Working Paper 03

Socio-Economic and Environmental Impacts of Urban River Pollution in Bangladesh

A Case of Buriganga

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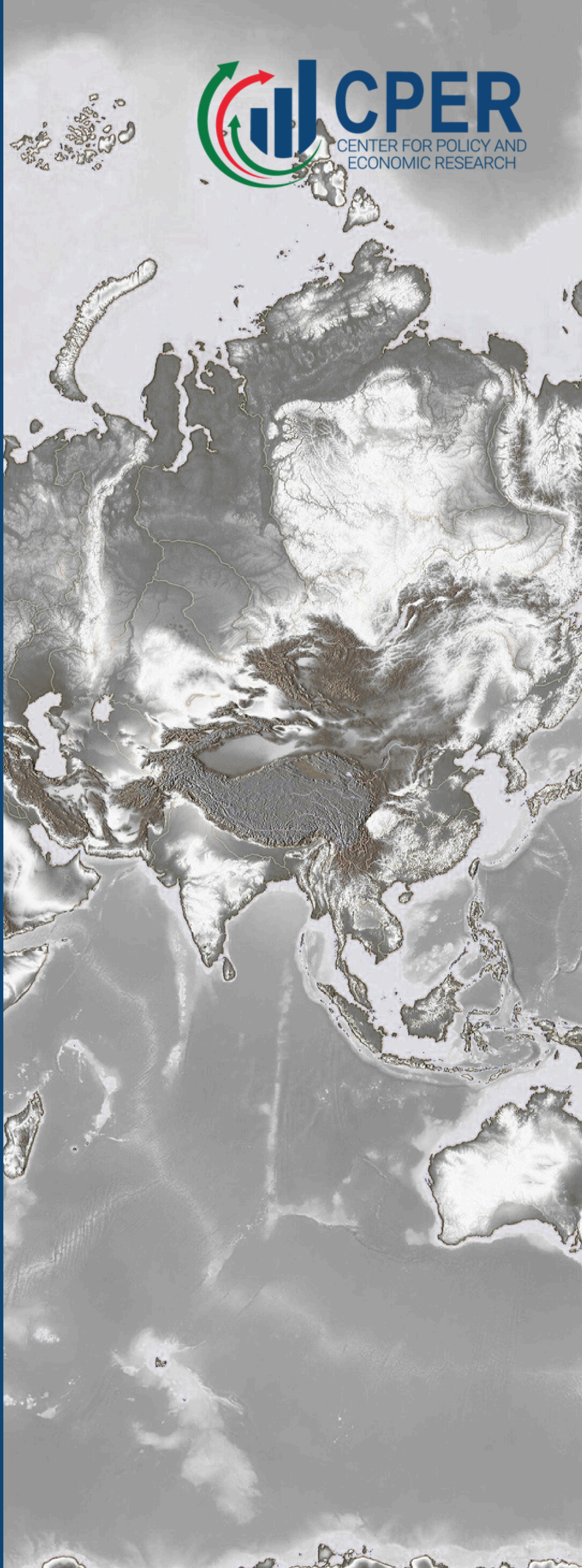
June 2023



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Abstract

This study examines the socio-economic and environmental impacts of pollution in the Buriganga River, focusing on community living conditions, water quality, and adaptive behaviors, while identifying strategies for sustainable pollution reduction. An exploratory mixed-methods approach was adopted, combining structured surveys (n = 250), expert interviews, and field observations across five pollution-affected urban areas in Dhaka. Quantitative data were analyzed using chi-square tests and logistic regression, while qualitative insights provided contextual depth and triangulation. Results indicate that Buriganga's pollution continues to reshape livelihoods, health, and environmental perceptions. Occupational shifts were significantly associated with gender and pollution awareness, while water use patterns varied by age and residential location. Despite reported improvements in water color and odor following tannery relocation, ecological recovery remains very insignificant, with tremendous biodiversity loss and health risks—including diarrhea, skin disease, and asthma—persisting. Expert opinions confirmed that industrial effluents, sewage mismanagement, waste dumping, and weak regulatory enforcement are the primary drivers of river health degradation in the Buriganga. By integrating quantitative and qualitative evidence, this study advances understanding of urban river pollution in developing contexts and offers policy-relevant insights for ecological restoration and sustainable urban river governance.

Keywords: Buriganga River, water pollution, socio-economic impacts, ecological degradation, quantitative analysis, SDG, Bangladesh.

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1. Introduction

Bangladesh, a densely populated deltaic nation in South Asia, relies extensively on its intricate river network for socio-economic sustenance, environmental stability, and ecological diversity. The country's rivers, including the Ganges-Brahmaputra-Meghna (GBM) system, serve as vital arteries for agriculture, transportation, fisheries, and water supply, supporting the livelihoods of millions (MoFA, 2014). There are 57 transboundary rivers in Bangladesh, with 54 shared with India, where water flow is influenced by seasonal rainfall and upstream diversions such as the Farakka Barrage (Thakur, 2020; Barua et al., 2019). However, rapid urbanization, industrialization, and population growth have precipitated severe environmental degradation, particularly in urban waterways. In Dhaka, the capital city with an estimated population exceeding 16.8 million (Sakamoto et al., 2019), peripheral rivers such as the Buriganga, Turag, Shitalakshya, and Balu have historically underpinned economic activities, including trade, navigation, and resource extraction (Banu, 2013). Nevertheless, these rivers now face existential threats from pollution, encroachment, and unsustainable practices, transforming them into conduits of waste rather than sources of prosperity (Chowdhury et al., 2011).

The Buriganga River, flowing along Dhaka's southwestern periphery, exemplifies this crisis. Originating as a distributary of the Dhaleshwari River, it spans approximately 27 km with an average width of 400 m and depths ranging from 7.6 m to 19 m (Islam et al., 2015). Historically revered as the "Old Ganges," the Buriganga has been integral to Dhaka's development since the Mughal era, facilitating commerce and providing essential ecosystem services (Islam et al., 2015). Today, it supports diverse livelihoods, including fishing, agriculture, and boat-based transportation, while also serving as a critical drainage and flood mitigation system (Alam, 2008). However, unchecked industrial discharges, municipal sewage, and domestic waste have rendered sections of its waters biologically dead, with pollution levels exceeding national and international thresholds (Bashar & Fung, 2020). Industries clustered along its banks, particularly tanneries in Hazaribagh and textile units, release untreated effluents containing heavy metals, chemicals, and organic pollutants, exacerbating water quality deterioration (Islam et al., 2015; Mohiuddin et al., 2015). This pollution not only impairs aquatic ecosystems but also imposes socio-economic burdens on river-dependent communities, manifesting in health risks, reduced productivity, and disruptions to livelihoods (Arefin & Mallik, 2017). Contextualized within Bangladesh's broader environmental challenges, the degradation of the Buriganga highlights the interplay between economic growth and ecological sustainability, underscoring the need for integrated assessments of pollution's multifaceted impacts (Hasan et al., 2019).

The pollution of the Buriganga River represents a profound environmental and socio-economic challenge, with cascading effects on human health, biodiversity, and economic viability. Despite governmental designations of the river as an Ecologically Critical Area (ECA) under the Environmental Conservation Rules (1997) and efforts by the Department of Environment to monitor water quality (Kolås et al., 2013), pollution persists unabated. Daily discharges of approximately 6,000 tons of liquid waste, including 8 million liters from tanneries alone, have elevated biochemical oxygen demand (BOD), reduced dissolved oxygen (DO), and introduced toxic contaminants, rendering the water unfit for human use or aquatic life (Kawser Ahmed et al., 2016; Akbor et al., 2017). This degradation stems from inadequate infrastructure, weak enforcement of regulations, and rapid, unplanned urbanization, which have facilitated illegal encroachments and waste dumping (Sathi et al., 2019; Rahman, 2009).

