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Environmental Condition Analysis of the Adjacent Area of Mawa Ferry Ghat, Munshiganj: Findings from a Field Study

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Abstract: Natural hazard identification and environmental condition evaluation start with familiarizing with landscape features. Based on the observation and focus group discussion, this study begins with the goals of identifying potential natural hazards and studying environmental conditions to determine whether development initiatives are the driver of modification on the north bank of the Padma, adjacent to the Mawa ferry ghat in Munshiganj. Approximately 29%, 24%, 18%, 11%, 9%, 5%, and 4% of the observed phenomena are associated with infrastructure, river, waterbody, barren land, wetland, river embankment, and vegetation cover. Natural hazards such as riverbank erosion (34% of observations), flooding (26%), waterlogging (34%), and lightning (5%) have necessitated the implementation of mitigation strategies. In addition, 97% of observations indicate that environmental conditions have transformed due to improper solid waste and wastewater disposal, unsanitary toilets, poor drainage infrastructures, and significant construction activity. Even the concentration of dissolved oxygen in the water sample and the moisture content of the soil sample does not fulfill the standards. Several proposals were also developed to preserve ecosystems and mitigate potential environmental threats. Although a limited number of studies have been conducted in this area, it will establish the foundation for further studies and community development.

Keywords: *Landscape Features; Potential Hazard; Environment Condition; Water Quality; Soil Quality.*

Introduction: Landscape features of the environment are significant because they contribute significantly to human health and life quality. However, the introduction of activities such as construction and manufacturing can harm landscape characteristics when development operations are implemented [1]. Both human intervention and natural processes can increase the frequency and intensity of natural disasters, which are the conclusion of hazards and have the destructive potential that exceeds the population's or place's ability to adapt [2], [3] and [4]. Moreover, the landscape features and potential hazards contribute to determining an area's environmental condition, which includes natural resources (such as flora and fauna), soil, surface water, groundwater, any existing or prospective drinking water source, subsurface strata, and ambient air [5]. Therefore, when evaluating current and prospective environmental conditions, it is crucial to evaluate how environmental change drivers may impact ecosystem functions, services, and human welfare [6].

In a developing nation such as Bangladesh, it is common for construction activities to continue fostering economic development and enhancing the people's standard of living, and environmental stability is a prerequisite for such sustainable development. In this study, an area adjacent to the Padma multipurpose bridge project, next to Mawa ferry ghat, on the north bank of the river Padma, in the northwestern Munshiganj district, has been selected to analyze the environmental conditions by identifying the changes in landscape features and the potential for hazards through field observations and focus group discussion. Water and soil samples were collected, and field and laboratory tests were done to assess environmental changes in the study area. As there is a strong association between metabolic rates and reproduction with water temperature, and warm water pollutants become more harmful as dissolved oxygen levels decrease, the temperature test is essential for determining whether or not water is suitable for the environment [7]. Water and soil pH tests are essential for determining their kind, i.e., acidic or basic. More free hydrogen ions indicate an acidic nature, whereas more free hydroxyl ions indicate a basic nature [8]. A pH measurement of water is essential for potable and wastewater treatment [9]. Several nutrients are unavailable to plants when soil pH is either low or too high. In contrast, a pH value that is too high or too low may remove microorganisms, resulting in less healthy soil [10]. The electrical conductivity test reveals the concentration of contaminants in a water sample, such as dissolved compounds, chemicals, and minerals. The higher the electrical conductivity, the greater the impurity concentration [9]. Each degree of Celsius in temperature raises the conductivity by approximately 1.9%; therefore, the conductivity increases as the water temperature rises [11]. The unit of measurement for electrical conductivity is the micro siemens per centimeter (µS/cm) [12]. Dissolved oxygen is a crucial indication of water quality because it shows aquatic resources, i.e., oxygen content, which is vital for the survival of fish and other aquatic life [13] and [14]. The soil water content determines the soil's moisture content. Soil water is a nutrient in and of itself, acting as a solvent and transporter of essential plant-growth nutrients. Therefore, crop production is determined by the availability of water rather than a lack of other essential elements. Additionally, the temperature of the soil is regulated by the soil's water content. The soil's water content is expressed as a ratio between 0 (totally dry) and the saturation porosity [15].

