Flood Risk Assessment Study of Basti District in Uttar Pradesh, India

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***Abstract*—Basti District in eastern Uttar Pradesh, India, is highly susceptible to recurring, devastating floods due to its geomorphological positioning within the low-lying alluvial plains of the Ganga Basin. The region is bounded and directly influenced by the highly dynamic, braided networks of the Ami and Ghaghara rivers, which frequently experience severe monsoonal discharge, lateral channel migration, and embankments breaches. This study conducts a comprehensive flood vulnerability and risk susceptibility assessment across Basti District to identify critical inundation zones and support target-driven disaster mitigation strategies. Integrated images of Remote Sensing (RS) and Geographic Information System (GIS) techniques were deployed together with population data in categorizing Basti district low, medium and high risk. A substantial percentage of the agricultural land and rural settlements proximal to the main river channels fall into the low, medium and high risk zones, primarily driven by low-lying slope gradients and high drainage density. The findings provide a vital spatial decision-support template for regional planners, offering data-driven insights to improve early warning systems, optimize relief operations, and guide structural soft-engineering interventions along the vulnerable banks of the Ghaghara and Rapti systems.**

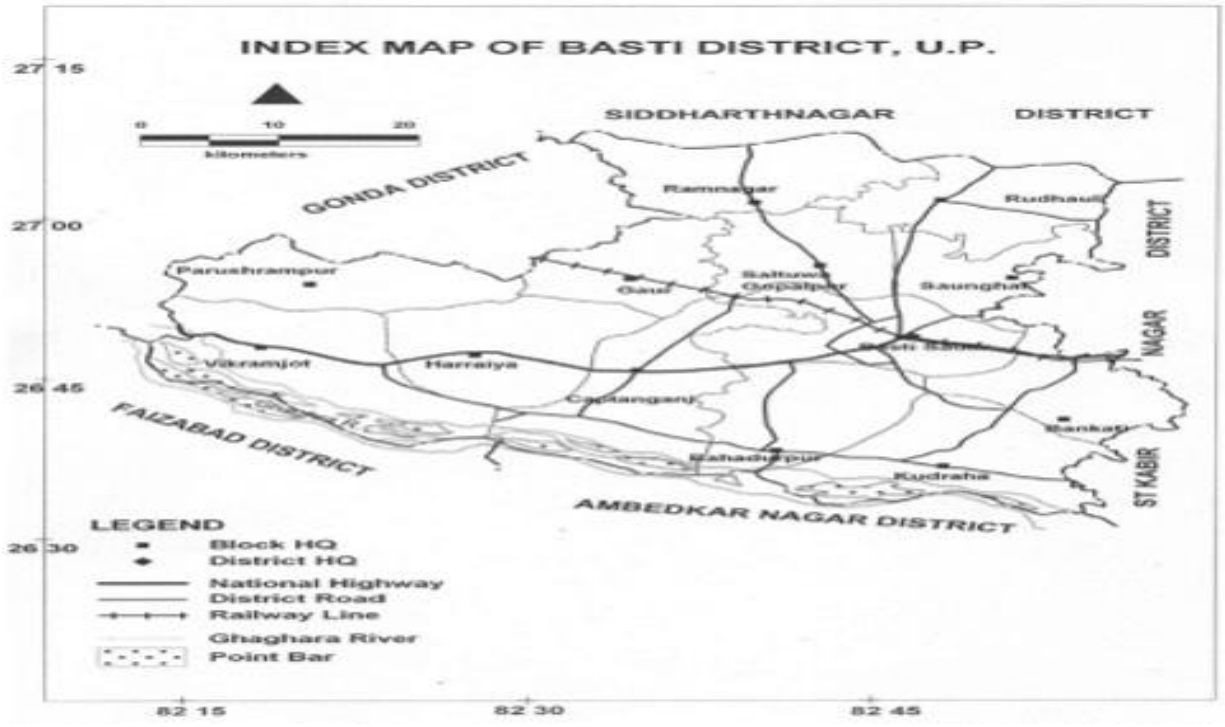
***Index Terms*—Flood Risk Assessment, GIS and Remote Sensing, Ami River, Ghaghara River, Basti District.**

I. INTRODUCTION

The Basti District in Uttar Pradesh, India, is highly vulnerable to recurrent seasonal flooding due to its geographical location in the Indo-Gangetic plains. Positioned within the Ghaghara River basin, the district experiences severe socio-economic disruptions, agricultural losses, and infrastructural damage during the monsoon season. Basti District is bounded by Siddharthnagar to the north, Sant Kabir Nagar to the east, Ambedkar Nagar to the south, and Gonda to the west. Ami the tributary of Rapti river and the Ghaghara, along with its tributaries like the Kuwano river, serves as the primary source of inundation. The flat topography combined with high-intensity monsoon rainfall leads to frequent river overflows and prolonged waterlogging, threatening local livelihoods that depend heavily on agriculture.
This Flood Risk Assessment Study provides a comprehensive evaluation of flood hazards, vulnerability, and risk zones across Basti District using advanced remote sensing and Geographic Information System (GIS) techniques.