Communities along the riverbanks, often comprising low-income households reliant on the Buriganga for fishing, irrigation, and daily needs, face heightened vulnerabilities (Rahman, 2009). Pollution-induced declines in fish stocks and agricultural yields undermine food security and income, while exposure to contaminated water contributes to waterborne diseases and respiratory ailments (Arefin & Mallik, 2017; Hasan, 2011). Ecologically, the river's altered physicochemical properties have decimated biodiversity, disrupting food chains and ecosystem services such as water purification and habitat provision (Kawser Ahmed et al., 2016; Mohiuddin et al., 2011). The problem is compounded by a lack of comprehensive, empirical data on the interplay between pollution sources, resident behaviors, and long-term impacts, hindering effective policy interventions (Majumder, 2009; Bhuiyan et al., 2014). This study addresses this gap by examining how pollution affects living conditions, water quality, and socio-economic dynamics, while exploring pathways for mitigation.

The primary aim of this study is to analyze the socio-economic, environmental, and ecological impacts of pollution in the Buriganga River. To achieve this aim, the study encompasses two specific objectives:

- To observe and assess the living conditions, pollution levels, water quality, and residents' behavior related to Buriganga River pollution.
- To obtain insights into the pollution of the Buriganga River and identify potential solutions.

The following research questions guide this study:

- What are the prevailing pollution levels and water quality parameters in the Buriganga River, and how do they influence the living conditions and behaviors of adjacent residents?
- What are the primary socio-economic, environmental, and ecological impacts of pollution on river-dependent communities and ecosystems?
- What insights can be derived from expert perspectives and field observations regarding the sources and persistence of pollution in the Buriganga River?
- What strategies and interventions can effectively mitigate pollution and restore the river's health, considering socio-economic constraints and ecological priorities?

This research holds substantial significance for environmental policy, sustainable development, and public health in Bangladesh and similar urbanizing contexts. Systematically analyzing the Buriganga River's pollution impacts provides empirical evidence to inform targeted interventions, bridging gaps in existing literature that often focus on biophysical assessments without integrating socio-economic dimensions (Ali et al., 2008; Kibria et al., 2015). The findings can guide policymakers in enhancing regulatory enforcement, such as through improved wastewater treatment and community engagement, which may potentially alleviate health burdens and restore ecosystem services (Rahman & Ancev, 2014; Ferdous et al., 2012). For river-dependent communities, the study highlights adaptive strategies to mitigate livelihood disruptions, fostering resilience amid environmental degradation (Saha & Hossain, 2009).

The study quantifies associations (e.g., occupational changes and pollution awareness), offering a new perspective on causality that is absent in descriptive studies (Liu et al., 2019). It resolves debates on governance by incorporating expert views on mitigation, such as wastewater treatment and enforcement, and extends beyond critique to provide practical recommendations (Das et al., 2021).

Ultimately, this research contributes a model for urban river management in deltas, enhancing equity in resource allocation (as indicated by Gini indices in Liu et al., 2019) and supporting sustainable development by linking local behaviors to broader ecological restoration efforts.

On a broader scale, the research contributes to global discourses on urban river management, aligning with Sustainable Development Goals (SDGs) 6 (Clean Water and Sanitation), 11 (Sustainable Cities and Communities), and 14 (Life Below Water). It underscores the economic value of healthy rivers, estimating potential gains from restored fisheries and agriculture, while advocating for interdisciplinary approaches that incorporate local knowledge (Bashar & Fung, 2020). Ultimately, this work can serve as a model for rehabilitating polluted waterways in densely populated deltas, promoting equitable and sustainable resource governance.

The scope of this study is confined to the Buriganga River within Dhaka's urban periphery, focusing on key pollution hotspots, including Hazaribagh, Kamrangirchar, Lalbagh, Narayanganj, and Sadarghat. It encompasses assessments of water quality parameters (e.g., BOD, DO, heavy metals), socio-economic surveys of residents, and expert insights into pollution sources and solutions. Data collection draws from field observations, laboratory analyses, and interviews conducted up to late 2022, ensuring relevance to contemporary conditions.

The remainder of this working paper is structured as follows: Section II outlines the research methodology, including data collection techniques, sampling procedures, and analytical frameworks. Section III presents the empirical findings from resident surveys and field observations. Finally, Section IV concludes with key implications, policy recommendations, and avenues for future research.

2. Methodology

This study employs a mixed-methods approach to investigate the socioeconomic, environmental, and ecological impacts of pollution in the Buriganga River, relying exclusively on primary data to address the research objectives. The methodology integrates quantitative surveys, qualitative expert interviews, and field observations to provide a comprehensive analysis of pollution dynamics and inform policy recommendations for river restoration.

2.1 Data Collection Methods

Primary data were collected through three complementary methods: structured surveys, expert interviews, and field observations, each designed to capture distinct aspects of the Buriganga River's pollution dynamics.

2.1.1 Structured Surveys

A questionnaire comprising 27 questions (Appendix 1) was administered to 250 respondents from January to June 2021 in five study areas: Hazaribagh, Kamrangirchar, Lalbagh, Sadarghat, and Narayanganj (Figure 1). The survey captured demographic characteristics (e.g., gender, age, education), socioeconomic factors (e.g., occupation, duration of residency), and pollution-related variables (e.g., water usage, health outcomes, awareness of pollution). The questionnaire was pilot-tested with family and friends to ensure validity, reliability, and clarity, with revisions to eliminate ambiguous or irrelevant questions (Jenn, 2006). Surveys were conducted via face-to-face interviews in Bengali by trained enumerators to maximize response rates and minimize misinterpretation, with strict adherence to ethical standards (informed consent, voluntary participation, confidentiality) (Islam, 2011).

Figure 1. Study area (Hazaribagh, Kamrangirchar, Lalbagh, Sadarghat, and Narayanganj)

2.1.2 Expert Interviews

Structured interviews were conducted with five experts in environmental management and policy: Mohammad Abdul Matin (Bangladesh Poribesh Andolon), Syeda Rizwana Hasan (Bangladesh Environmental Lawyers Association), Professor Dr. A. K. Enamul Haque and Professor Dr. Basanta Kumar Barmon (East West University), and Dr. Yousuf (GPAD). Guided by four predetermined questions (Appendix 2), these interviews explored the river's condition, the causes of pollution, its socioeconomic and ecological impacts, and potential mitigation strategies. Conducted in formal settings, the interviews provided in-depth qualitative insights from stakeholders with specialized expertise (Gläser & Laudel, 2009).

2.1.3 Field Observations

Multiple boat expeditions across the five study areas facilitated direct assessments of pollution sources (e.g., industrial discharges, waste disposal practices), water quality, and local living conditions. Observations were systematically documented to provide contextual evidence of environmental degradation, complementing survey and interview data (Al-Mizan et al., 2020).

2.2 Sample Selection

The target population comprised residents and stakeholders in Hazaribagh, Kamrangirchar, Lalbagh, Sadarghat, and Narayanganj, selected for their high pollution levels and significant reliance on the Buriganga River for livelihoods (e.g., fishing, boating) and domestic needs (Alim-ul Bahar, 2012; Moniruzzaman et al., 2012; Papry, 2019; Paul, 2008; Rashedul Islam, 2018). A sample size of 250 respondents was determined based on practical considerations for exploratory research, ensuring sufficient statistical power for categorical analyses while balancing resource constraints (Edgar & Manz, 2017). Convenience sampling, a non-probability technique, was employed due to its efficiency and suitability for accessing river-dependent communities in urban settings (Stratton, 2021). Respondents were selected from accessible locations within the study areas, reflecting varying pollution intensities due to proximity to former tannery sites and urban waste sources. While convenience sampling may introduce selection bias, triangulation with qualitative data from interviews and observations mitigates concerns about external validity (Bornstein et al., 2013).

