FLOOD HAZARDS OF NORTH 24 PARGANAS DISTRICTS IN WEST BENGAL: CAUSES, IMPACTS AND MANAGEMENT

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Abstract

North 24 Parganas district in West Bengal, India, confronts significant flood hazards stemming from a complex interplay of factors. The region is particularly susceptible to flooding due to heavy monsoon rainfall, a rising sea level, riverine flooding, land subsidence, and the overarching influence of climate change. These floods, occurring with regularity, result in severe consequences, encompassing loss of life, extensive damage to infrastructure, disruption of livelihoods, and the salinization of agricultural land. The multifaceted nature of these hazards necessitates a comprehensive and multi-pronged approach to flood management. Strategies encompass pre-monsoon preparedness to anticipate and mitigate risks, a robust response mechanism during the monsoon season, and effective post-monsoon recovery efforts. Coastal protection measures become crucial to shield vulnerable areas from rising sea levels, while sustainable river management strategies are essential to regulate water flow and prevent riverine flooding. Additionally, groundwater management plays a pivotal role in addressing waterlogging issues. Urban planning initiatives must integrate flood resilience considerations to minimize the impact on densely populated areas. The paper emphasizes the importance of implementing mitigation strategies that go beyond short-term solutions and prioritize long-term climate-resilient development. A critical aspect highlighted in the analysis is the need for an integrated and community-based approach to flood management. Engaging local communities in the decision-making process, incorporating traditional knowledge, and fostering community resilience are vital components of a holistic strategy. The paper underscores the significance of recognizing the interconnectedness of various factors contributing to flood hazards and advocates for a coordinated effort among government agencies, local communities, and stakeholders. By addressing the causes and impacts of floods through a comprehensive and collaborative framework, North 24 Parganas can enhance its resilience, ensuring sustainable development in the face of recurring flood challenges.

Keywords: Flood hazards, North 24 Parganas, West Bengal, Climate change, Resilience

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1. Introduction

North 24 Parganas, situated in the deltaic region of West Bengal, India, exhibits a diverse range of physiographic and soil characteristics shaped by the intricate network of rivers, particularly the expansive Ganges delta (Ghosh & Dutta, 2022). Lacking hills, the district is segmented into three main physiographic zones: the Ichhamati-Raimangal Plain, North Bidyadhari Plain, and North Hugli Flat. The Ichhamati-Raimangal Plain, spanning the northern and eastern regions, features a variety of soils, ranging from mature black or brownish loam to recent alluvium (Mondal & Mukherjee, 2021). The local slope towards the south is drained by the Ichhamati and Raimangal rivers, contributing to unique topographical features shaped by the dynamic forces of these rivers.

The North Bidyadhari Plain, characterized by sewerages and marshes with saltwater lake regions, presents challenges related to water management and salinity (Biswas & Ghosh, 2020). The landscape reflects the intricate interplay of natural forces and human activities in North 24 Parganas, making water resource management and salinity issues crucial for sustainable development (District Disaster Management Plan, 2023-2024). While details about North Hugli Flat are not explicitly provided, it can be inferred that this zone, like the others, is influenced by

the dynamics of the Ganges delta. The absence of hills and the presence of a flat terrain contribute to the unique character of North 24 Parganas, making it a significant region in the deltaic plain of West Bengal, with its physiographic and soil features playing a vital role in shaping the local environment and influencing land use patterns.

The Sunderbans, located in the southern regions of North 24 Parganas and South 24 Parganas districts, stands as the world's largest mangrove forest and a UNESCO World Heritage site (North 24 Parganas District Flood Hazard Assessment Report, 2020). Nestled at the confluence of the Ganges, it represents an active delta continually expanding southwards. The Sunderbans' captivating landscape includes tidal waterways, expansive mudflats, salt-tolerant mangrove forests, and an intricate network of rivers, canals, and creeks.

Mangroves, a defining feature of the Sunderbans, serve a crucial role in shore protection and sediment accumulation, contributing to the region's ecological stability. The area boasts rich biodiversity, hosting iconic species such as the royal Bengal tiger, diverse bird species, spotted deer, crocodiles, and snakes (World Wildlife Fund India, 2020). The ongoing ecological processes, notably the formation of new bars and islands, contribute to the dynamic and distinctive nature of the Sunderbans ecosystem.

The Ganges Delta, encompassing Nadia, Kolkata, North 24 Parganas, South 24 Parganas, and the eastern half of the Murshidabad district, is shaped by the Ganges River, dividing into three distinct parts: the old delta, mature delta, and active delta (Asian Development Bank, 2021). This expansive deltaic plain not only includes the Sunderbans but also influences the surrounding districts. The Ganges Delta is a region of immense ecological significance, characterized by its complex riverine network and dynamic landforms (Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report, 2022). The interplay of water and sedimentation in the delta contributes to fertile soils and diverse ecosystems, making it a vital area for both ecological research and conservation efforts.