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The final objective of the study is to portray the Padma bridge project's neighboring area's environment in light of the various consequence findings.

Methodologies: Identifying landscape features is critical for recognizing potential natural hazards and analyzing environmental conditions in any area. Fifty-five observations were made in the study area on the north bank of the river Padma, according to their physical characteristics and potential to exacerbate environmental conditions negatively. The Garmin eTrex 10 outdoor handheld GPS navigation device was used to determine the absolute coordinates of the observations. Additionally, images were collected during the field investigations for ease of presentation and enhanced narrative purposes. Moreover, focus group discussions with residents of the study area and literature review help to identify different hazardous situations and analyze environmental conditions by comparing observed characteristics. Categorizing landscape features enables the identification of each environmental condition and its associated description. Several graphs display the observations, which aids in visualizing the overall scenario of the study area. To store and evaluate the coordinates and descriptions of landscape features, Microsoft excel 365 was used, and utilizing these coordinates in the google maps area indication was achieved. Temperature, pH, electrical conductivity, and dissolved oxygen tests are performed on the collected ground and surface water samples. Besides this, soil samples are taken and evaluated for pH and moisture content. Each test report provides information about the soil and water quality and emphasis the environmental soundness in the fieldwork area. However, it is essential to mention that the samples were collected in January, a relatively dry season in Bangladesh. As the study's drawbacks, parameters like BOD and COD have not been tested because of the limitation of the lab facility. In addition, time was a significant factor in the study tour, which was not very long.

Study Area Parishad of Lohajang Upazilla in Munshiganj District. Haldia Union Parishad covers an area of 8.881 square kilometers [16], and the Shimulia village is home to 1838 residents [17]. The location is notable since it is the site of the Padma Bridge construction.

Profile: The study area includes the Mawa ferry ghat, the west Shimulia resettlement area, Jelepara in east Shimulia, and adjacent areas on the north bank of the river Padma in Bangladesh's central region, which is administered by the Haldia Union.

Geographically, the study area is located between the latitudes of 23°28'26"N and the longitudes of 90°18'17"E [18]. The Mawa land port, the Mawa ferry ghat no. 03, the Padma Bridge stake yard, the Padma Ferry Terminal (Shimulia-Kumarbhogh), and the Shimulia Bazaar are significant sites in the study site. The research area is surrounded by a buffer zone that extends 1400 meters east and west of the Mawa ferry ghat parking point and 1000 meters north.

Fig. 1: Study area map [19].

The area is bounded south by the Padma River, north by the Mawa-Munshiganj highway, west by the Mawa Bazaar road, and east by Khoria Jame Mosque Road. This low flood plain is located 65.4 kilometers south of Dhaka and has good road and water connectivity.

Results and Discussion:

Landscape Features Identification: The field investigation identified 55 numbers and seven distinct categories of landscape features in the studied area. The study area's seven identified landscape elements include infrastructure, river, waterbody, barren land, wetland, river embankment, and vegetation cover. In figure 02, all 55 observations of landscape characteristics are displayed with their associated locations.

Fig. 2: Identified landscape features with locations in the study area.