2.3 Analytical Techniques

2.3.1 Chi-Square Tests of Independence

Pearson's chi-square test of independence was used to examine the associations between categorical variables, assessing the socioeconomic, environmental, and ecological impacts of pollution in the Buriganga River. This non-parametric test evaluates whether observed frequencies deviate significantly from expected frequencies under the null hypothesis (H_0) of independence, using the formula:

$$\chi^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \tag{1}$$

where χ^2 is the test statistic, O_{ij} represents observed frequencies, E_{ij} denotes expected frequencies, and i and j indicate row and column indices, respectively. The test was applied to categorical data from the 2021 survey (n = 250), despite using convenience sampling, due to the categorical nature of the variables and the exploratory scope of the study. The chi-square test identifies statistically significant associations ($p < 0.05$) but does not establish causation; therefore, careful interpretation of relationships is required (McHugh, 2013).

Six groups of tests were conducted using equation 1, each focusing on a dependent variable paired with multiple independent variables, as detailed in Table 1. These groups align with logistic regression models to systematically explore associations. For each group, the chi-square test assessed whether the dependent variable was significantly associated with each independent variable, with H_0 positing no relationship (independence) and H_1 indicating a relationship (dependence). If variables were uncorrelated ($p \geq 0.05$), they were considered independent, implying no influence between them. Significant associations ($p < 0.05$) suggest dependence, informing subsequent logistic regression analyses.

Table 1. Chi-Square Test Variables

Test Group	Dependent Variable	Independent Variables
1	Occupational Change	Gender, age group, education level, area of residence, residency duration, pollution knowledge, pollution awareness, pollution status, disease history, disease types, restoration perceptions
2	Water Usage	Gender, age group, education level, area of residence, residency duration, pollution knowledge, pollution awareness, water condition, disease history, disease types, restoration perceptions
3	Water Condition Perception (color, taste, smell)	Gender, age group, education level, area of residence, pollution knowledge, pollution awareness, primary pollution cause
4	Aquatic Life Status (fish, flora, fauna, aquatic organisms)	Water condition, pollution status, water quality impacts (color, taste, smell)
5	Livelihood Viability	Gender, age group, education level, pollution knowledge, pollution awareness, water condition, awareness of regulations, and the primary pollution cause
6	Disease Prevalence	Gender, age group, education level, area of residence, residency duration, pollution knowledge, pollution awareness, water usage types, restoration perceptions

Notes: The chi-square test uses Equation 1: $\chi^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$. All variables are categorical, derived from the 2021 survey (n = 250).

2.3.2 Logistic Regression Analysis

This study employs logistic regression to analyze the data, taking into account both the sampling method and the categorical nature of the dependent variables. Logistic regression is particularly suited for situations where the outcome of interest is binary or categorical. The dependent variable in such models enables prediction, evaluation, and interpretation of associations between independent variables and the probability of an event occurring.

By examining the coefficients of the explanatory variables, logistic regression provides valuable insights into how changes in the values of independent variables influence the likelihood of the event represented by the dependent variable. These insights facilitate understanding of the relationships among variables and support the formulation of predictions and inferences.

The logistic regression model is generally expressed as:

$$L_i = \left(\frac{P_i}{1 - P_i}\right) = exp(\beta_1 + \beta_2 X_2 + \ldots + \beta_k X_k) \quad (2)$$

where L_i is the log of the odds ratio, linear in both the explanatory variables (Xs) and the parameters (βs), this transformation, known as the *logit*, represents the log of the probability of success P_i. More specifically,

$$Y_i = \left(\frac{P_i}{1 - P_i}\right) = \exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + u_i) \quad (3)$$

Where Y_i (odds for an event) is a dependent variable, changed occupation, contains 0 and 1 values (0 = no, 1 = yes), which is linear in parameters, and for all Xs (independent variables). The P_i is the probability of an event, $P_i/1 - P_i$ indicates the odds of an event, and βs are the intercept and slope coefficients. Finally, the u_i is the stochastic error term.

After incorporating the study-specific variables, all of the model's variables are presented in Table 2 according to Equation 3 as follows:

Table 2. Logistic Regression Models and Variables

Model	Dependent Variable (Y_i)	Independent Variables (X_i)
1	Occupational Change	Gender (X1), age group (X2), education level (X3), area of residence (X4), residency duration (X5), pollution knowledge (X6), pollution awareness (X7), pollution status (X8), disease history (X9), disease types (X10), restoration perceptions (X11)
2	Water Usage	Gender (X1), age group (X2), education level (X3), area of residence (X4), residency duration (X5), pollution knowledge (X6), pollution awareness (X7), water condition (X8), disease history (X9), disease types (X10), restoration perceptions (X11)
3	Water Condition Perception (color, taste, smell)	Gender (X1), age group (X2), education level (X3), area of residence (X4), pollution knowledge (X5), pollution awareness (X6), primary pollution cause (X7)
4	Aquatic Life Status (fish, flora, fauna, aquatic organisms)	Water condition (X1), pollution status (X2), water quality impacts (color, taste, smell; X3), pollution impact (X4)
5	Livelihood Viability	Gender (X1), age group (X2), education level (X3), pollution knowledge (X4), pollution awareness (X5), water condition (X6), awareness of regulations (X7), primary pollution cause (X8)
6	Disease Prevalence	Gender (X1), age group (X2), education level (X3), area of residence (X4), residency duration (X5), pollution knowledge (X6), pollution awareness (X7), water usage types (X8), restoration perceptions (X9)

Notes: All dependent variables are binary (0 = no, 1 = yes). Models use Equation 3: $Y_i = \left(\frac{P_i}{1-P_i}\right) = \exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + u_i)$. Data from 2021 survey (n=250).

3. Results and Discussion

3.1 Survey Results

3.1.1 Description of Data and Variables

Table 3 presents summary statistics, offering insights into the demographic distribution and perceptions of respondents across five regions along the Buriganga River. Kamrangirchar accounted for the most significant proportion of respondents (28%), followed by Hazaribagh (24%), Lalbagh (20%), Sadarghat (14%), and Narayanganj (13%). This geographical distribution is critical for understanding varied environmental impacts and community perceptions of riverine pollution, as spatial variability significantly influences ecological degradation assessments (Majed et al., 2022).

Gender was a key demographic variable, with respondents categorized as male or female. Approximately 70% of the 250 participants were male, and 29% were female, reflecting societal patterns that influence environmental perceptions and behaviours due to differing gender roles (Marter-Kenyon et al., 2022). Age was classified into five categories: 18–30, 31–40, 41–50, 51–60, and 61 years and above. Table 3 indicates that only 10% of respondents were aged 18–30, suggesting limited engagement of younger demographics with riverine issues, while 64% were over 50, likely possessing extensive experience and historical insights into the Buriganga River's environmental changes, particularly those linked to the Hazaribagh Tannery (Santos Silva & Klasen, 2021).

Educational attainment, another critical factor influencing decision-making (Mamun & Arfanuzzaman, 2020; Mamun et al., 2023; Morelli et al., 2022), was categorized into three levels: primary, secondary, and higher secondary and above. No respondents lacked formal education, and few had post-secondary qualifications, leading to the designation of "higher secondary and above" as the highest category. Approximately 45% of respondents had a primary education, 30% had a secondary education, and 24% had a higher secondary education or above.

Approximately 83% of respondents were employed, while 17% were unemployed. Occupations were categorized into seven groups: boatman (7%), farmer (20%), fisherman (4%), housewife (14%), laborer (25%), small business owner (26%), and others (4%).

Additionally, approximately 78% of respondents had changed occupations, indicating significant environmental impacts on livelihoods near the Buriganga River. The 22% who maintained their original occupations, primarily housewives or those in less river-dependent roles, suggest a complex socioeconomic dynamic that warrants further exploration.

Approximately 15% of respondents had lived near the river for less than 5 years, likely experiencing limited exposure to tannery-related pollution due to the relocation of tanneries from Hazaribagh to Savar in 2016. Additionally, 25% had resided there for 11–20 years, and 39% had resided there for over 20 years. These longer-term residents likely possess valuable insights into the river's ecosystem and pollution dynamics, as prolonged exposure to polluted water bodies can significantly impact community health and economic conditions.

Approximately 84% reported familiarity with water pollution, while 16% did not. A separate question on general pollution awareness revealed that 92% acknowledged awareness, with only 8% reporting none. The similarity between the 16% who are unaware of water pollution and the 15% with less than 5 years of residence may suggest reduced visibility of pollution after the tannery relocation.

