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Reproductive Health Vulnerabilities among Women Living with Salinity: Evidence from Satkhira, Bangladesh

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Abstract

This study examines how climate change–induced salinity intrusion shapes women’s reproductive health vulnerabilities in coastal Bangladesh, focusing on Satkhira District. Using a convergent mixed-methods design, quantitative data were collected from 175 women and analyzed through logistic regression, while qualitative insights were generated from in-depth interviews and focus group discussions to capture lived experiences and contextual dynamics. The findings reveal a significant association between saline water exposure and adverse reproductive health outcomes, including reproductive tract infections (RTIs), menstrual irregularities, and gestational hypertension. Nevertheless, these outcomes are not driven by environmental exposure alone. Instead, they emerge through the interaction of freshwater scarcity, limited healthcare access, and gendered barriers to care-seeking. Qualitative evidence demonstrates how saline water use becomes embedded in everyday practices—particularly menstrual hygiene management (MHM)—transforming routine behaviors into pathways of chronic health risk. This study substantially advances climate-health scholarship by extending the Socio-Ecological Model. It identifies embodied practices, especially MHM, as critical mediating mechanisms linking environmental exposure to biological outcomes. It also advances the Gender and Climate Change Framework by demonstrating that vulnerability is differentiated across income, education, and intra-household power relations. Overall, the study highlights that reproductive health vulnerabilities in salinity-affected regions are co-produced through environmental stressors, gendered practices, and structural inequalities. It calls for integrated, gender-responsive interventions that combine sustainable freshwater provision, accessible reproductive healthcare, and efforts to address underlying social constraints in climate-vulnerable coastal settings.

Keywords: *Climate Change and Health; Coastal Bangladesh; Gender Vulnerability; Menstrual Hygiene Management; Reproductive Health; Salinity Intrusion*

Introduction

Climate change–induced salinity intrusion has emerged as a critical environmental challenge in coastal Bangladesh, driven by sea-level rise, reduced upstream freshwater flow, and the expansion of shrimp aquaculture (Intergovernmental Panel on Climate Change, 2021; Rahman et al., 2018). In districts such as Satkhira, increasing salinity in soil and water has significantly reduced access to safe freshwater, affecting both livelihoods and health outcomes (World Bank, 2016; Ahsan & Warner, 2014). While the environmental and agricultural consequences of salinity are well

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documented, its implications for women's reproductive health remain comparatively underexplored.

Women in salinity-affected areas face heightened risks due to the intersection of environmental exposure and gendered social structures (Abedin et al., 2019; Sinha et al., 2024). Their daily responsibilities—such as water collection, household maintenance, and menstrual hygiene management (MHM)—require frequent contact with saline water, increasing exposure to potential health risks (World Health Organization, 2014; United Nations Development Programme, 2019). At the same time, structural constraints, including limited mobility, restricted decision-making power, and financial dependency, reduce their ability to access healthcare and adopt preventive measures (Nasreen, 2022; Shammi et al., 2019). These overlapping conditions place women at increased risk of reproductive health problems, including reproductive tract infections (RTIs), menstrual irregularities, and pregnancy-related complications such as hypertension (Khan et al., 2011; Rasheed et al., 2016).

Existing studies have established important links between salinity exposure and adverse reproductive and maternal health outcomes in Bangladesh and comparable deltaic regions (Khan et al., 2014; Chakraborty et al., 2019; Tran et al., 2021). Nevertheless, much of this literature tends to examine environmental exposure and gender vulnerability in isolation, often relying on linear cause-effect models in which salinity is treated as a direct driver of health outcomes and social factors are positioned as secondary modifiers. Such approaches provide valuable insights but remain limited in their ability to explain how environmental risks become embedded in everyday practices and how vulnerabilities are reproduced over time through interactions between ecological, social, and institutional processes.

In Bangladesh, salinity intrusion is not solely the consequence of climate change but also the result of long-standing political-economic and governance processes. The rapid expansion of export-oriented shrimp aquaculture since the 1980s has accelerated soil and surface water salinization through the intentional retention of brackish water within coastal polders. At the same time, reduced upstream freshwater flow, particularly during the dry season, together with weak local water governance and unequal distribution of freshwater resources, has intensified water insecurity in districts such as Satkhira. Consequently, women's reproductive health vulnerabilities emerge not only from environmental exposure but also from broader socio-political processes that shape access to safe water and healthcare.

To address this gap, the present study adopts a convergent mixed-methods approach to examine how salinity exposure and structural inequalities jointly shape reproductive health vulnerabilities among women in Satkhira. By integrating quantitative analysis with qualitative insights, the study moves beyond linear interpretations of environmental risk and highlights the role of everyday practices, social constraints, and institutional limitations in shaping health outcomes (Fetters et al., 2013).