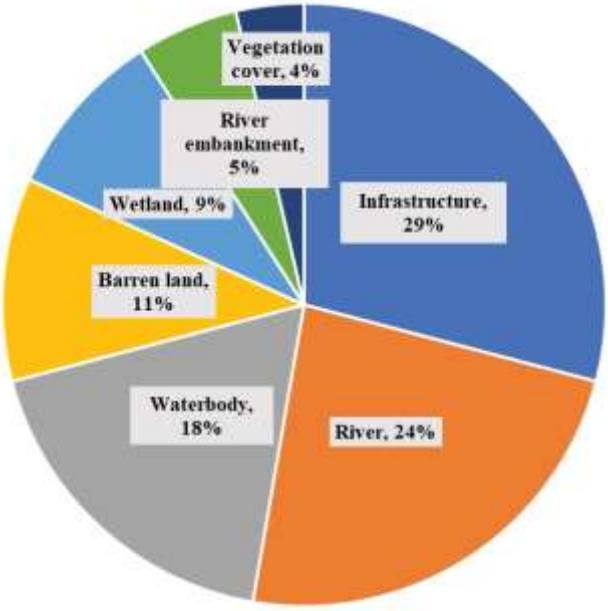

Fig. 3: Identified landscape features.

According to figure 03, sixteen of the fifty-five observations, or 29%, were classified as infrastructure. Though the research area primarily encompasses many components of the Padma multipurpose bridge project's resettlement zone, it is relatively common for infrastructure to be the most frequently observed feature. The six observations of unhygienic infrastructure in figure 04 tell the story of the unhygienic toilet, drainage, waste, clogged drains, stagnant water beneath a building causing odor and aiding mosquito breeding, and an unhygienic tube well due to the proximity of a pit latrine. Five infrastructure observations of building and locality destruction describe the residents' relocation of nearly three kilometers and the destruction of the Kumarpara Union Parishad building, the old Shimulia-Nurani Madrasah, and the Bhaour Government Primary School building. Two observations documented the resort's construction and land expansion with sand filling. The Bhaour Government Primary School building was renovated; the No. 9 Shimulia Ghat Government Primary School building was used as a shelter during floods; and road connection was hampered by waterlogging, as the last three infrastructure features noted.

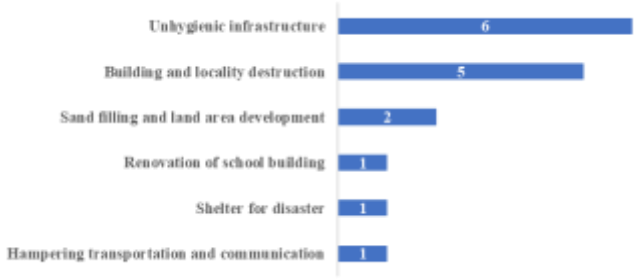

Fig. 4: Infrastructure.

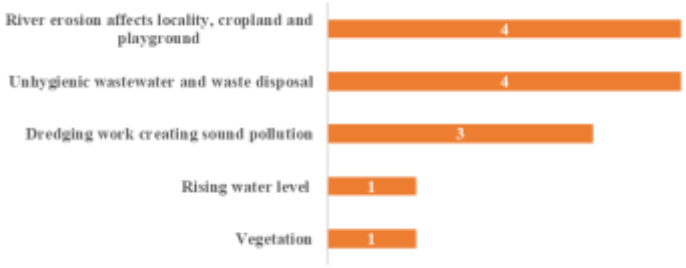

Fig. 5: River.

The research location is on the north bank of the Padma, and the feature "river" takes second place with 13 points and 24% of the 55 observation points in figure 03. Figure 05 has a total of 04 points indicating that river erosion has impacted around 14 villages, including Bhaour, Ranigaon, and Ghoria, destroying farmland and playgrounds in Khoria. The following four observations were made about open drainage of untreated wastewater into the river and uncontrolled disposal of solid garbage. Additionally, three observations identified dredging work with heavy equipment at Trawler Ghat, Shimulia, to clear the channel without taking any measures about noise pollution. The last two observations were made about the river's water level rise and vegetation with hyacinths.