The Ganges Delta, spanning across Murshidabad and Nadia districts, forms what is known as the Old Delta. In this region, the process of river formation is complete, and the landscape is characterized by silted rivers, swamps, beels, and oxbow lakes (Mondal & Mukherjee, 2021). The Bagri region, consisting of Murshidabad and Nadia, showcases the matured stage of delta evolution, where rivers have established their courses, creating a diverse and complex network of water bodies. Murshidabad, historically significant for being the erstwhile capital of Bengal during the Mughal era, is nestled within the Old Delta. Here, the silted rivers have settled into their current paths, forming a landscape punctuated by swamps, beels (shallow lakes), and oxbow lakes. The Bagri region's topography is a result of centuries of sedimentation and the intricate interplay of river dynamics.

Moving towards the central part of the Ganges Delta, Kolkata and North 24 Parganas constitute the Mature Delta. This region is marked by slow and meandering rivers that frequently shift courses, contributing to the ever-changing landscape (Asian Development Bank, 2021). Swamps, beels, and oxbow lakes continue to be prominent features, creating a picturesque and varied terrain. Kolkata, the capital of West Bengal, situated on the banks of the Hooghly River, reflects the historical and cultural significance of the delta, while North 24 Parganas, with its diverse physiographic features, further exemplifies the complexity of the mature deltaic landscape.

As we progress southwards, South 24 Parganas emerges as the Active Delta, where the process of delta formation is ongoing (Asian Development Bank, 2021). This region showcases the dynamic nature of deltaic landscapes, with constant changes in landforms and river courses. The active delta is characterized by the deposition of sediment and the formation of new bars and islands. The complex network of waterways continues to shape the terrain, creating a vibrant and ever-evolving environment.

Physiographic and Soil Characteristics of North 24 Parganas

In summary, North 24 Parganas, positioned within the Ganges Delta, presents a diverse tapestry of physiographic features and soils influenced by the complex dynamics of delta evolution. From the mature delta in the central region, where rivers meander and create a labyrinthine landscape, to the active delta in the south, where the landscape undergoes continuous transformation, the district encapsulates a mosaic of landscapes (Ghosh & Dutta, 2022). Fertile plains, marshes, swamps, and the ecologically vital Sunderbans mangrove forest contribute to the environmental significance of North 24 Parganas. The district stands as a testament to the intricate processes that have shaped the Ganges Delta over time, making it a distinctive and environmentally crucial region in West Bengal.

2.Objective:

The primary objective of this study is to conduct a comprehensive analysis of river drainage areas in North 24 Parganas, West Bengal, with a focus on understanding the hydrological and spatial dynamics that shape the district's landscape. Specifically, the study aims to identify and assess the significance of key rivers, including Ichhamati, Bidyadhari, Kodala, and Jamuna, by analyzing their total drainage area, percentage contribution to the district, and their respective roles in influencing water availability, topography, and ecosystem dynamics. The research aims to provide critical insights into the hydrological patterns of the region, contributing valuable information for sustainable water resource management, flood control, and ecological conservation.

3.Sample:

The study focuses on four major rivers in North 24 Parganas: Ichhamati, Bidyadhari, Kodala, and Jamuna. These rivers have been selected based on their prominence and significance in the district's hydrology. Data for each river includes total length within the district, place of origin, and altitude at origin. This information is crucial for understanding the spatial distribution and topographical characteristics of these water bodies. The study will utilize official data sources and maps, including Table 2: Salient Features of Important Rivers and Streams in 24 Parganas North District, to gather relevant information for the analysis.

4.Methodology:

The research will adopt a multi-step methodology to achieve its objectives. Firstly, data on the total length, place of origin, and altitude at origin for each river will be extracted from official records, particularly Table 2. Subsequently, the study will involve spatial mapping and visualization techniques to represent the geographical distribution of these rivers within the district. Quantitative analysis will be conducted to calculate the percentage of the district's area drained by each river, emphasizing the relative significance of Ichhamati and the smaller contributors, Bidyadhari, Kodala, and Jamuna. Comparative analysis will be employed to identify variations in hydrological patterns and assess the diverse roles of these rivers in shaping the district's landscape. The findings will be discussed in the context of the region's environmental sustainability, local agriculture, and overall water resource management, emphasizing the need for informed decision-making in the socio-economic and environmental aspects of North 24 Parganas.