This study substantially advances climate-health theory through three original contributions. First, it extends the Socio-Ecological Model by reconceptualizing vulnerability as a dynamic and recursive process, in which health outcomes feed back into and reinforce existing environmental and socioeconomic constraints. Second, it identifies embodied everyday practices—particularly menstrual hygiene management (MHM)—as critical mediating pathways through which salinity exposure becomes biologically internalized, thereby linking macro-level environmental change to micro-level health outcomes. Third, it advances the Gender and Climate Change Framework by demonstrating that vulnerability within salinity-affected populations is differentiated rather than

uniform, shaped by variations in income, education, and intra-household power relations. By foregrounding these contributions, the study moves beyond exposure-driven explanations and provides a more integrated understanding of how reproductive health vulnerabilities are co-produced through the interaction of environmental stressors, gendered practices, and structural inequalities in coastal contexts.

Building on these limitations, this study fundamentally reconceptualizes existing applications of the Socio-Ecological Model. In doing so, it highlights menstrual hygiene management (MHM) as a critical embodied pathway through which salinity exposure becomes biologically internalized, while also demonstrating how adverse health outcomes further reinforce existing socioeconomic and environmental constraints over time. Through this integrated perspective, the study offers a more dynamic and practice-centered understanding of gendered climate-health vulnerability in coastal settings. Guided by this approach, the study addresses two key research questions:

- How does salinity exposure affect women's reproductive health in Satkhira?
- What coping strategies do women employ to manage these challenges?

Literature Review

Environmental Stressors and Reproductive Health

Existing literature consistently identifies salinity intrusion as a major environmental stressor in coastal Bangladesh, linked to declining water quality, agricultural disruption, and public health risks (Rahaman et al., 2025; Shammi et al., 2019). Similar patterns in the Sundarbans of India and the Mekong Delta of Vietnam suggest that salinity-induced health risks characterize deltaic ecosystems broadly, not just Bangladesh (Chakraborty et al., 2019; Xiao et al., 2021). However, the magnitude and mechanisms of these effects remain contested: while epidemiological studies emphasize direct physiological impacts, social science research argues that effects are mediated by poverty, gender relations, water governance, and healthcare accessibility. This suggests salinity should be understood as a socially mediated risk rather than a universally deterministic exposure.

Yet these studies largely treat health outcomes as direct consequences of exposure, with limited attention to the social processes through which risks are experienced. Consequently, the literature under-theorizes how environmental stressors interact with everyday practices and structural inequalities, particularly in shaping gendered health outcomes.

Salinity's Direct Impact on Reproductive Health

A substantial body of research documents the association between saline water exposure and reproductive health complications, including RTIs, menstrual irregularities, and hypertensive disorders during pregnancy (Khan et al., 2011; Khanam, 2021). For instance, Khan et al. (2011) demonstrate a strong link between high sodium intake from drinking water and elevated blood pressure among pregnant women. Similar findings from India and Vietnam reinforce the consistency of this relationship across contexts (Tran et al., 2021).

Despite broad agreement regarding the association between saline exposure and reproductive health, studies differ in explaining causality. Biomedical research largely attributes adverse outcomes to sodium exposure, whereas recent interdisciplinary studies emphasize the interaction of environmental stress with social vulnerability, healthcare inequalities, and adaptive capacity. This

unresolved debate highlights the need for integrated analytical approaches capable of explaining both biological and social mechanisms.

Gendered Vulnerabilities

Feminist political ecology offers an important corrective by emphasizing that environmental risks are experienced unevenly due to gendered roles and power relations (Rocheleau et al., 1996). Studies in Bangladesh highlight that women's responsibilities in water collection and household maintenance increase their exposure to saline water, while patriarchal norms restrict their access to healthcare (Nasreen, 2022).

Existing scholarship often portrays women as a homogeneous vulnerable population. Nevertheless, emerging evidence increasingly demonstrates that vulnerability varies substantially according to socioeconomic status, education, household bargaining power, and access to freshwater resources. These contrasting findings challenge generalized assumptions about gendered vulnerability and point toward the importance of intersectional analysis.

Reproductive Health System Limitations

Research on healthcare systems in coastal regions consistently identifies structural barriers, including inadequate facilities, shortage of skilled providers, and cultural stigma (Shammi et al., 2019). These constraints limit women's access to reproductive healthcare and exacerbate health risks associated with salinity exposure.

Furthermore, there remains considerable debate regarding whether inadequate healthcare infrastructure merely exacerbates environmental risks or actively co-produces reproductive health vulnerability through institutional exclusion. Existing studies rarely conceptualize governance failures as integral components of climate-health vulnerability.

Water Insecurity and Psychosocial Impacts

Water insecurity has been linked not only to physical health risks but also to psychological stress, particularly among women managing menstruation and pregnancy under constrained conditions (Ahmed, S. M., et al., 2005; Rashid & Michaud, 2000). Studies in Bangladesh and India highlight the emotional burden associated with water scarcity and male outmigration (Khan et al., 2011).

However, the psychosocial dimension remains underdeveloped and weakly connected to reproductive health outcomes in the literature. Most studies acknowledge stress as a consequence but do not examine how it may act as a mediating or reinforcing factor in health vulnerability.