According to figure 03, 18% of observations were classified as waterbodies. Among these ten points of the waterbody, the first four discuss the blockage caused by artificial barriers and disturbances in the water navigation system; an improper water navigation system results in approximately two acres of land being submerged, and the absence of an adequate drainage system at Mawa Government Primary School and Bepari Bazaar results in massive water blockage.

Following that, the dryness of the waterbody creates flora and fauna's extinction; a water channel dried up despite its connection to the Padma, as described in 03 sites of figure 06. The last three-item concern vegetation with hyacinths, fish farming, and uncontrolled open dumping of solid waste.

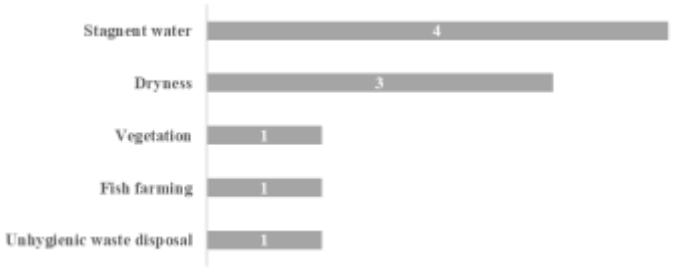

Fig. 6: Waterbody.

Fig. 7: Barren land.

According to figure 03, 11% of observations contain six sites of barren land. Among them, 03 points discuss the improper disposal of domestic solid trash in areas near the central mosque in the resettlement area. The remaining 02 refers to less vegetation, while 01 refers to sand stacking in figure 07.
Five wetland elements in figure 08 illustrate how low-lying land with uncontrolled waste disposal, diverse vegetation cover, a lack of a drainage system, and sand stacking degrade the wetland.

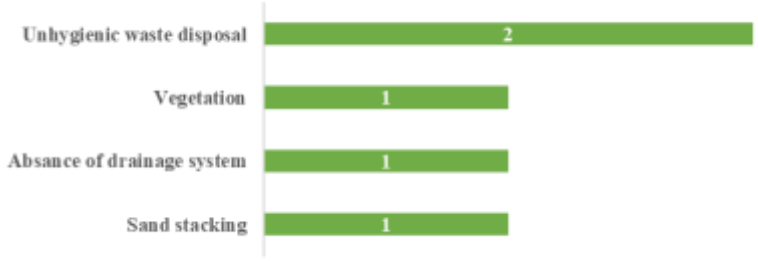

Fig. 8: Wetland.

Fig. 9: River embankment.

Three sites on the river embankment correspond to the dumping of sand-filled geotextile bags for embankment protection and tree planting, dispersed with various solid waste such as different reinforced cement concrete structures impacted by river erosion a few years ago, as seen in figure 09.
According to figure 03, only two vegetation types were detected with recent tree plantations, accounting for 4% of 55 observations.

Identification of Potential Natural Hazards: Throughout the field survey, 38 potential natural hazards were categorized into 04 categories (riverbank erosion, waterlogging, flood, and lightning) based on their properties in the research location.
According to figure 10, riverbank erosion occurred in 13 locations, resulting in the displacement of residents; the collapse of the Kumarpara Union Parishad and Bhaour Government Primary School; the demolition of the west Shimulia local market, and 14 villages, including Bhaour, Ranigaon, and Ghoria; the destruction of the Khoria playground; and the damage of the riverbank resulted in demolished concrete waste.

Fig. 10: Identified potential natural hazards.

The following 13 observations of waterlogging in figure 10 include: stagnant water caused by sedimentation behind the stake yard of the Padma multipurpose bridge project; low land, high precipitation, and an inefficient water navigation system; debris and waste; soil contamination; water contamination; mosquito breeding; foul odor; water channel is overgrown with hyacinths; and road connectivity is severely hampered due to waterlogging in the field study area.
Flood is the third natural hazard identified in the research area, with ten citations in figure 10. The absence of a drainage system results in the Padma's water level rise, which destroys many crops, properties, and roads and submerges approximately 2 acres of

land. In addition, the severe uneven settlement of various reinforced cement concrete-made structures along the riverfront in Shimulia ferry ghat area, Wari Bazaar, and along the river in Khoria all contribute to citing the flood as a potential natural hazard. The final natural hazard detected in the research region is lightning, which was documented twice in figure10. Unfortunately, the network pole near the riverfront, opposite the BIWTA office in the resettlement area, Shimulia, does not have any lightning arrestor.