Regarding perceptions of the Buriganga River's water quality, 96% of respondents deemed the water harmful for use, while only 4% considered it safe. This high perception of harm, despite only 84% acknowledging pollution awareness, suggests that some respondents recognize the water's unsuitability without fully understanding the concepts of pollution. Studies confirm that the river's water quality parameters, including temperature, dissolved oxygen, and biochemical oxygen demand, exceed permissible limits set by the Bangladesh Environmental Conservation Rules, rendering it unsuitable for aquatic life and human use (Fatema et al., 2018; Mustari & Afsana, 2021). Elevated levels of heavy metals, such as chromium, cadmium, and lead, further pose significant risks to ecosystems and public health (Majed et al., 2022). Awareness of pollution-related laws was also investigated, with 64% of respondents indicating that they were unaware of any regulations, and 36% claiming to be knowledgeable. The Bangladesh government has mandated effluent treatment plants for industrial units; however, inconsistent compliance highlights the need for more rigorous enforcement and public education on environmental governance.

Respondents' perceptions of the river's pollution status revealed that 59% considered the water non-polluted, while 41% believed it remained polluted. Conversely, 59% reported using river water for various purposes, including drinking (14%), household activities (16%), and bathing, personal hygiene, or livelihood-related tasks (30%), while 41% abstained from using it. Among non-users, reasons included pollution concerns (5%), unpleasant odor (7%), health risks (20%), and accessibility issues (9%). The significant water usage, despite warnings against using polluted river water for drinking (Islam et al., 2019), suggests a perceived improvement in water quality.

The primary causes of pollution, as identified by respondents, were industrial waste (40%), land grabbing/illegal establishments (28%), household waste (13%), public ignorance (10%), and chemical/fertilizer use (8%). These findings reflect the ongoing industrial impacts despite tannery relocation, which are compounded by unregulated land use and inadequate waste management.

Water characteristics (colour, taste, and smell) were perceived as improved by 85% of respondents, while 15% reported no change, particularly in Hazaribagh and Kamrangirchar, areas historically affected by tannery pollution. Persistent contamination from small- and medium-scale industries highlights the need for more effective governmental intervention.

The survey also assessed the presence of fish, flora, and fauna, with 49% reporting scarcity and 51% noting availability, which varied by proximity to polluted areas, including Hazaribagh, Kamrangirchar, and Lalbagh. Health risks from consuming river fish were noted (Hossain et al., 2021). Livelihood opportunities were deemed limited by 84% of respondents, with only 16% optimistic about potential earnings from the river.

Health impacts were significant, with 74% of respondents reporting water pollution-related diseases, including diarrhea (30%), skin diseases (29%), asthma (27%), cancer (7%), and other conditions (6%). These findings suggest that persistent health risks persist despite tannery relocation. Regarding river restoration, 84% believed it was unlikely due to ongoing pollution sources, while 16% saw potential with government intervention addressing domestic, industrial, and solid waste pollution.

Finally, respondents were asked about the potential impacts of pollution alleviation. Most (72%) anticipated improvements across all sectors (environment, health, livelihoods, and recreation), while 9% expected environmental benefits and 6% foresaw enhancements in specific areas.

Table 3. Summary Statistics

Variable	Mean	Standard Deviation
Area:		
Hazaribagh	0.244	0.430
Kamrangirchar	0.284	0.452
Lalbagh	0.196	0.398
Narayanganj	0.132	0.339
Sadarghat	0.144	0.352
Gender:		
Female	0.292	0.456
Male	0.708	0.456
Age:		
18-30	0.1	0.301
31-40	0.096	0.295
41-50	0.16	0.367
51-60	0.408	0.492
61 and above	0.236	0.425
Education:		
Primary	0.452	0.499
Secondary	0.304	0.461
Higher Secondary & Above	0.244	0.430
Employment:		
Unemployed	0.172	0.378
Employed	0.828	0.378
Occupation:		
Boatman	0.072	0.259
Farmer	0.2	0.401
Fisherman	0.044	0.206
Housewife	0.14	0.348
Labourer	0.252	0.435
Small Business	0.26	0.440
Others	0.032	0.176
Changed Occupation:		
No	0.216	0.412
Yes	0.784	0.412
Duration of stay near Buriganga		
Less than 5 years	0.152	0.360
6-10 years	0.208	0.407
11-20 years	0.252	0.435
20 and above	0.388	0.488
Know about Pollution		
No	0.164	0.371

Yes	0.836	0.371
Awareness of Pollution		
No	0.088	0.284
Yes	0.912	0.284
Water Condition:		
Harmful to use	0.96	0.196
Good to use	0.04	0.196
Awareness of law:		
No	0.644	0.480
Yes	0.356	0.480
Pollution Status:		
Not Polluted	0.592	0.492
Polluted	0.408	0.492
Status of Use of Water:		
No	0.592	0.492
Yes	0.408	0.492
Different Water Use:		
Drinking Water	0.136	0.343
Household	0.16	0.367
Bath/ Personal Hygiene/ Livelihood & Recreation	0.296	0.457
Do Not Use	0.408	0.492
Not Use Why:		
Polluted	0.048	0.214
Smell	0.072	0.259
Health	0.2	0.401
Accessibility	0.072	0.259
Others	0.016	0.126
Not applicable	0.592	0.492
Primary Cause of Pollution:		
Household Waste	0.132	0.339
Industrial Waste	0.404	0.492
Chemical and Fertilized	0.08	0.272
Land Grabbing/Illegal Establishment	0.28	0.450
People's Ignorance	0.104	0.306
Water Condition Status (Colour, Taste & Smell):		
Same as Before	0.152	0.360
Improved	0.848	0.360
State of Fishes, Flora-Fauna & Other Aquatic Animals:		
Near Non-Existence	0.492	0.501
Fish are Available	0.508	0.501
Possible to Earn Livelihood:		
No	0.836	0.371
Yes	0.164	0.371
Suffer from Disease:		
No	0.26	0.440
Yes	0.74	0.440
Types of Disease Suffered:		
Asthma	0.272	0.446

Skin	0.288	0.454
Diarrhoea	0.308	0.463
Cancer	0.072	0.259
Others	0.06	0.238
Will Back to Normal:		
No	0.836	0.371
Yes	0.164	0.371
Impact of Pollution:		
Livelihood	0.06	0.238
Environment	0.096	0.295
Health	0.064	0.245
Recreation	0.056	0.230
All of these	0.724	0.448

3.1.2 Findings from Chi-Square Tests

Table 4 presents the chi-square test results for six groups, each examining the independence between a dependent variable and various independent variables. In Group 1, the chi-square tests assessed associations with the dependent variable "change in occupation." A significant association was found between "change in occupation" and "gender" at a 0.1% significance level ($Pr < 0.001$), indicating that gender influences occupational changes over the past decade. Similarly, a significant association was observed between "change in occupation" and "pollution status" at a 5% significance level ($Pr < 0.05$), suggesting that perceptions of river pollution impact occupational choices. These findings underscore the influence of gender and environmental conditions on shaping occupational dynamics. However, no significant associations were found between "change in occupation" and other variables, including age, education, area of residence, duration of stay near the Buriganga River, pollution awareness, disease history, types of diseases, or river restoration prospects, leading to the acceptance of H_0 for these relationships.

In Group 2, significant associations were identified between "water use status" and both "age" and "area of residence" at a 0.01% significance level ($Pr < 0.001$). Additionally, "duration of stay near Buriganga," "pollution awareness," "water condition," and "disease history" showed significant associations with "water use status" at a 5% significance level ($Pr < 0.05$). These results suggest that demographic and environmental factors significantly influence whether individuals use river water. Other variables in this group showed no significant associations, indicating independence from water use status.