Gaps in the Literature

Overall, the literature provides strong evidence on the existence of salinity-related health risks, but several critical gaps remain:

- A dominance of linear cause–effect models, with limited attention to multi-level interactions
- Insufficient focus on everyday practices (e.g., MHM) as mediating pathways
- Lack of intersectional analysis, leading to overgeneralization of women's vulnerability
- Weak integration of environmental, social, and institutional factors into a unified framework
- Limited qualitative insights into lived experiences and coping mechanisms

Contribution of the Present Study

This study substantially advances existing scholarship by addressing these gaps by moving beyond descriptive and linear approaches to develop a multi-level and process-oriented understanding of vulnerability. Unlike previous research, it integrates environmental exposure with gendered practices and institutional constraints within a recursive socio-ecological framework.

This study advances climate-health scholarship by fundamentally reconceptualizing reproductive health vulnerability as a recursive socio-ecological process rather than a linear consequence of environmental exposure. In doing so, it extends the explanatory scope of both the Socio-Ecological Model and the Gender and Climate Change Framework by demonstrating that environmental risks are continuously reproduced through interactions among gendered practices, institutional arrangements, and socioeconomic inequalities. By synthesizing global evidence with local lived experiences, this study provides a more dynamic and explanatory account of reproductive health vulnerability in salinity-affected coastal settings.

Theoretical and Conceptual Framework

This study employs the Socio-Ecological Model (SEM) (Bronfenbrenner, 1979) to analyze how salinity, a societal-level stressor, interacts with individual (e.g., MHM practices), interpersonal (e.g., gendered roles), community (e.g., healthcare infrastructure), and societal (e.g., freshwater policies) factors to shape reproductive health outcomes in Satkhira. The Gender and Climate Change Framework (Alston, 2014) complements this by highlighting how women's water-related roles amplify their vulnerability to salinity, a pattern relevant to other coastal regions like India and Vietnam (Amin et al., 2025).

Conceptual Framework

The framework builds on the Socio-Ecological Model, extending it through a recursive, process-based understanding of vulnerability rather than treating environmental exposure as a linear determinant of health. It conceptualizes reproductive health outcomes as emerging from dynamic interactions across structural, community, and individual levels.

At the structural level, climate-driven salinity intrusion reduces freshwater availability, compounded by poverty and inadequate infrastructure. At the community level, weak healthcare services, water governance challenges, and restrictive social norms limit women's access to resources and care. At the individual level, daily practices—particularly menstrual hygiene management, water use, and care-seeking behavior—mediate the link between exposure and outcomes.

Two key pathways emerge: a direct pathway, where saline water consumption contributes to conditions like gestational hypertension, and an indirect pathway, where repeated exposure through everyday practices—especially during menstruation—leads to reproductive tract infections. Together, these pathways show how environmental risk becomes biologically internalized through routine, gendered practices. A central feature is the framework's emphasis on feedback loops: adverse outcomes such as chronic infections or pregnancy complications reinforce vulnerability by raising healthcare costs, reducing physical capacity, and deepening economic strain—showing vulnerability as continuously reproduced rather than static. Finally, vulnerability is differentiated:

income, education, and intra-household decision-making power shape women's ability to cope, so risks remain unevenly distributed even within similar environmental contexts.

Figure 1 A recursive socio-ecological framework of reproductive health vulnerability in salinity-affected coastal contexts

ENVIRONMENTAL FACTORS		SOCIOECONOMIC BARRIERS
• Salinity intrusion • Water scarcity • Climate change	↓ Environmental stress	• Limited healthcare access • Poverty and education • Social norms
Environmental stress →	REPRODUCTIVE HEALTH OUTCOMES	← Structural constraints
Reinforcing feedback →	↓	← Reinforcing feedback
Reproductive tract infections and gynecological issues	↕ Feedback loop	Gestational hypertension and maternal complications
↘	INDIVIDUAL FACTORS • Menstrual hygiene practices • Health knowledge • Coping strategies	↙

The framework illustrates how salinity exposure interacts with structural constraints, gendered practices, and institutional limitations across multiple levels to shape women's reproductive health outcomes. It emphasizes both direct and mediated pathways, as well as feedback loops through which health outcomes reinforce existing socioeconomic and environmental vulnerabilities over time.

Application to the Study

The integration of the SEM and the Gender and Climate Change Framework provides a comprehensive lens to examine the gendered health vulnerabilities caused by salinity intrusion in Satkhira. By elucidating direct and indirect pathways, the framework underscores the need for multi-level interventions, such as sustainable freshwater systems and gender-sensitive health programs, to mitigate adverse reproductive health outcomes. This approach offers actionable insights for policymakers and practitioners in climate-vulnerable regions, addressing the complex interplay of environmental degradation, gender inequities, and health disparities.

Methodology

Research design, area, and sample size

A convergent mixed-methods parallel design was adopted, integrating quantitative surveys (n=175) with qualitative in-depth interviews (n=5) and focus group discussions (FGDs, n=30) to achieve triangulation and a comprehensive understanding of the phenomenon (Creswell & Plano Clark, 2018; Fetters et al., 2013). The study was conducted in Gabura Union, Shyamnagar Upazila,

Satkhira District — an area with documented high soil and water salinity levels (Dasgupta et al., 2015).