5. Analysis

Table 1: Drainage system with description of Main River

S.No	Name of the River	District of North 24 Pgns area (in sq km)	% Area Drained in the District
1	Ichhamati	303.257	8.06
2	Bidyadhari	36.348	0.96
3	Kodala	23.907	0.63
4	Jamuna	8.384	0.22

The analysis of river drainage areas in North 24 Parganas unveils critical insights into the hydrological and spatial dynamics shaping the district's landscape. Ichhamati, encompassing a vast area of 303.257 sq km and draining 8.06% of the district, emerges as the primary hydrological force, suggesting a widespread influence on water availability and ecosystem dynamics. This substantial coverage implies Ichhamati's pivotal role in shaping the topography and underscores its significance for local agriculture, environmental sustainability, and overall water resource management. Bidyadhari, Kodala, and Jamuna, with smaller drainage areas of 36.348 sq km (0.96%), 23.907 sq km (0.63%), and 8.384 sq km (0.22%) respectively, contribute to the district's hydrology to varying degrees. While these rivers cover comparatively smaller percentages of the district, their roles are significant in local ecosystems and water networks. The data serves as a valuable tool for policymakers and environmental planners, aiding in the formulation of strategies for sustainable water resource management, flood control, and ecological conservation. Understanding the spatial distribution and hydrological significance of these rivers provides a foundation for informed decision-making, particularly in a region where water resources play a crucial role in the

socio-economic and environmental fabric of the community. This analysis underscores the importance of considering the diverse contributions of each river in the broader context of North 24 Parganas' hydrological and ecological landscape.

Table 2: Salient Features of Important Rivers and Streams in 24 Parganas North District

S.No	Name of River/Stream	Total Length in District (km)	Place of Origin	Altitude at Origin (m)
1	Ichhamati	78.018	Nalabara, West Bengal	5
2	Bidyadhari	60.58	Bamunbaria, West Bengal	8
3	Kodala	29.884	Haringhata, West Bengal	10
4	Jamuna	41.923	Tribeni, West Bengal	3

The analysis of the rivers and streams in North 24 Parganas, based on their total length in the district, place of origin, and altitude at origin, provides valuable insights into the geographical and topographical characteristics of the region. Ichhamati, with a substantial length of 78.018 km and originating in Nalabara, West Bengal, at an altitude of 5 meters, is a major watercourse influencing the district's hydrology. The relatively longer length indicates its extensive flow within the district, while the low altitude at its origin suggests a flat and deltaic landscape. Bidyadhari, with a total length of 60.58 km, originating in Bamunbaria at an altitude of 8 meters, showcases a significant watercourse contributing to the district's hydrological network. The slightly higher altitude at its origin compared to Ichhamati implies potential variations in topography and water flow patterns. Kodala, originating in Haringhata at an altitude of 10 meters, covers a length of 29.884 km, reflecting a shorter yet significant watercourse in the district. The higher altitude at its origin may indicate a source in an elevated terrain, influencing the downstream landscape. Jamuna, with a length of 41.923 km and originating in Tribeni at an altitude of 3 meters, represents another noteworthy river in the district. The lower altitude at its origin, along with a moderate length, suggests its role as a contributor to the district's hydrological system. The analysis of these rivers and streams not only provides essential data for understanding the geographical features but also aids in formulating strategies for water resource management, flood control, and environmental conservation in North 24 Parganas. The variations in length and altitude at origin underscore the diverse topography and hydrological characteristics shaping the district's landscape.

Table 3: Dist. - North 24 Parganas Rainfall Data (mm.) 2016 – 2020

Month	2020	2019	2018	2017	2016
Jan	36.7	0	0	0	0.7
Feb	4.4	139.7	0	0	84.4
Mar	83.8	81.6	2.4	44.2	37.8
Apr	115.8	63.2	85.7	5.2	2.5
May	330.5	88.7	162.9	87.6	146
Jun	400.2	98.7	254	258.6	225.8
Jul	337.5	208.7	388.1	502.3	427.1
Aug	394	421.6	259.8	257.2	473.4
Sep	162.7	322.7	169.7	238.4	135
Oct	51.9	204.7	67.5	288.5	111.3
Nov	16.8	98.2	0	39	30.7
Dec	0	9.5	12.5	28.8	0

Source: Indian Meteorological Department, Nagpur

The presented data represents monthly precipitation (in millimeters) for the years 2016 to 2020, offering insights into the annual rainfall patterns in the region. In January 2020, there was a notable increase in precipitation compared to the previous years, with a recorded value of 36.7 mm, indicating a deviation from the usual dry

conditions of January. February witnessed a substantial decrease in rainfall in 2020 compared to the exceptionally high levels in 2019, suggesting a return to more typical conditions. March 2020 experienced higher precipitation than the preceding years, showcasing variability in seasonal patterns. April recorded the highest rainfall in 2020, reaching 115.8 mm, surpassing the levels of the preceding years. May and June 2020 continued this trend, with significant increases in precipitation compared to the respective months in the previous years. July 2020 exhibited lower rainfall compared to the exceptionally high levels in 2017, yet it remained considerable. August 2020 showed a decline in precipitation compared to the previous year but remained substantial. September 2020 recorded less rainfall than the exceptionally high levels in 2019, indicating a fluctuation in seasonal patterns. October 2020 demonstrated a decrease in precipitation compared to 2019 but exceeded the levels of 2017 and 2018. November and December 2020 showcased varying levels of rainfall compared to the respective months in the previous years.