For Group 3, a highly significant association was found between "water condition status" (color, taste, and smell) and "age" at a 0.1% significance level ($Pr < 0.001$), with a p-value of 0.000. A significant relationship was also observed between "water condition status" and "area of residence" at a 5% significance level ($Pr < 0.05$). These findings indicate that age and residential location influence perceptions of water quality improvements. Conversely, variables such as pollution knowledge, pollution awareness, and primary pollution causes showed no significant association with water condition status, supporting H_0.

In Group 4, no significant associations were found between "status of fishes, flora-fauna, and other aquatic animals" and variables including water condition, pollution status, water condition status, and pollution impact. The chi-square test accepted H_0, indicating independence between these variables and the presence of aquatic life.

Table 4. Chi-Square Test Result

	Chi-Square Test Result					
	Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Group 6**
	Changed Occupation	**Status of Use of Water**	**Water Condition Status**	**State of Fishes, Flora-Fauna & Other Aquatic Animals**	**Possible to Earn a Livelihood**	**Suffer from a Disease**
Gender	51.5058***	0.1184	0.1227	…	0.5488	0.3942
Age	4.0313	17.3204**	43.6766***	…	4.67	1.4852
Education	3.7767	4.5022	0.4837	…	0.7588	1.8179
Area of Residence	3.217	24.7651***	10.2639*	…	…	11.3245*
Duration of stay near Buriganga	0.7675	8.7156*	…	…	…	1.3659
Know about Pollution	0.5935	2.7001	0.0122	…	1.1023	1.6916
Awareness of Pollution	0.0181	5.1093*	0.1664	…	0.7044	1.3466
Water Condition	…	4.0912*	…	0.0027	0.3112	…
Awareness of law	…	…	…	…	0.7354	…
Pollution Status	6.3089*	…	…	2.2413	…	…
Different Water Use	…	…	…	…	…	6.0773
Primary Cause of Pollution	…	…	1.8366	…	2.5764	…
Water Condition Status (Color, Taste & Smell)	…	…	…	0.0601	…	…
Suffer from a Disease	1.1346	4.8675*	…	…	…	…
Types of Disease Suffered	3.2329	6.1523	…	…	…	…
Will the River Go Back to Normal	0.1262	0.8989	…	…	…	0.4179
Impact of Pollution	…	…	…	2.896	…	…
N	**250**	**250**	**250**	**250**	**250**	**250**

Note: *Pr<0.05, **Pr<0.01, ***Pr<0.001

Similarly, Group 5 tests revealed no significant associations between the "possibility of earning a livelihood" and variables such as age, education, area of residence, knowledge of pollution, awareness of pollution, water quality, awareness of laws, or primary pollution causes, suggesting that these factors do not directly influence livelihood opportunities.

In Group 6, a significant association was identified between "suffering from disease" and "area of residence" at a 5% significance level ($Pr < 0.05$), indicating that location influences health outcomes related to water pollution. No other variables in this group showed significant associations with disease prevalence, supporting the null hypothesis for those relationships.

3.1.3 Results of Logistic Regression

Table 5 presents the results of logistic regression models analyzing factors that influence various outcomes related to the pollution of the Buriganga River. Each model uses a binary dependent variable, with odds ratios indicating the likelihood of an outcome relative to a reference group, holding other variables constant.

Model 1: Change in Occupation

The dependent variable, "change in occupation" (0 = no change, 1 = change in the past decade), revealed significant gender disparities. Males had 22.915 times higher odds of changing occupations compared to females ($p < 0.001$), reflecting socio-cultural norms in Bangladesh where men, as primary breadwinners, face greater economic pressures to adapt employment (Khan & Rahman, 2016). This aligns with Menzel & Woodruff (2019), who highlight socioeconomic factors driving occupational mobility. Age also influenced outcomes, with the 41–50 age group showing 0.171 times lower odds of occupational change compared to the 18–30 reference group ($p < 0.05$), suggesting greater career stability or reluctance to shift due to established commitments (Cardoso & Hartmann, 2023). Similarly, respondents with higher secondary education or above had 0.268 times lower odds of changing occupations ($p < 0.01$), indicating that higher education may correlate with job satisfaction or access to stable careers (Heidenreich, 2022).

Knowledge of water pollution significantly affected occupational change. Respondents aware of water pollution had 0.092 times lower odds of changing occupations compared to those unaware ($p < 0.001$), possibly due to economic dependence or limited alternative opportunities (Reza & Yousuf, 2016). Conversely, those acknowledging water pollution had 6.331 times higher odds of changing occupations ($p < 0.05$), likely driven by awareness of health risks prompting safer work environments (Lin et al., 2022). Additionally, individuals reporting water pollution had 5.379 times higher odds of occupational change ($p < 0.01$), reflecting adaptive responses to environmental stressors. However, those with family members suffering from pollution-related diseases had 0.304 times lower odds of changing occupations ($p < 0.05$), possibly due to constraints like healthcare proximity or medical costs (Schlosberg, 2007; Walker et al., 2015). These findings suggest complex interactions between environmental awareness, health impacts, and occupational mobility, warranting further research into policy interventions for equitable employment opportunities.

Model 2: Water Use Status

The dependent variable, "water use status" (0 = non-usage, 1 = usage), showed age and residential area as significant predictors. Respondents aged 41–50, 51–60, and 61 and above had 0.103, 0.146, and 0.150 times lower odds, respectively, of using river water compared to the 18–30 reference group ($p < 0.01$, $p < 0.05$, $p < 0.05$), likely due to heightened awareness of pollution risks among older individuals. Residents in Kamrangirchar and Sadarghat had 2.673 and 4.841 times higher odds of using river water, respectively, compared to Hazaribagh ($p < 0.05$, $p < 0.01$), where severe pollution from industrial waste and sewage deters usage (Islam et al., 2019). These patterns reflect environmental determinism, where local conditions shape resource utilization (Hartshorne, 1939; Peet, 1985). Targeted water quality improvements and alternative water sources are crucial in addressing these disparities.

Model 3: Water Condition Status

The dependent variable, "water condition status" (0 = same as before, 1 = improved color, taste, and smell), showed significant age and area effects. Respondents aged 41–50, 51–60, and 61 and above had 14.176, 10.247, and 30.501 times higher odds, respectively, of perceiving water quality improvements compared to the 18–30 group ($p < 0.001$), reflecting greater environmental awareness among older individuals (Barmon et al., 2012; Mamun et al., 2018). Conversely, residents of Kamrangirchar had 0.157 times lower odds of acknowledging improvements ($p < 0.05$), likely due to persistent pollution from local industries (Rashedul Islam, 2018). These findings suggest the need for tailored interventions, such as educational campaigns and infrastructure investments, to address area-specific pollution challenges.

Model 4: State of Fishes, Flora-Fauna, and Other Aquatic Animals

The dependent variable, "state of fishes, flora-fauna, and other aquatic animals" (0 = near non-existence, 1 = available), showed no significant associations with water condition, pollution status, water condition status, or pollution impact. Insignificant favourable odds ratios suggest a weak correlation between improved water conditions and the presence of aquatic life, but the river's severe degradation likely limits recovery (Kibria et al., 2015; Bashar & Fung, 2020). Future research should incorporate broader ecological indicators to assess the health of ecosystems.

Model 5: Possibility of Earning a Livelihood

The dependent variable, "possibility of earning a livelihood" (0 = no, 1 = yes), yielded no significant coefficients, though favourable odds ratios suggest a potential trend. The complexity of environmental and economic interactions may obscure direct relationships (Gross & Enck, 2021; Manisalidis et al., 2020). Further studies should include qualitative data and community-level economic analyses to explore these dynamics.

Model 6: Suffer from Disease

The dependent variable, "suffer from disease" (0 = no, 1 = yes), identified residential area and water use as significant predictors. Kamrangirchar and Lalbagh residents had 0.226 and 0.299 times lower odds of suffering from water pollution-related diseases compared to Hazaribagh ($p < 0.01$, $p < 0.05$), possibly due to varying exposure levels or access to cleaner water (Reza & Yousuf, 2016; Whitehead et al., 2019). Unexpectedly, non-users of river water had 2.681 times higher odds of disease ($p < 0.05$), potentially due to reliance on contaminated alternative sources or sanitation issues (Bashar & Fung, 2020). This warrants further investigation into water access and health risks.