Dumuria and Napitkhali were selected through multi-stage sampling because both villages are located within the salinity-affected Gabura Union and provide the specific field sites for the quantitative and qualitative components of the study.

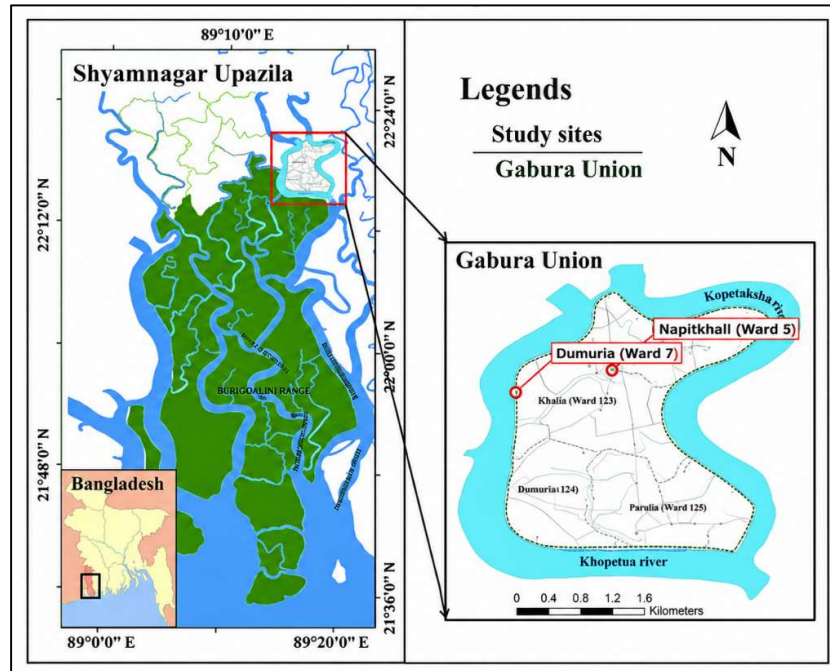
Researcher Positionality and Reflexivity

The researcher is a female Bangladeshi sociologist with over 10 years of experience in gender and environmental research in rural Bangladesh. Having grown up in a semi-urban setting and worked extensively in coastal communities, the researcher acknowledges that her position as an educated, middle-class academic outsider may have influenced participants' responses. To address potential power imbalances, the researcher maintained reflexivity throughout the research process by keeping a detailed reflexive journal, discussing preliminary interpretations with local community health workers, and engaging in member-checking with selected participants. All interviews and FGDs were conducted in the local dialect by the researcher herself, which helped build rapport but also required conscious efforts to avoid leading questions or imposing academic interpretations on participants' lived experiences.

Table 1. Research Design Matrix

Method	Actor(s)	Sample Size	Location
Survey	Women (aged 15–49)	175 (97 Dumuria, 78 Napitkhali)	Dumuria, Napitkhali
In-depth Interview	Health workers	5 (3 Dumuria, 2 Napitkhali)	Dumuria, Napitkhali
FGD	Women (aged 15–49)	20 (2 groups, 10 each)	Dumuria, Napitkhali
FGD	Family members	20 (2 groups, 10 each)	Dumuria, Napitkhali

Figure 2 Map showing the study area and study sites in Gabura Union, Shyamnagar Upazila, Satkhira District, Bangladesh.



Source: Author's own map, based on Banglapedia (2014) and the study's field/GIS data.

Data collection and instruments

Data were collected from February 12 to April 30, 2024. A structured questionnaire, adapted from Khan et al. (2011) and Shammi et al. (2019), included 25 closed-ended and 5 open-ended items on MHM, pregnancy complications, and socioeconomic factors, pilot-tested with 15 women. Semi-structured interviews (45–50 minutes) with health workers and FGDs (60–75 minutes) with 30 participants explored experiences and coping strategies (McNamara, 1999). Participants were recruited via community health workers.

Sample Size Justification

The quantitative sample size of 175 was determined to be adequate for detecting moderate effect sizes in logistic regression, considering the number of predictors and the study's exploratory nature. For the qualitative component, five in-depth interviews and four FGDs (total n=30) were conducted until thematic saturation was reached.

Sampling Limitations

The study adopts a purposive sampling strategy that exclusively includes women who self-reported salinity-related reproductive health problems. While this approach ensures depth and relevance of

experiential data, it introduces a significant methodological limitation by systematically privileging already-affected cases.

This sampling decision risks producing a form of selection bias, where the findings may disproportionately reflect more severe or visible health conditions, while excluding women who are equally exposed to salinity but remain asymptomatic, underdiagnosed, or less likely to articulate health concerns due to stigma or normalization. As a result, the study may overestimate the strength and uniformity of the relationship between salinity exposure and reproductive health outcomes. Moreover, by focusing only on “affected” women, the design limits the ability to construct a comparative analytical framework between affected and non-affected populations. This limitation is particularly important given that vulnerability is not uniform but differentiated across socioeconomic and intra-household contexts. Excluding women without reported health issues may obscure important variations in coping capacity, adaptive practices, and protective factors.