The analysis highlights the dynamic nature of precipitation patterns over the five-year period. The data suggests that 2020 experienced significant deviations in rainfall compared to the preceding years, with notable increases in certain months, such as January, April, and June. These variations underscore the complex interplay of meteorological factors influencing the region's climate. Understanding these patterns is crucial for local authorities, farmers, and environmental planners for effective water resource management, agriculture planning, and flood preparedness. Additionally, the data could contribute to the assessment of climate trends and the formulation of strategies for adapting to changing precipitation patterns in the region.

Table 4: Flood Hazards of North 24 Parganas Districts in West Bengal: Causes, Impacts & Management

Cause	Impact	Management Strategy
Heavy Monsoon Rainfall: - Over 1500 mm annual rainfall concentrated in monsoon months (June-October) - Localized intense bursts exceeding 100 mm/day	- Loss of life, injuries, and displacement - Damage to houses, infrastructure, and agricultural land - Disruption of transportation and communication networks - Spread of waterborne diseases	- Pre-monsoon preparedness: Strengthen embankments, dredge rivers, clean drainage channels, raise awareness, stockpile essentials. - Monsoon response: Evacuation to shelters, rescue operations, emergency medical care, food and water distribution. - Post-monsoon recovery: Reconstruction of infrastructure, livelihood support, disease control measures.
Rising Sea Level: - Exacerbates tidal flooding during cyclones and high tides - Increased salinity intrusion into freshwater sources	- Loss of coastal land, damage to coastal infrastructure - Salinization of agricultural land, reduced crop yields - Increased risk of erosion and displacement	- Coastal protection: Building seawalls, mangrove restoration, sand dune stabilization, land-use planning. - Adaptation strategies: Salt-tolerant crops, improved water management, relocation of vulnerable communities.
Riverine Flooding: - Overflowing of major rivers like Ichamati, Hooghly, and Matla - Breaches in embankments due to poor maintenance or erosion	- Inundation of agricultural land, loss of crops and livestock - Damage to roads, bridges, and irrigation systems - Disruption of livelihoods and economic activity	- Sustainable river management: Dredging, afforestation in catchment areas, improved flood forecasting and warning systems. - Strengthening embankments: Regular maintenance, use of erosion-resistant materials, community-based management.
Land Subsidence: - Excessive groundwater extraction leading to land subsidence and increased flood vulnerability	- Increased risk of flooding in low-lying areas - Damage to buildings and infrastructure - Disruption of drainage systems	- Groundwater management: Regulation of extraction, rainwater harvesting, promotion of alternative water sources. - Urban planning: Proper drainage systems, building codes addressing subsidence risks, awareness campaigns.
Climate Change: - Increased frequency and intensity of extreme weather events like cyclones and floods - Changes in rainfall patterns and river flows	- Exacerbation of all existing flood hazards - Long-term impact on water availability and food security - Increased risk of climate-induced migration	- Mitigation strategies: Reducing greenhouse gas emissions, promoting renewable energy, sustainable land-use practices. - Climate-resilient development: Infrastructure design considering future flood risks, livelihood diversification, community-based adaptation plans.

6. Conclusion

In conclusion, the North 24 Parganas district faces a formidable challenge from flood hazards, necessitating both immediate and sustained interventions. Tackling the root causes, notably climate change and unsustainable land-use practices, is imperative to effectively mitigate future flood risks. Management strategies must be all-encompassing, covering pre-disaster preparedness, emergency response mechanisms, post-disaster recovery initiatives, and the implementation of long-term adaptation measures. The involvement of local communities in decision-making processes and the execution of solutions is paramount for fostering resilience on the ground. Furthermore, directing resources towards research and development for flood-resistant infrastructure and early warning systems can significantly enhance the region's preparedness and response capabilities. By embracing a holistic and proactive approach, North 24 Parganas has the opportunity to forge a more resilient future and curtail the adverse impacts of floods. This calls for collaborative efforts from governmental bodies, local communities, and other stakeholders to create a comprehensive and sustainable flood management framework that safeguards lives, infrastructure, and livelihoods in the face of persistent flood challenges.

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