Table 5. Logistic regression estimation in the six different models

	Changed Occupation	Status of Use of Water	Water Condition Status	State of Fishes, Flora-Fauna & Other Aquatic Animals	Possible to Earn a Livelihood	Suffer from a Disease
Gender:						
Male	22.915***	1.086	1.28	…	1.382	0.644
	(10.848)	(0.345)	(0.578)	…	(0.540)	(0.269)
Age:						
31-40	0.297	0.269	1.184	…	2.269	1.843
	(0.224)	(0.239)	(0.729)	…	(1.781)	(1.270)

41-50	0.171*	0.103**	14.176***	…	2.694	3.078
	(0.44)	(0.085)	(10.595)	…	(1.934)	(2.288)
51-60	0.261	0.146*	10.247***	…	1.019	2.644
	(0.205)	(0.117)	(6.158)	…	(0.823)	(1.734)
61 and above	0.647	0.150*	30.501***	…	1.617	2.430
	(0.524)	(0.131)	(27.586)	…	(1.303)	(1.696)
Education:						
Secondary	1.135	1.072	1.369	…	1.364	0.635
	(0.543)	(0.411)	(0.684)	…	(0.568)	(0.258)
Higher Secondary & Above	0.268**	0.779	0.846	…	1.339	0.946
	(0.125)	(0.281)	(0.444)	…	(0.602)	(0.375)
Leaving Area:						
Kamrangirchar	0.687	2.673*	0.157*	…	…	0.226**
	(0.371)	(1.114)	(0.116)	…	…	(0.113)
Lalbagh	1.162	0.849	0.267	…	…	0.299*
	(0.713)	(0.375)	(0.203)	…	…	(0.163)
Narayanganj	0.734	2.483	0.500	…	…	0.365
	(0.564)	(1.222)	(0.475)	…	…	(0.212)
Sadarghat	0.287	4.841**	0.617	…	…	0.419
	(0.197)	(2.763)	(0.490)	…	…	(0.235)
Duration of stay near Buriganga:						
6-10 years	2.629	0.786	…	…	…	0.518
	(2.116)	(0.530)	…	…	…	(0.345)
11-20 years	3.729	0.522	…	…	…	0.648
	(3.246)	(0.337)	…	…	…	(0.430)
20 and above	1.973	0.42	…	…	…	0.359
	(1.650)	(0.287)	…	…	…	(0.246)
Know about Pollution						
Yes	0.092***	1.144	0.811	…	0.744	1.456
	(0.064)	(0.668)	(0.907)	…	(0.502)	(0.815)
Awareness of Pollution						
Yes	6.331*	0.443	0.954	…	0.804	1.236
	(5.859)	(0.342)	(1.225)	…	(0.683)	(0.906)
Water Condition:						
Good to use	…	2.088	…	0.923	0.394	…
	…	(2.293)	…	(0.600)	(0.445)	…
Awareness of law:						
Yes	…	…	…	…	1.001	…
	…	…	…	…	(0.461)	…
Pollution Status:						
Polluted	5.379**	…	…	0.681	…	…
	(3.241)	…	…	(0.181)	…	…
Different Water Use:						
Household	…	…	…	…	…	1.559
	…	…	…	…	…	(0.924)
Bath/ Personal Hygiene/ Livelihood & Recreation	…	…	…	…	…	2.324
	…	…	…	…	…	(1.214)
Do Not Use	…	…	…	…	…	2.681*
	…	…	…	…	…	(1.335)
Primary Cause of Pollution:						
Industrial Waste	…	…	1.346	…	1.792	…
	…	…	(0.849)	…	(1.089)	…
Chemical and Fertilized	…	…	1.880	…	1.288	…
	…	…	(1.528)	…	(1.129)	…
Land Grabbing/Illegal Establishment	…	…	2.017	…	1.692	…
	…	…	(1.412)	…	(1.079)	…

People's Ignorance	…	…	1.301	…	0.613	…
	…	…	(1.044)	…	(0.562)	…
Water Condition Status (Color, Taste & Smell):						
Improved	…	…	…	0.933	…	…
	…	…	…	(0.341)	…	…
Suffer from Disease:						
Yes	0.304*	0.599	…	…	…	…
	(0.160)	(0.242)	…	…	…	…
Types of Disease Suffered:						
Skin	1.291	0.854	…	…	…	…
	(0.808	(0.328)	…	…	…	…
Diarrhoea	0.437	1.372	…	…	…	…
	(0.219)	(0.555)	…	…	…	…
Cancer	0.212	0.395	…	…	…	…
	(0.180)	(0.239)	…	…	…	…
Others	0.566	1.247	…	…	…	…
	(0.447)	(0.932)	…	…	…	…
Will River Go Back to Normal?:						
Yes	3.444	0.56	…	…	…	1.353
	(2.796)	(0.304)	…	…	…	(0.813)
Impact of Pollution:						
Environment	…	…	…	1.868	…	…
	…	…	…	(1.238)	…	…
Health	…	…	…	2.320	…	…
	…	…	…	(1.732)	…	…
Recreation	…	…	…	2.889	…	…
	…	…	…	(2.218)	…	…
All of these	…	…	…	1.503	…	…
	…	…	…	(0.814)	…	…
Constant:	3.571	26.304***	1.893	0.806	0.094*	2.965
	(5.159)	(29.369)	(2.245)	(0.497)	(0.094)	(3.161)
N	250	250	250	250	250	250

Note: Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

3.2 Expert Opinions and Field Observations

3.2.1 Findings and Discussion of Expert Opinion

The expert interviews reveal a consensus on the dire pollution crisis of the Buriganga River, driven by industrial, urban, and agricultural activities, with profound socioeconomic, environmental, and health repercussions. While interviewees highlighted overlapping sources—such as untreated effluents from tanneries and textiles, sewage from Dhaka's burgeoning population, and pesticide-laden runoff—they also emphasized unique challenges and mitigation pathways. These insights align with empirical studies (e.g., Majed et al., 2022; Kibria et al., 2015), underscoring the need for integrated, multi-stakeholder interventions to restore this vital waterway.

First Interview: Mohammad Abdul Matin

Matin, from the Bangladesh Poribesh Andolon (BAPA)—a leading NGO focused on environmental protection and enhancing quality of life—stressed the river's essential role in providing water supply, transportation, and livelihoods for millions, despite its ranking among the world's most polluted. He identified heavy contamination from industrial waste (including heavy metals, chemicals, and pathogens), urban sewage, and agricultural runoff, which is exacerbated by siltation that impairs navigability. Impacts include health risks such as cholera and typhoid, economic losses in fisheries and tourism, and ecological degradation, including wetland loss and aquatic mortality. Matin advocated for wastewater treatment plants, improved sanitation, sustainable farming, and wetland restoration. BAPA's collaborations on these fronts have yielded modest gains, but it calls for sustained advocacy and holistic strategies to overcome persistent barriers.

Second Interview: Syeda Rizwana Hasan

Hasan, of the Bangladesh Environmental Lawyers Association (BELA), attributed degradation to urbanization and industrialization, with pollutants from untreated effluents, poor sewage systems, solid waste, and runoff mirroring documented stressors. Socioeconomic effects encompass eroded livelihoods in fishing and irrigation, while environmental harms involve biodiversity decline and habitat disruption. She emphasized the threats to health and well-being, urging rigorous regulatory enforcement, upgraded sewage infrastructure, awareness campaigns, and community conservation efforts. BELA's legal advocacy promotes government-led initiatives for treatment plants, sanitation upgrades, runoff reduction, and wetland restoration to preserve ecological integrity.