Therefore, while the sampling strategy aligns with the study’s qualitative emphasis on lived experiences, it simultaneously restricts generalizability and limits causal inference, making it difficult to fully capture the spectrum of reproductive health outcomes in salinity-affected settings. Future research would benefit from incorporating comparative or mixed sampling designs, including women with varying levels of exposure and health outcomes, to provide a more balanced and analytically robust understanding.

Data Analysis Procedures, Validity and Reliability

Quantitative data were analyzed using SPSS v26, with logistic regression models controlling for age, education, and income. Qualitative data underwent thematic analysis using Braun and Clarke’s (2006) framework in NVivo 12. To confirm the validity of the study, this study followed triangulation. Qualitative data and quantitative information yielded similar outputs. Reliability was ensured with validated instruments (Cronbach’s alpha: 0.82), and validity was enhanced through pilot testing and member checking.

Ethical Statement

The study adhered to ethical guidelines set by the Bangladesh Medical Research Council. All participants provided written informed consent, and confidentiality was maintained through anonymized data storage and reporting. Participants were informed of their right to withdraw at any time, and no identifying information was included in the analysis or reporting. Ethical approval was obtained from the Training and Research Section of Bangladesh Open University (Approval No.: BOU/Training-448/Internal Research/2022-2023/1580-1).

Results

Quantitative Findings

One of the major problems in Shyamnagar (saline prone area) is the scarcity of fresh drinking water.

Table 2. Demographic Characteristics of Study Participants

Characteristic	Category	Frequency (n=175)	Percentage (%)
Age (years)	15–24	38	21.7
	25–34	72	41.1
	35–49	65	37.1

Education Level	No Formal Education	62	35.4
	Primary Education	57	32.6
	Secondary or Higher	56	32.0
Household Income (BDT/month)	<10,000	128	73.1
	10,000–20,000	39	22.3
	>20,000	8	4.6
Marital Status	Married	141	80.6
	Unmarried	34	19.4
Pregnancy History	At Least One Pregnancy	108	61.7
	No Pregnancy	67	38.3
Residency Duration	≥15 years	175	100.0
Primary Water Source	Saline (Ponds/Tube Wells)	161	92.0
	Freshwater (Limited Access)	14	8.0

Note. Data collected from women aged 15–49 in Dumuria (n=97) and Napitkhali (n=78), Gabura Union, Satkhira, February–April 2024. Mean age: 32.4 years (SD=8.2).

The demographic profile reflects a structurally vulnerable population where low income and inadequate education intersect with near-universal exposure to saline water. Rather than being incidental, these characteristics collectively constrain women’s capacity to avoid or mitigate environmental risk, reinforcing their dependence on unsafe water sources. The near-total reliance on saline water signals not a behavioral choice but a systemic failure in freshwater provision, setting the foundation for subsequent health vulnerabilities observed across the study.

Table 3. Impact of Salinity on Menstrual Hygiene Management (MHM)

MHM Challenge	Frequency (n=175)	Percentage (%)	Odds Ratio (OR)	95% CI	p-value
Difficulty Maintaining MHM	137	78.3	2.73	1.45–5.12	0.002
Specific Health Issues					
Skin Irritations	112	64.0	-	-	-
Rashes	91	52.0	-	-	-
Reproductive Tract Infections (RTIs)	68	38.9	-	-	-

Note. Logistic regression controlled for age, education, and income. Data reflect challenges reported by women using saline water for MHM in Dumuria and Napitkhali, Satkhira, February–April 2024. CI = Confidence Interval.

The high prevalence of menstrual hygiene challenges indicates that saline exposure is not merely an environmental issue but a direct bodily burden experienced during routine practices. The concentration of symptoms such as irritation and infections suggests that MHM is a critical pathway through which environmental stress translates into reproductive health risks. When read alongside Table 2, these findings demonstrate convincingly that, where limited resources and environmental exposure jointly shape adverse outcomes.

Table 4. Prevalence of reproductive health issues and socioeconomic barriers

Variable	Percentage (%)	Number (n)	Description
Saline water use for menstrual hygiene	68.6%	120	Women using saline water for menstrual hygiene due to limited freshwater access
Menstrual irregularities	72.3%	126	Women reporting prolonged or irregular menstrual cycles
Hypertensive disorders during pregnancy	18.3%	32	Women experiencing gestational hypertension linked to high salt intake
Limited healthcare access	64.0%	112	Women reporting barriers to accessing healthcare services
Freshwater scarcity	81.1%	142	Women facing limited access to freshwater for daily activities

The co-occurrence of high saline water use, menstrual irregularities, and inadequate healthcare access reveals a layered vulnerability structure, rather than isolated risk factors. Notably, the overlap between freshwater scarcity and healthcare barriers suggests that environmental and institutional deficits reinforce each other, restricting both prevention and treatment. This pattern establishes that health outcomes are not solely driven by exposure but are amplified by systemic constraints.