II. STUDY AREA

Basti district forms a part of Central Ganga Plain of Uttar Pradesh, and lies in the doab of Ghaghra and Rapti. It covers an area of 2688 sq.km. The district lies between the parallels of 26° 23' and 27° 30' North and Latitude and 82° 17' and 83° 20' East longitude. Its maximum length from north to south is about 75 km. and breadth from east to west about 70km.



. Figure 1

Table 1

SN	BLOCK	POPULATION
1	Ramnagar	170624
2	Saltaua Gopal Pur	187948
3	Paras Rampur	168180
4	Gaur	225346
5	Harraiya	149625
6	Vikram Jot	155556
7	Kaptanganj	127516
8	Dubaulia	100738
9	Rudhauli	117008
10	Sau Ghat	198155
11	Basti	233908
12	Bankati	180176
13	Bahadurpur	172030
14	Kudaraha	139557

Source: Primary Census Abstract C.D. Block wise, Uttar Pradesh - District Basti – 2011, India, 2011

III. OBJECTIVES

The primary objectives of a flood risk assessment study for Basti District in Uttar Pradesh are to identify flood-prone inundation zones, evaluate local socio-economic and infrastructural vulnerabilities, and establish data-driven disaster management and mitigation strategies. Identifying and categorizing low, medium and high -risk, low-lying, and vulnerable zones. Enhancing forecasting models to predict

riverine and monsoon-driven floods early. Recommending structural barriers and non-structural land-use zoning plans.

IV. METHODOLOGY

Combine Data: Use satellite images and census numbers with map layers. Near Real time Inundation Map of Basti district of Uttar Pradesh state Statistics prepared by FMISC, Lucknow based on the analysis of Radarsat-2 SAR satellite data on September 03, 2021, National Remote Sensing Centre, ISRO, Dept. of Space, Govt. of India, Hyderabad. Find vulnerable zones: Show areas near the Ami and Ghaghara rivers that are vulnerable to flooding. Count People: count the people living in those risk zones.

V. DRAINAGE

The district has two main river systems namely, the Ghaghra and Rapti, both of which ultimately form a part of the great Gangetic system. The other streams of the district are the Kuwano, its tributaries are, the Rawai, the Manwar and the Katnehia, and the Ami is a tributary of Rapti. River Ghaghra is formed by the combined waters of Kauriyala, Girwa, Chauka and other streams, which have their origin in the mountains of Kumaun and Nepal. The Ghaghra forms the southern boundary of the district. The river flows continually shifting channel within a broad sandy bed. During the rains it carries immense volume of water, but in dry weather it shrinks to small dimensions. The river has a constant tendency to change its course during the floods, and in this manner large tracts of land from time to time are shifted either to the northern or southern banks, rendering the total area of the district subject to incessant variation. Many point bar deposits are present within the course of river, locally known as Deyara. In monsson season Rapti and Ghaghra river cross its bank and submerged adjoining area. Manwar or Kawano are tributaries of Ghaghra river in the district.

VI. CLIMATE AND RAINFALL

The climate of the district is more equable than the adjoining districts to the south. The year may be divided into four seasons. The winter season, from mid-November to February is followed by the summer season lasting till about the middle of June. The period from mid-June to the end of September constitutes the south-west monsoon season. October to mid-November is the post monsoon or transition period. During the winter seasons the mean minimum temperature is about 9 degrees Celsius and means maximum is 23 degrees Celsius while during the summer seasons the minimum is about 25 degree Celsius and mean maximum is about 44 degrees Celsius. During south-west monsoon and the post monsoon seasons the relative humidity is high, being above 70 percent. Thereafter the humidity decreases and, in the summer, air is very dry. Winds are in general very light with a slight increase in force in the late summer and monsoon seasons. The average annual wind velocity in the district ranges from 2 to 7.1 km/hrs. The average annual rainfall in the district is 1169.8 mm. Maximum rainfall occurs during the monsoon period i.e. June to September having 87% of annual rainfall. July is the wettest month having the normal rainfall of 341.50 mm followed by August with normal rainfall of 311 mm.