Environmental Conditions Analysis: The 15 sites associated with construction, development, dredging, sand staking, and air and noise pollution account for 28% of the 54 observations in figure 11. For land development purposes, cropland and ditch areas have been reduced and filled with dredged and lifted sand. The land development process is relatively regular on the East Shimulia resettlement project, next to the Mouch sluice gate, the Amena Hakim Madrasah, and Jelepara. Additionally, dredged sand has been staked in front of the network pole near the riverfront, opposite the BIWTA office in Shimulia's resettlement area, alongside the east Rampura mosque road in west Shimulia, alongside the west Shimulia Modhyapara Central Mosque Road, and adjacent to the new Shimulia Ghat area. Without protective measures, such as covering, this massive sand staking operation could result in significant air pollution. Increased dust particle concentration in the atmosphere affects air quality. As this sand is dredged and the byproduct of this phenomenon is sound pollution, there is no mechanism to control it. Additionally, sand lifting contributes to sand staking, which has a detrimental effect on riverfront communities. Furthermore, the new development of many hotels along the Mawa Ferry Ghat and Shimulia ghat roads and a brick manufacturing factory in East Shimulia may result in environmental degradation due to improper landscape planning practices such as waste dumping unhygienically.

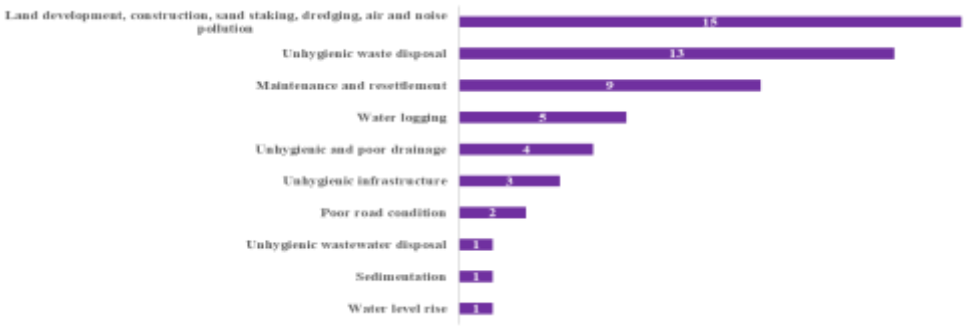

Fig.11: Identified environmental conditions.

Unhygienic waste dumping was cited in old ferry ghat, no 3 ferry ghat, and Shimulia ferry ghat. Beside the east Rampura Mosque Road in the west Shimulia resettlement project and adjacent to Shopner Tajmohol restaurant, and in the China resettlement project, unhygienic waste dumping was also found. Additionally, massive industrial garbage was disposed of near the Padma bridge stake yard's backside gate, such as demolished pieces of reinforced concrete structures. Thirteen unsanitary waste disposal sites accounted for 24% of the 54 observations in figure 11. Moreover, domestic solid waste clogs drain in the China resettlement project area, resulting in a two-acre waterlogging scenario. Additionally, the roadside open waste disposal beside east Rampura Mosque Road in the west Shimulia resettlement project led to various animals devouring the waste particles.

Maintenance and resettlement were accounted for 09 observations in figure 11. Riverbank erosion damaged around 14 villages, including Bhaour, Ranigaon, Ghoria, Kumarpara Union Parishad, East Shimulia Government Primary School, Bhaour Government Primary School, and the playground in Khoria, east Shimulia. These demolished facilities must be relocated and restored. The road network in Khoria, ward 03, Shimulia, has also been destroyed and requires reconstruction. Additionally, certain spots in west Shimulia require road diversion.