Table 5. Logistic Regression Analysis of Health Outcomes Associated with Saline Water Exposure

Health Outcome	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value	Description
Reproductive Tract Infections (RTIs)	2.5	1.14–5.48	0.021	Increased risk of RTIs associated with saline water use for menstrual hygiene
Gestational Hypertension	3.1	1.36–7.06	0.008	Increased risk of gestational hypertension linked to high salt intake from water

This table presents the logistic regression results, showing associations between saline water exposure and specific reproductive health outcomes, adjusted for age, education, and income.

The regression results confirm a statistically significant association between saline exposure and reproductive health risks; however, these relationships should be interpreted within a broader structural context. The elevated odds of RTIs and hypertension suggest that salinity acts as a key risk amplifier, but not in isolation. When considered alongside the socioeconomic patterns identified in earlier tables, these findings imply that biological risk is mediated through social and environmental conditions, rather than being purely physiological.

Taken together, the findings across Tables 2–5 demonstrate that reproductive health vulnerabilities emerge from the intersection of environmental exposure, socioeconomic disadvantage, and institutional limitations, rather than from any single factor alone. This reinforces

the need for a multi-level analytical approach, which is further explored through the qualitative findings in the following section.

Qualitative Findings

Thematic analysis of in-depth interviews and FGDs identified three key themes: (1) salinity-driven health challenges, (2) socioeconomic barriers to healthcare access, and (3) adaptive coping strategies. Greater emphasis is placed on participants' voices to capture the lived realities of salinity-induced reproductive health vulnerabilities.

Theme 1: Salinity-Driven Health Challenges

Women consistently linked saline water use for menstrual hygiene management (MHM) to persistent reproductive health problems, particularly infections, irritation, and discomfort.

A 32-year-old mother from Dumuria explained:

"Using salty water during my period causes burning and itching. It never fully goes away."

Similarly, a younger participant (age, 19) noted:

"Since I started menstruation, I've only used this water. I thought the pain was normal."

A pregnant woman (age, 26) highlighted additional concerns:

"During pregnancy, the itching became worse. I was afraid something might happen to my baby."

Older women also reflected on long-term exposure:

"We have been using this water for years. These problems are part of our lives now." (45-year-old, Napitkhali)

Health workers confirmed these patterns:

"Most women come with repeated infections. The problem is not one-time—it keeps returning."

These accounts demonstrate how salinity exposure is experienced not as an isolated risk but as a chronic and normalized condition affecting women across life stages.

Theme 2: Socioeconomic Barriers to Healthcare Access

Participants described multiple barriers to accessing healthcare, including financial constraints, distance, and gendered mobility restrictions.

A low-income participant (age, 38) stated:

"The clinic is far, and I cannot afford transport. So I just tolerate the pain."

A younger unmarried woman (age, 22) emphasized stigma:

"Talking about these issues feels (shameful). I don't feel comfortable going to a doctor."

A pregnant respondent highlighted dependency:

"I need permission and money from my husband. If he says no, I cannot go."

Even relatively better-off participants faced structural barriers:

“We can arrange money somehow, but there is no specialist nearby. We still don’t get proper care.” (age, 34)

Health workers further noted systemic limitations:

“We have very limited resources. Many women come late when the condition becomes serious.”

These narratives reveal that healthcare access is not only a matter of availability but is deeply shaped by economic capacity, gender norms, and institutional gaps.

Theme 3: Adaptive Coping Strategies

Women reported various coping strategies, though most were partial, temporary, or constrained by environmental and financial limitations.

Rainwater harvesting was mentioned as a preferred alternative:

“When it rains, we store water for washing. That is the only time we feel comfortable.” (age, 29)

However, its seasonal limitation was evident:

“In the dry season, there is no option. We have to go back to salty water.” (age, 41)

Some women relied on traditional remedies:

“We use boiled leaves to clean ourselves. It gives a little relief, but not fully.” (age, 35)

Younger participants expressed frustration with limited options:

“We know this water is harmful, but we don’t have a choice.” (age, 18)

A relatively better-off woman described selective coping:

“Sometimes we buy water for drinking, but we cannot afford it for everything.” (age, 30)

These responses highlight both agency and constraint, showing that while women actively attempt to manage risks, their strategies are shaped—and often limited—by structural and environmental conditions.

These qualitative insights complement the quantitative findings by illustrating how statistically significant associations—such as increased RTIs and healthcare barriers—are experienced in everyday life.

Integration of Findings

The convergent mixed-methods design of this study enables a deeper, more nuanced understanding of reproductive health vulnerabilities by allowing qualitative data to explain the mechanisms behind the quantitative associations rather than merely confirming them. While the two datasets largely converge, the integration also reveals important areas of divergence that enrich interpretation without contradicting the core findings. This joint analysis directly supports the study’s conceptual framework by demonstrating how environmental exposure (salinity) interacts with social and institutional layers through everyday practices, producing and sustaining vulnerability in a recursive manner.