VII. GEOMORPHOLOGY

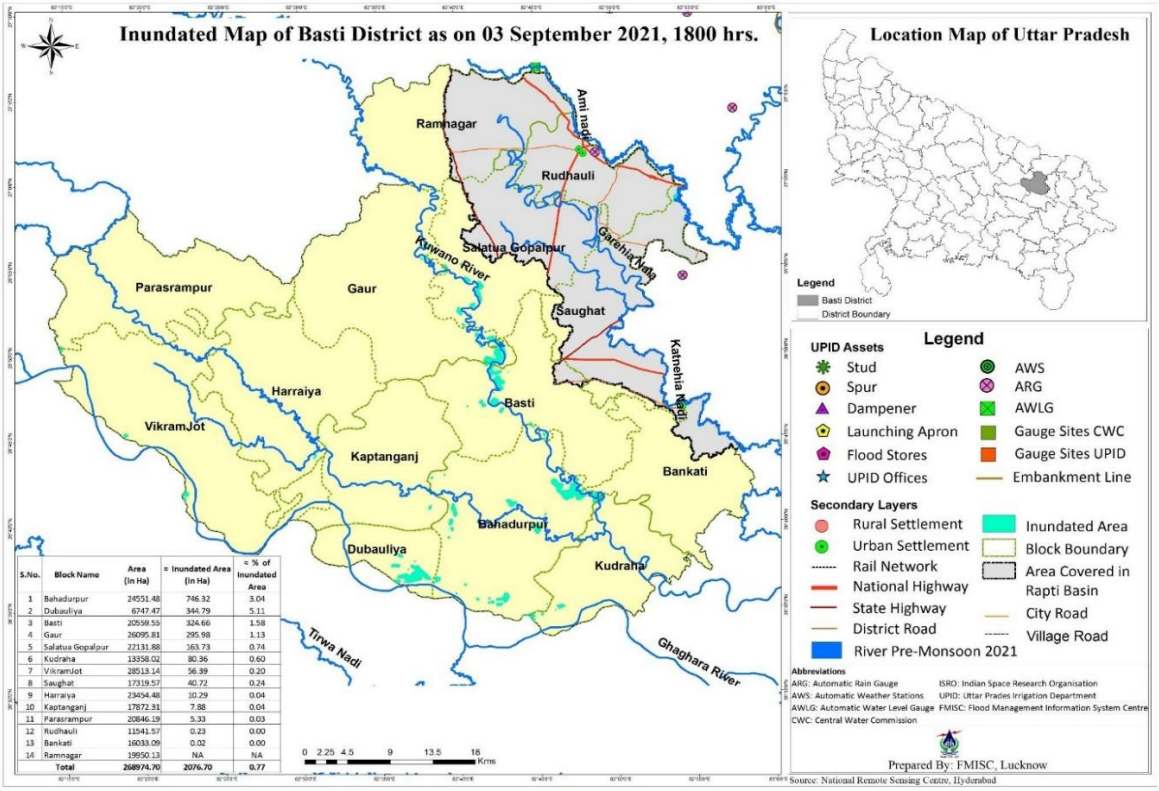
The district, in spite of its apparent uniformity of aspect, it divided topographically into several distinct tract namely, the low valley of the Ghaghra in the south, extending from that river to its tributary, the Kuwano; the central upland, between the latter river and the rapti; and the low and ill-drained paddy belt between the Rapti and the Nepal boundary. The altitude of the Basti district ranges between76 to 92 m amsl. The district can be almost divided into two identifiable units, the upland plains underlain by Older Alluvium and the lowland plains underlain by Newer Alluvium. Younger alluvial plain is found along the Ghaghra river and it is flat to sloping slightly undulated terrain. It is produced by extensive deposits of alluvium and usually occur adjacent to flood plains and consist of various fluvial land forms which include back swamp, oxbow lake, old meander, meander scar, paleochannel and point bar. It mainly comprises of younger unconsolidated alluvial materials of varying lithology. In the younger alluvial plain area, the ground water table is very shallow and ground water yield prospects are excellent. Older alluvial plain is similar to younger alluvial plain but are formed at the earlier stage of depositional regimes comprising of

unconsolidated sediments, hence occurring comparatively far from the present flood plains of the river. Groundwater prospects are good to very good.