The five observations of waterlogging in figure 11 depict a complicated scenario of odorous, black-colored, and aesthetically objectionable stagnant water adjacent to the "Ajgor Mia" house in the west Shimulia resettlement project, as well as stagnant water alongside the Padma bridge casting yard fence. This stagnant water is an ideal breeding ground for mosquitoes that transmit malaria. In addition, road connectivity is likely to be significantly harmed due to waterlogging in east Shimulia. Moreover, waterlogging harms the infrastructure in east Shimulia.

In figure 11, four unhygienic and poor drainage instances accounted for 7% of the 54 observations. In the Shimulia ferry ghat area and Padma bridge resettlement area (RS-08), west Shimulia, poor drainage, direct septic tank connection, blockage due to lack of lid, and trash dumping in drains were noted. Due to the lack of a drainage system in Mawa Government Primary School, Bepari Bazaar, a large amount of water has become clogged. These unsanitary conditions and inadequate drainage can result in malaria, as stagnant water is a familiar mosquito breeding source. Odor is also a regular and unavoidable occurrence due to unsanitary structures.

Three unhygienic infrastructures were identified, accounting for 6% of the 54 observations in figure 11. First, the existing plinth level of the production tube well in front of the central mosque at the Padma bridge resettlement area (RS-08) is not paved, resulting in water pollution. Additionally, the unsanitary toilets found in Wari, tube well, and a pit latrine coexisting in the Shimulia ferry ghat neighborhood may pose health risks, such as diarrhea or cholera. Two locations with poor road conditions have been found in Jelepara, east Shimulia. These two points illustrate how the sand lifting pipe crosses the local road, causing

inconvenience to patients, pregnant women, and senior citizens and the danger of slope failure due to poor compaction during construction.

According to figure 11, sedimentation obstructs water passage behind the Padma bridge's stake yard (near fishing boat parking). However, one statement depicts untreated wastewater being discharged directly into the river near No 3 Ferry Ghat. Lastly, one location in Jelepara, east Shimulia, discusses how river training activity alters the direction of water movement or flow, resulting in an undesirable rise in water level. The rise in water levels may cause floods.

(a) River embankment (b) Collapsed by riverbank erosion

(c) Collapsed by riverbank erosion (d) Stagnant water

(e) Stagnant black water (f) Poor drainage system

(g) Mismanagement of waste (h) Mismanagement of wastewater

Fig. 12: Identified different natural hazards and environmental condition scenarios.

Water Sample Test Results:

Temperature: The temperature of the 09 groundwater samples ranged from 24.20˚C to 26.50˚C, with a mean of 25.07 degrees Celsius. The standard deviation was therefore calculated to be 0.90˚C. The mean temperature of the 15 surface water samples was 25.25 degrees Celsius, ranging from 24.10 to 26.80 degrees Celsius. The calculated standard deviation was 0.95˚C. Therefore, both coefficients of variation of 0.04<1 indicate that the distribution of temperature values is adequately centered around the mean value.

The mean temperature of 25.07 and 25.25 degrees Celsius is relatively close to the room temperature of 20 degrees Celsius, the recommended temperature for drinking water [20]. As a result, it is of a virtually satisfactory standard.

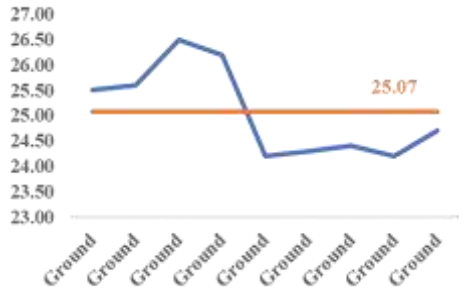

Fig. 13: Temperature test results of groundwater sample.