First, the logistic regression shows a statistically significant association between saline water use for menstrual hygiene management (MHM) and reproductive tract infections (RTIs) (OR = 2.5,

95% CI: 1.14–5.48, $p = 0.021$). Qualitative accounts explain why this elevated risk occurs. Women repeatedly described saline water as causing immediate and persistent physiological irritation that becomes a chronic pathway for infection. A 32-year-old mother from Dumuria stated: “Using salty water during my period causes burning and itching. It never fully goes away.” A 19-year-old participant added: “Since I started menstruation, I’ve only used this water. I thought the pain was normal.” Health workers corroborated this by noting, “Most women come with repeated infections. The problem is not one-time—it keeps returning.” These narratives illustrate that the statistical association is not merely correlational; it is the embodied outcome of routine MHM practices that turn limited freshwater access into a daily vector for infection.

Second, 78.3% of surveyed women reported difficulty maintaining MHM (OR = 2.73, 95% CI: 1.45–5.12, $p = 0.002$). The qualitative data clarify why this difficulty is so widespread. Participants emphasised that saline water use is not a behavioural preference but a structural necessity imposed by freshwater scarcity. A 41-year-old woman from Napitkhali explained: “In the dry season, there is no option. We have to go back to salty water.” Even when women attempted alternatives (rainwater harvesting or boiled-leaf remedies), these were described as partial and temporary. This explains the high prevalence: the quantitative figure reflects systemic water insecurity rather than individual failure, transforming an environmental constraint into a gendered reproductive health burden.

Third, the regression indicates that saline water exposure is significantly associated with gestational hypertension (OR = 3.1, 95% CI: 1.36–7.06, $p = 0.008$). Qualitative evidence reveals why this link persists despite awareness. Pregnant women reported being unable to reduce salt intake because safer water was either unavailable or unaffordable. A 26-year-old pregnant participant shared: “During pregnancy, the itching became worse. I was afraid something might happen to my baby.” Another woman noted that even when families could buy limited freshwater, it was prioritised for drinking and not for the larger volume needed for hygiene or cooking. Thus, the elevated odds ratio is mediated by economic and gendered power dynamics that constrain behavioural change during a physiologically vulnerable period.

Areas of divergence (no contradictions)

While quantitative data indicate near-uniform exposure (92% of women rely on saline water as the primary source), qualitative findings highlight meaningful variation in lived experiences and coping capacity. Some women (particularly those with slightly higher income or supportive family members) reported selective coping strategies such as seasonal rainwater storage or occasional purchase of freshwater. In contrast, the majority—especially poorer, less-educated, or less mobile women—described complete dependence on saline water. This divergence does not contradict the quantitative pattern; rather, it illustrates the moderating role of income, education, and decision-making autonomy that the conceptual framework identifies. The variation explains why the same environmental exposure produces different intensities of health outcomes across the sample.

Overall convergence and theoretical implication

The integration illustrates that the statistically significant associations (RTIs, MHM difficulties, and gestational hypertension) are not isolated biological effects of salinity. Instead, qualitative data provide the “why”: salinity becomes a chronic health risk precisely because it is embedded in routine gendered practices (MHM, water collection) and amplified by socioeconomic and institutional barriers (freshwater scarcity, healthcare access, patriarchal norms). This joint evidence validates the study’s triangulation approach and strengthens the recursive dimension of the Socio-

Ecological Model—poor health outcomes feed back into deeper poverty and restricted access, perpetuating vulnerability over time.

By moving beyond parallel presentation to explicit mechanistic explanation, this integrated analysis offers a richer, multi-layered account of how climate-induced salinity produces gendered reproductive health risks in Satkhira.

Discussion

Unlike many deltaic settings, reproductive health vulnerability in coastal Bangladesh is shaped by a distinctive combination of export-oriented shrimp aquaculture, contested freshwater governance, and climate-induced salinity intrusion. These interacting processes have transformed freshwater scarcity from an environmental concern into a structural condition affecting women's everyday reproductive health practices. Consequently, the findings should be interpreted within the broader political ecology of coastal Bangladesh, where environmental degradation and institutional governance jointly shape health inequalities.

This study advances understanding of reproductive health vulnerabilities in salinity-affected coastal Bangladesh by demonstrating that adverse health outcomes are not produced by environmental exposure alone, but emerge through the interaction of ecological stressors, gendered social relations, and institutional constraints. By integrating quantitative associations with qualitative lived experiences, the findings move beyond linear interpretations of climate–health linkages and instead conceptualize vulnerability as a dynamic, socially mediated, and recursive process.

Consistent with existing literature, the study identifies statistically significant associations between saline water exposure and adverse reproductive health outcomes, including reproductive tract infections (RTIs) and gestational hypertension (Khan et al., 2011; Khan et al., 2014). Similar patterns have been reported in other deltaic regions, such as the Indian Sundarbans and the Mekong Delta, where salinity intrusion has been linked to gynecological complications and maternal health risks (Chakraborty et al., 2019; Tran et al., 2021). Nevertheless, rather than treating these outcomes as direct consequences of environmental exposure, the present study demonstrates that salinity operates as a risk amplifier embedded within broader structural conditions. The elevated risks observed are therefore shaped by constrained access to freshwater, limited healthcare infrastructure, and gendered barriers to care-seeking, reinforcing insights from the social determinants of health literature (Ahmed, S. M., et al., 2005; Marmot, 2005; Solar & Irwin, 2010).

