees and adaptation planning processes; and (iv) developing awareness programmes addressing the social consequences of climate stress for girls' education and early marriage.

6.6. STRENGTHEN UPAZILA-LEVEL GOVERNANCE COORDINATION

The documented failures of government-NGO coordination including programme duplication, gaps in coverage, and inconsistent monitoring require a structural response. An upazila-level Climate Adaptation Coordination Mechanism should be established, with a mandate to: map all ongoing adaptation programmes, identify coverage gaps and beneficiary overlaps, establish shared data systems on vulnerability and resilience indicators, and create a forum for joint planning between government, NGO, and community actors. This mechanism would be consistent with the 'adaptive governance' framework advocated by (Choudhury et al., 2021).

7. Limitations and Future Research

Several limitations should be acknowledged. First, the study is geographically bounded to three unions within Taltali Upazila, which may limit the direct generalisability of the findings to other sub-district contexts. Nevertheless, the analytical framework and governance-related insights developed in this research are intended to be transferable to comparable coastal upazila settings across southwestern Bangladesh.

Second, the study relies partly on self-reported household survey data, which may be subject to recall bias, particularly regarding historical climate-related events,

livelihood losses, and income estimates. Although triangulation was undertaken through key informant interviews and field observations, some degree of reporting bias may remain.

Third, the cross-sectional nature of the research captures vulnerability and governance conditions at a specific point in time. Consequently, the study is limited in its ability to assess long-term changes in household resilience, institutional effectiveness, and adaptation outcomes. Longitudinal investigations would provide a more comprehensive understanding of evolving climate vulnerability and governance dynamics.

Future research could build upon these findings in several ways. First, longitudinal monitoring of household vulnerability and resilience outcomes in Taltali would help evaluate the long-term impacts of governance reforms and adaptation interventions. Second, comparative studies across upazila-level contexts in Barguna and neighbouring districts, such as Patuakhali and Pirojpur, could test the wider applicability of the governance failure mechanisms identified in this study. Third, GIS-based hydrological modelling of the Taltali canal network could provide quantitative evidence to support infrastructure planning and investment prioritisation. Fourth, further research is needed to explore the gendered dimensions of climate vulnerability through intersectional and feminist analytical approaches. Finally, participatory action research involving water user committees and local institutions could generate practical insights into community-based governance reforms and collaborative adaptation strategies.

8. Conclusions

This study explored the relationships among vulnerability, resilience, and governance in Taltali Upazila, a climate-vulnerable coastal region of Bangladesh. The findings indicate that community vulnerability is shaped not only by environmental hazards such as salinity intrusion, cyclones, and freshwater scarcity, but also by socio-economic inequalities and governance challenges that limit access to adaptation resources.

Despite these constraints, local communities demonstrate significant resilience through collective action, traditional knowledge, and adaptive livelihood strategies. However, strengthening long-term resilience requires more inclusive and climate-just governance that ensures equitable resource distribution and meaningful community participation. Overall, the study highlights that effective climate adaptation depends not only on technical solutions but also on addressing the institutional and social factors that influence vulnerability and resilience in coastal communities.

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