Fig. 14: Temperature test results of surface water sample.

pH: The pH ranges from 6.5 to 8.2 in the groundwater samples obtained during the field investigation. The pH value of most drinking water is between 6.5 to 8.5 [21], and all groundwater samples collected fit within this range, showing that the groundwater is safe to drink.

Surface water samples have a pH value ranging from 6.2 to 8.1. All lakes and streams have a general pH level (usually between 6 and 8), allowing natural species to flourish [22], and all obtained samples fall within this range. Which also suggests the best-suited surface water for any living creature's survival.

Electrical Conductivity: The electrical conductivity of the 24 water samples obtained varies between 209 and 598 µS/cm, which are within the conductivity range of drinking water, i.e., 50 and 1500 µS/cm, representing the least disturbed water sample [11].

Dissolved Oxygen: The dissolved oxygen concentration in healthy water should be greater than 6.5 mg/L to 8 mg/L [23]. While each organism has a different dissolved oxygen tolerance range, water with a DO concentration of less than 3 mg/L is generally considered dangerous, while water with less than 1 mg/L DO is considered hypoxic and inhospitable [24].

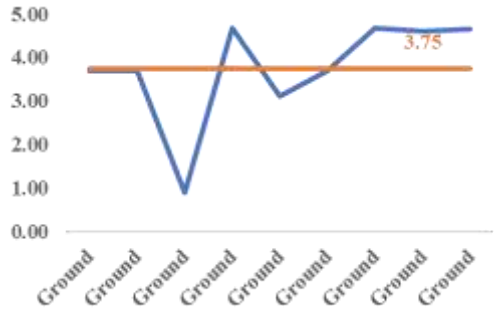

Fig. 15: Dissolved Oxygen (DO) test results of groundwater sample.

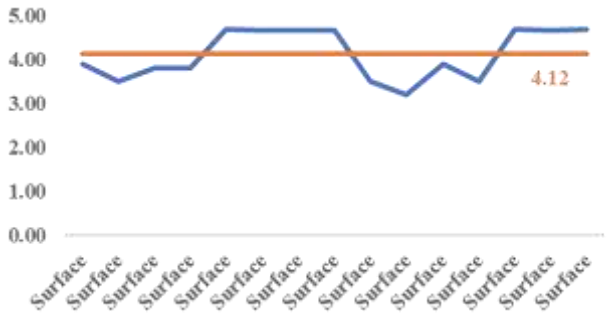

Fig. 16: Dissolved Oxygen (DO) test results of surface water sample.

The dissolved oxygen (DO) concentration of the 09 groundwater samples ranged from 0.90 mg/L to 4.67 mg/L, with a mean of 3.75 mg/L. The standard deviation was therefore calculated to be 1.21 mg/L. The mean dissolved oxygen (DO) concentration of the 15 surface water samples was 4.12 mg/L, ranging from 3.20 to 4.68 mg/L. The calculated standard deviation was 0.56 mg/L. Therefore, both coefficients of variation of 0.32 and 0.14<1 indicate that the distribution of dissolved oxygen (DO) concentration values are adequately centered around the mean value. Thus, both DO mean value above the tolerance range indicates a barely good fit but should not be considered healthy water.

Soil Sample Test Results:

pH: The pH values for the four soil samples were 7.79, 8.64, 6.92, and 8.16. Therefore, the sample with a pH value of 6.92 was classified as neutral, i.e., 6.5 to 7.5, while the remaining samples were within an acceptable range for the alkaline group because the soil's pH value above 7.5 is considered alkaline [25].

Moisture Content: The moisture content of the four soil samples was 12.50%, 18.11%, 8.52%, and 22.43%. Although the sample yielding 8.52% may not fall into the general category of moisture content between 10% and 45% [26], all samples fall outside the range suitable for agriculture, such as vegetables requiring 41 to 80% moisture [27].