Third Interview: Professor Dr. A. K. Enamul Haque

Haque pinpointed indiscriminate dumping of household, industrial, and plastic waste, worsened by drainage overflows and oil spills from transport hubs. This pollution heightens health risks for vulnerable communities, diminishes livelihoods such as fishing, and erodes aesthetic value, disrupting ecosystems. Mitigation entails enforcing waste regulations, dredging riverbeds, establishing treatment facilities, curbing non-point pollution via sustainable agriculture, and educational outreach. Haque underscored collaborative efforts among government, communities, and industries to foster collective responsibility in restoration.

Fourth Interview: Professor Dr. Basanta Kumar Barmon

Barmon depicted the river as toxic and lifeless, with invasive species, such as the Sakar fish, threatening biodiversity, especially during certain seasons. Key drivers include unregulated waste, encroachments, weak enforcement, and low awareness. Consequences include job losses, a decline in tourism, groundwater contamination, and disruptions to the food chain. He recommended strict regulations, treatment infrastructure, dredging, removal of encroachment, awareness programs, and alternative livelihoods, emphasizing the importance of stakeholder partnerships for achieving enduring sustainability.

Fifth Interview: Dr. Yousuf

Yousuf highlighted untreated waste and encroachments as core issues, degrading water flow and ecosystems. Impacts affect health, fisheries, tourism, property values, and broader environmental imbalances. Strategies include the Save Buriganga Master Plan, a National River Commission, riverfront development with dredging, strengthened waste rules (e.g., 2021 and 2023), EPR policies, expanded sewerage, and community initiatives to promote stewardship.

In synthesizing these views, a unified theme emerges: pollution's multifaceted origins demand coordinated action beyond isolated fixes. Prioritizing enforcement, infrastructure, and education could yield transformative results, though political will and resource allocation remain hurdles. Future research should quantify the efficacy of interventions to inform policy.

3.2.2 Expert's Opinion at a Glance

Table 6 synthesizes insights from interviews with five experts on the environmental challenges, pollution sources, socioeconomic and ecological impacts, and proposed mitigation strategies of the Buriganga River. The table consolidates responses to four key questions, highlighting convergent and divergent perspectives to inform effective policy and research directions.

Table 6. Synthesis of Expert Insights on Buriganga River Pollution and Mitigation Strategies

Expert	Current Condition of the Buriganga River	Primary Causes of Water Pollution	Socioeconomic and Environmental Impacts	Mitigation Strategies
Mohammad Abdul Matin (BAPA)	Severely polluted with industrial waste, sewage, and siltation, reducing navigability.	Industrial waste (tanneries, textiles, chemicals), untreated sewage, and agricultural runoff	Health risks (waterborne diseases, respiratory issues), reduced tourism and fish production, loss of aquatic life, and degradation of wetlands.	Wastewater treatment plants, improved sanitation, reduced agricultural runoff, and wetland restoration.
Syeda Rizwana Hasan (BELA)	Severely degraded due to industrial effluents, sewage, and solid waste	Industrial effluents, untreated sewage, solid waste, and agricultural runoff	Livelihood losses (fishing, water use), biodiversity loss, and ecosystem disruption	Enforce environmental regulations, establish wastewater treatment, improve sanitation, reduce agricultural runoff, and restore wetlands
Professor Dr. A. K. Enamul Haque	Critically polluted with garbage, waste, and encroachments	Household and industrial waste, untreated sewage, and transportation hub discharges	Health risks, reduced livelihoods, biodiversity loss, and degraded aesthetics	Enforce waste management regulations, establish wastewater treatment, control non-point source pollution, and raise public awareness
Professor Dr. Basanta Kumar Barmon	Severely degraded with toxic, foul-smelling water, lacking aquatic life	Industrial and domestic waste, illegal encroachments, and inadequate waste treatment	Job losses, reduced tourism, groundwater contamination, and biodiversity decline	Enforce regulations, establish waste treatment facilities, dredge the river, address encroachments, and promote public awareness
Dr. Yousuf (GPAD)	Critically polluted with untreated household, industrial, and sewage waste	Household, industrial, and sewage waste, riverbank encroachments	Health risks, livelihood impacts, tourism decline, biodiversity loss	Implement the Save Buriganga Master Plan, enforce Solid Waste Management Rules 2021, establish the National River Commission, and promote sustainable practices

3.2.3 Findings of Field Observation

Field observations along the Buriganga River, conducted via multiple boat expeditions across various sectors, provided critical insights into the river's condition, pollution sources, local living conditions, and potential mitigation avenues. These on-site investigations complemented survey and expert data, offering a direct assessment of environmental and socioeconomic challenges.

A prominent issue observed was the widespread, unregulated disposal of household and industrial waste. Despite local authority notices prohibiting waste dumping, enforcement was visibly inadequate, particularly in Lalbagh and Hazaribagh. Groups, including children, were observed filling cement bags with waste shaped like pillows, a practice linked to clandestine land reclamation along riverbanks. Residents confirmed that these activities, often supported by influential figures, drive up land prices, incentivizing illegal land acquisition. This organized enterprise complicates demolition efforts, as unauthorized structures, primarily shops, are established on reclaimed land. Even when court injunctions are obtained, bureaucratic delays—often spanning years due to political influence—hinder enforcement, allowing new establishments to reemerge and perpetuate a cycle of environmental degradation (Al-Mizan et al., 2020).

Industrial pollution was another significant concern. Small-scale plastic, textile, and leather factories, many of which operate illegally, were observed discharging untreated chemicals, paints, and raw materials directly into the river during daylight hours. These facilities often lack modern waste treatment systems, using the river as a convenient dumping ground. Residents reported that some operations evade regulation through bribery, though recent interventions by the Bangladesh Army to control river activities show promise for improved oversight (Majed et al., 2022).

Transportation-related pollution further exacerbates the river's condition. Small, engine-operated boats transporting construction materials (e.g., sand, bricks) from neighboring districts were observed discharging oil and waste into the river, contributing to water quality degradation. Agricultural runoff, including pesticides, fertilizers, and chemicals from adjacent lands, was also evident, with farmers soaking raw jute in river sections for fiber separation, releasing contaminants and causing a putrid odor (Kibria et al., 2015). These practices threaten aquatic ecosystems and compromise the usability of water.

Inadequate sanitation infrastructure significantly contributes to pollution. Numerous plastic pipes were observed discharging untreated human waste from households lacking proper sewage systems, particularly in nearby slums. This continuous contamination underscores the urgent need for improved sanitation facilities to reduce the river's pollution load (Islam et al., 2019).

These observations underscore the multifaceted nature of the Buriganga River's pollution, which is driven by unregulated waste disposal, industrial activities, transportation, agriculture, and inadequate sanitation. Further studies characterizing specific pollutant profiles and their impacts could inform targeted mitigation strategies, complementing the proposed regulatory and infrastructural interventions.

4. Conclusions and Policy Recommendations

This study examined the socio-economic, environmental, and ecological impacts of pollution in the Buriganga River using a mixed-methods approach that combined structured surveys, expert interviews, and field observations. The analysis revealed that river pollution has profoundly shaped community livelihoods, health outcomes, and environmental quality. Quantitative evidence demonstrated that pollution influenced occupational mobility, with gender and awareness of environmental risks significantly associated with changes in employment. Water usage patterns varied by age and location, reflecting both risk perception and the necessity of water. In contrast, perceptions of water quality improvements were strongly shaped by age and residential proximity to pollution hotspots. Logistic regression results underscored the complexity of these relationships, showing that both socio-demographic and ecological factors influenced livelihood strategies, health risks, and perceptions of river recovery.

The survey findings were reinforced by expert interviews, which highlighted the systemic causes of pollution—industrial effluents, untreated sewage, weak regulatory enforcement, and unplanned urbanization—as well as the resulting deterioration of aquatic biodiversity, health, and livelihoods. Field observations corroborated these concerns, documenting visible pollution sources and degraded ecological conditions. Collectively, the evidence suggests that the Buriganga River remains severely compromised, despite the relocation of tanneries and partial mitigation efforts, with ongoing threats to socio-economic stability and ecological sustainability.