This study substantially advances the Socio-Ecological Model by moving beyond its conventional static application. In contrast, the findings here support a recursive systems perspective, in which health outcomes actively feed back into the conditions that produce them. For instance, recurrent RTIs and pregnancy-related complications not only reflect existing vulnerabilities but also deepen them by reducing women's productivity, increasing healthcare expenditures, and reinforcing household-level economic constraints. These feedback loops demonstrate that vulnerability is not a fixed state but an ongoing process reproduced over time.

This study also reconceptualizes menstrual hygiene management (MHM) as an embodied pathway linking environmental exposure with reproductive health outcomes. While previous

research has acknowledged gendered exposure to environmental risks, it has rarely specified the mechanisms linking macro-level environmental change to micro-level health outcomes. The findings show that routine practices, such as using saline water during menstruation or pregnancy, transform structural constraints into chronic physiological stress. This insight bridges public health perspectives with Feminist Political Ecology by demonstrating how environmental conditions are experienced and reproduced through daily, gendered practices.

In addition, this study illustrates the intersectionally differentiated nature of marginalization within seemingly uniform exposure conditions. Although the majority of women in the study rely on saline water, the intensity and lived experience of health risks vary significantly across socioeconomic and intra-household contexts. Women with relatively higher income or greater decision-making autonomy are better able to adopt coping strategies, such as rainwater harvesting or purchasing freshwater, whereas poorer and more socially constrained women remain fully dependent on saline sources. This variation underscores that climate-induced health risks are not only gendered but also intersectionally differentiated, shaped by income, education, and power relations. As illustrated in Figure 1, the findings confirm the recursive and multi-level dynamics of vulnerability.

Importantly, the integration of quantitative and qualitative findings establishes a more comprehensive understanding of how vulnerability operates in practice. While statistical analysis identifies significant associations between salinity exposure and health outcomes, qualitative evidence explains the underlying mechanisms, revealing how these risks are normalized and sustained in everyday life. This convergence strengthens the validity of the findings and supports the argument that reproductive health vulnerabilities are co-produced through the interaction of environmental, social, and institutional factors. These findings should be interpreted with caution given the study's sampling strategy, which focused exclusively on women who self-reported salinity-related reproductive health problems. This may have amplified the observed associations by foregrounding more severe or visible cases, while underrepresenting asymptomatic or less-articulated experiences. As such, the results are more indicative of the intensity and lived experience of vulnerability than its full population-level distribution.

From a policy perspective, the findings suggest that addressing reproductive health vulnerabilities in salinity-affected regions requires moving beyond single-sector interventions. Efforts focused solely on healthcare provision or behavioral change are unlikely to be effective unless accompanied by structural interventions that improve access to safe freshwater and address gendered barriers to care. Integrated approaches combining water security, reproductive healthcare, and gender empowerment are therefore essential for reducing long-term vulnerability in coastal communities.

Overall, this study reconceptualizes climate-related reproductive health vulnerability by shifting focus from salinity as a direct cause of health problems toward understanding how environmental stressors, gendered practices, and structural inequalities interact to produce and sustain reproductive health risks over time, empirically validating the recursive, multi-level dynamics proposed in the conceptual framework.

Conclusion

This study illustrates that salinity intrusion in coastal Bangladesh is significantly associated with adverse reproductive health outcomes among women, including reproductive tract infections (RTIs), menstrual irregularities, and gestational hypertension. However, these outcomes cannot be understood as the direct effects of environmental exposure alone. Rather, they are produced through the interaction of salinity with socioeconomic disadvantage, institutional limitations, and gendered social relations, which together shape both risk and women's capacity to respond.

By integrating quantitative findings with qualitative lived experiences, the study shows that statistical associations are embedded in everyday practices, particularly menstrual hygiene management and water use. At the same time, variations in coping strategies reveal that vulnerability is not uniform; it is mediated by factors such as income, education, and decision-making autonomy, leading to differentiated health outcomes even under similar environmental conditions. This study substantially advances both the Socio-Ecological Model and the Gender and Climate Change Framework to incorporate a recursive understanding of vulnerability, where health outcomes reinforce and reproduce existing disadvantages. It also refines the Gender and Climate Change Framework by highlighting the intersectional nature of gendered vulnerability in salinity-affected contexts.

From a policy perspective, the findings underscore the need for integrated and multi-level interventions. Addressing reproductive health risks in coastal regions requires not only improving healthcare access but also ensuring sustainable freshwater availability and reducing gender-based barriers to care. Future research should adopt longitudinal and comparative approaches to better capture the evolving nature of salinity exposure and its long-term health impacts, as well as to evaluate the effectiveness of targeted interventions in reducing vulnerability in climate-affected communities.

Data availability statement

All data are freely available in the manuscript.

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