Recommendations:

- ☑ Dredging, cement concrete blocks, and geotextile bags loaded with sand on slopes are used in the study area to protect river banks from erosion. After implementing upper mentioned techniques, river erosion has taken place in recent years, and demolishing Kumarpara Union Parishad building, old Shimulia-Nurani Madrasah, west Shimulia local market, Khoria playground, and Bhaour Government Primary School building, may biological bank protection systems also be used to get a better result. Moreover, measures for noise pollution are necessary for dredging at Trawler Ghat, Shimulia.
- ☑ Unsanitary management of waste and wastewater is one of the major causes of environmental degradation observed in the old ferry ghat, adjacent to Shopner Tajmohol restaurant, adjacent to no 3 ferry ghat, Shimulia ferry ghat area, adjacent to the central mosque at the Padma bridge resettlement area (RS-08), adjacent to the east Rampura Mosque Road and adjacent to the Padma bridge stake yard's backside gate. Without efficient waste and wastewater management, living in a healthy environment is a nightmare. Landfills and water treatment plants absent in the studied area are primarily required for successful waste and wastewater management. Public awareness and proper planning are also critical for sanitized waste and wastewater management.
- ☑ Drains in the studied Padma bridge resettlement area (RS-08) must have covers to eliminate odors, and drainage of stagnant water is vital to prevent mosquito breeding. Direct connection of septic tanks and trash dumping in drains must be stopped. The drainage network of the studied area needs to be extended because the absence of an adequate drainage system at Mawa Government Primary School and Bepari Bazaar results in massive water blockage.
- ☑ Cropland and ditch areas have been reduced in the East Shimulia resettlement project, next to the Mouch sluice gate, the Amena Hakim Madrasah, and Jelepara due to land development purposes. Therefore, for efficient watershed management, it is vital to protect mainly ditch and low-lying areas, which store the precipitation. It is also essential to clear existing water navigation channels and remove obstructions to prevent waterlogging, the second most identified natural hazard in the study area.
- ☑ The plinth level of tube wells in front of the central mosque at the Padma bridge resettlement area (RS-08) must be paved to reduce health hazards such as diarrhea and cholera, And the toilets need to be made more hygienic. Besides, public awareness is also crucial in this regard.
- ☑ The best choice is to increase lightning awareness to reduce lightning-related deaths at a more tolerable level, as there are no lightning arrestors on the network pole near the riverfront, opposite the BIWTA office in the resettlement area, Shimulia.
- ☑ Sustainable planned development is vital as various natural vegetation cover decreases daily, which can put biodiversity under stress in the studied area.

Conclusion: The study area is situated on the Padma riverside, and near the Padma bridge project, infrastructure, river, and waterbody are prevalent landscape components commonly viewed. In addition, combining observable phenomena from field investigations and group conversations with residents enables the identification of riverbank erosion, flooding, waterlogging, and lightning as the most significant hazards in the study area. Moreover, the ultimate goal of the evaluation of the environmental conditions of the study area is achieved with the findings of unsanitary waste and wastewater management, noise and water pollution, inefficient and inadequate drainage systems, decreasing natural vegetation cover and ditch and low-lying areas, and so on. Furthermore, the collected water samples indicate that the water is incompatible with being considered healthy due to the low dissolved oxygen concentration. In the case of soil samples, the percentage of moisture content does not conform to the range of values considered agriculturally suitable, yet pH test results reveal the soil's alkalinity. For sustainable growth of the new settlements and older localities without jeopardizing the existing ecosystem, precise planning necessitates, and several viable approaches for rehabilitating the research location's environmental conditions have been detailed. Besides this, based on the practical observations, some steps of remedies for each consequence were also established. Finally, it is revealed during the literature search that very few studies have been conducted in this area, and this study, based on field observation, serves as the foundation for future research and the appropriate maintenance and welfare of the community.

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