This research contributes to the broader literature on urban river pollution in developing contexts by adopting a holistic framework that integrates socio-economic and environmental dimensions. Unlike prior studies that have primarily focused on physicochemical parameters, this study foregrounds community perceptions, livelihood impacts, and expert insights, thereby offering a multidimensional understanding of pollution dynamics. By linking statistical associations with qualitative perspectives, the paper advances methodological triangulation in environmental research, demonstrating how mixed-methods approaches can illuminate the intersection of pollution, human behavior, and ecological degradation. Importantly, the study situates the Buriganga River's crisis within the broader discourse on sustainable urban development, providing empirical evidence that can guide context-sensitive interventions.

While the study offers robust insights, several limitations must be acknowledged. First, the reliance on convenience sampling introduces potential selection bias, which may limit the generalizability of findings beyond the sampled communities. Second, the cross-sectional design captures conditions at a single point in time, thus constraining the ability to assess seasonal or long-term variations in pollution and its impacts. Third, although expert interviews enriched the analysis, they reflect a limited number of voices and may not encompass the full spectrum of stakeholder perspectives. Lastly, while the study identified associations between socio-economic and environmental variables, causal inferences remain tentative given the exploratory scope of the research.

The findings underscore an urgent need for integrated and enforceable policies to address pollution in the Buriganga River. Strengthening regulatory enforcement of effluent treatment, expanding sewage management infrastructure, and enhancing waste disposal systems are critical priorities. Awareness gaps identified among residents highlight the need for community-based environmental education, particularly targeting vulnerable groups with limited formal education. The observed occupational shifts and health risks highlight the importance of designing livelihood diversification programs and accessible healthcare services for river-dependent populations. Furthermore, ecological restoration measures—such as wetland rehabilitation, dredging, and biodiversity protection—must be pursued in tandem with socio-economic interventions to achieve meaningful recovery. The study also emphasizes the importance of multi-stakeholder engagement, where government agencies, civil society organizations, industries, and local communities collaborate to develop and implement sustainable river management strategies.

Future research should pursue longitudinal studies to capture temporal variations in pollution and its impacts, including seasonal shifts in water quality, biodiversity, and community adaptation strategies. Expanding the sample size and employing probability-based sampling techniques would enhance generalizability and allow for more nuanced subgroup analyses. Further ecological assessments, incorporating both biological and chemical indicators, could enhance the understanding of the relationships between environmental parameters and socio-economic outcomes. Comparative studies across multiple rivers in Bangladesh and other urban deltas would also enrich global debates on sustainable river governance. Ultimately, future research should explore participatory approaches that integrate community voices into policy design, thereby bridging the gap between empirical analysis and practical solutions.

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Appendices

Appendix 1. Survey Questionnaire with Rationale

Questions	Answers	Rationale
Question 1: Gender of the participants	0=Female & 1=Male	To assess if there are gender-specific perceptions or impacts of pollution that could inform targeted interventions.
Question 2: Age of the participants	1= 18-30 years, 2=31-40 years, 3=41-50 years, 4=51-60 years & 5=61+ years	To determine how age influences awareness and attitudes towards pollution and its effects.
Question 3: The education level of the participants	1= Primary, 2= Secondary School & 3=Higher Secondary College	To explore the relationship between educational attainment and knowledge about pollution.
Question 4: Area where the respondents live	1= Hazaribagh, 2= Kamrangirchar, 3=Lalbagh; 4=Narayanganj& 5=Sadarghat	To identify geographic variations in the impact of pollution and access to clean water.
Question 5: Employment status of the participants	0= Unemployed, 1= Employed	To understand the economic dimensions of pollution, such as its effect on employment opportunities.
Question 6: Occupation type of the participants	1= Boatman, 2=Farmer, 3=Fisherman, 4=Housewife, 5=Labourer, 6=Small Business, 7= Other	To assess the impact of pollution on various occupational groups and their reliance on the river.
Question 7: Has the participant changed occupation in the past ten years?	0=No and 1= Yes	To investigate whether pollution has influenced occupational mobility or changes.
Question 8: Duration of stay near Buriganga	1= <5 years, 2=6-10 years, 3=11-20 years and 4=20+ years	To examine the long-term exposure to pollution and its perceived changes over time.

Question 9: Do you know what water pollution is?	0= No, 1=Yes	To assess the baseline understanding of water pollution among the participants.
Question 10: Are you aware of the water pollution of the Buriganga in your area?	0= No, 1=Yes	To measure local awareness of the river's pollution status.
Question 11: How do you rate the water condition in your area?	0= Harmful to use and 1= Good to use.	To capture the participants' perception of the water quality and its usability.
Question 12: Are you aware of any law enacted to prevent pollution in the Buriganga?	0= No, 1= Yes	To evaluate the awareness of environmental regulations and their perceived effectiveness.
Question 13: What is the water condition of the river?	0= Not Polluted, 1= Polluted	To obtain the participant's assessment of the river's current condition.
Question 14: Do you use the Water of the Buriganga River?	0= No, 1= Yes	To determine the extent of reliance on the river for various needs.
Question 15: If yes, then how?	1= Drinking water, 2= Household, 3= Bath / Personal Hygiene, 4= Livelihood, 5= Recreation and 6= Do not use.	To understand the specific uses of the river water, which can highlight areas of critical dependency.
Question 16: If not, then why?	1= Polluted, 2=Smell, 3= Health, 4= Accessibility, 5=Others and 6= Not applicable	To identify the reasons for not using the river water, which can indicate the perceived severity of pollution.
Question 17: In your opinion, what is the primary cause of pollution of the River Buriganga?	1= Household Waste, 2= Industrial Waste, 3= Chemical and Fertilized, 4= Land Grabbing/Illegal establishment and 5= People's Ignorance.	To pinpoint the perceived main contributors to pollution, which is essential for addressing the root causes.
Question 18: Did you use this water when you first moved to this area?	0= No, 1= Yes	To track changes in usage patterns, which can reflect the progression of pollution over time.

Question 19: How has the water's colour, taste, and smell changed?	0= The Water is the same as before, 1= It has improved	To document subjective changes in water quality, which can be correlated with health outcomes.
Question 20: What is the state of fish, flora, fauna, and other aquatic animals in the Buriganga?	0= Near to non-existence, 1= Fishes are available	To assess the ecological impact of pollution on river biodiversity.
Question 21: Do you think it is possible to earn a livelihood from the Buriganga?	0= No, 1= Yes	To understand the economic potential of the river and the impact of pollution on livelihoods.
Question 22: What is the impending need of the people in this area that can improve the overall health condition and help prevent pollution?	1= Drinking Water, 2= Sanitation, 3= Health Clinic, 4= Air Quality, 5= Waste Management, 6= All of the Above	To identify community priorities for improving environmental health and reducing pollution.
Question 23: Do you or any of your family members suffer from any disease that you think is a result of river pollution?	0= No, 1= Yes	To link health outcomes with pollution exposure, which is critical for public health interventions.
Question 24: What kind of disease do people normally suffer from?	1= Asthma, 2= Skin, 3= Diarrhoea, 4= Cancer, 5= Other	To identify common health issues potentially associated with pollution, informing healthcare responses.
Question 25: Is it possible to reverse the pollution and bring the river condition back to normal?	0= No, 1= Yes	To gauge optimism and potential for remediation efforts among the local population.
Question 26: What impact will Buriganga have on the area if the pollution is reversed?	1= Livelihood, 2= Environment, 3= Health, 4= Recreation, 5= All of these	To understand the perceived benefits of pollution reversal, which can motivate community action.
Question 27: Lastly, have you participated in a similar survey before, and do you think your opinion matters?	0= No, 1= Yes	To evaluate prior engagement with environmental surveys and the value placed on individual contributions to the research.

Appendix 2. Expert Opinion Questions

No.	Questions
Q1	What is the current condition and status of the Buriganga River?
Q2	What are the current causes of water pollution in the Buriganga River?
Q3	What are the socioeconomic, environmental, and ecological effects of pollution on the Buriganga River?
Q4	What strategies can mitigate the existing pollution and its associated impacts?

Notes: Questions were administered in structured face-to-face interviews with five experts in 2021.

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