VII. SOIL CHARACTERISTICS

The soils of the district consist broadly of “Matiyar” or clay, “Dumat” or loam. The hard clay soil or Matiyar is ideal for rice cultivation and very fertile. The Dumat or loam is also fertile soil, ideal for cultivation of various types of crops. This is the reason for high crop yields in the district. In the southern tahsil of Harriya and Basti the prevailing form of soil is loam, while in the north the area of clay approximates a extend to that of loam. The main variety of soils in the district are the loamy of dumat, the clayey or matiyar and the sandy soil is found along the high banks of river Ghaghra. Soils of the district are generally calcareous and similar to the alluvial soils. As regards of fertility, the district Basti is grouped under the medium category

Basti district is located in the northeastern part of Uttar Pradesh, India. It's bordered by Sant Kabir Nagar to the east, Gonda to the west, Faizabad and Ambedkar Nagar to the south, and Sidharth Nagar to the north. The Ghaghra river separates Basti from Faizabad and Ambedkar Nagar. The district is 2,688 square kilometers in area and is located between 26° 23′ and 27° 30′ North latitude and 82° 17′ and 83° 20′ East longitude. The district headquarters are in Basti town. Basti district is made up of four tehsils: Basti Sadar, Harraiya, Bhanpur, and Rudhauli. It also has 14 development blocks but only 6 blocks come under Rapti river basin, 139 Nyay Panchayats, two Parganas (Amorha and Nagar), and 10 Gram Sabhas. In 2006, the Ministry of Panchayati Raj named Basti one of the country's 250 most backward districts. The district receives funds from the Backward Regions Grant Fund Programme (BRGF).



S.No.	Block Name	Area (In Ha)	Inundated Area (In Ha)	% of Inundated Area
1	Bahadurpur	24551.48	746.32	3.04
2	Dubauliya	6747.47	344.79	5.11
3	Basti	20559.55	324.66	1.58
4	Gaur	26095.81	295.98	1.13
5	Salatua Gopalpur	22131.88	163.73	0.74
6	Kudrahia	13358.02	80.36	0.60
7	Vikramjot	28513.14	56.39	0.20
8	Saughat	17319.57	40.72	0.24
9	Harraiya	23454.48	10.29	0.04
10	Kaptanganj	17872.31	7.88	0.04
11	Parasrampur	20846.19	5.33	0.03
12	Rudhauli	11541.57	0.23	0.00
13	Bankati	16033.09	0.02	0.00
14	Ramnagar	19950.13	NA	NA
	Total	268974.70	2076.70	0.77

Figure 2

.Source:FMISC UP

Table 2

Sn	Block	Area	Inundated Area	Population (Rural)	% of Inundated Area	Population (Rural) At Risk = Popn * % of Inundated Area
1	Ramnagar	19950.13	NA	170624	0.00 %	0
2	Saltaua Gopal Pur	22131.88	163.73	187948	0.74 %	1390.81
3	Paras Rampur	20846.19	5.33	168180	0.03 %	50.45
4	Gaur	26095.81	295.98	225346	1.13 %	2546.40
5	Harraiya	23454.48	10.29	149625	0.04 %	59.85
6	Vikram Jot	28513.14	56.39	155556	0.20 %	311.11
7	Kaptanganj	17872.31	7.88	127516	0.04 %	51.00
8	Dubaulia	6747.47	344.79	100738	1.58 %	1591.66
9	Rudhauli	11541.57	0.23	117008	0.00 %	0
10	Sau Ghat	17319.57	40.72	198155	0.24 %	475.57
11	Basti	20559.55	324.66	233908	5.11 %	11952.69
12	Bankati	16033.09	0.02	180176	0.00 %	0
13	Bahadurpur	24551.48	746.32	172030	3.04 %	5229.71
14	Kudaraha	13358.02	80.36	139557	0.60 %	837.34
	TOTAL	268974.7	2076.70	2326367	-	24496.59

Source: FMISC UP

Table 3

Blocks of district	Vulnerability in terms of (Percentage of inundated area)	Risk in terms of (Population)
Ramnagar, Saltaua Gopal Pur, Paras Rampur, Harraiya Vikram Jot, Kaptanganj, Rudhauli, Sau Ghat, Bankati, Kudaraha	(0.00% <= 1.00) % - low	3176
Gaur, Dubaulia,	(1.0 - <2.00) % - medium	4138
Bahadurpur , Basti	(2.00 % - <5.11) % - high	17182

VIII. RISK AND VULNERABILITY ASSESSMENT

Based on the inundation map of Basti district (Figure 1) sourced from FMISC Uttar Pradesh, Lucknow, Population (Rural) At Risk= Population * % of Inundated Area (Table 2). Important Considerations: Uniform Distribution Assumption: This formula assumes people are spread evenly across each sub-unit. If a neighborhood is 50% flooded, the formula assumes 50% of the people are affected. In reality, people often cluster in specific areas (like high ground or near coasts), which can lead to over- or under-estimation. In Rapti river basin of Basti district Bahadurpur , Basti blocks are at highest risk in terms of damage and losses (Table 3). Vulnerability in terms of percentage of inundated area ranges from 2.00 % to 5.11 %. At the same time percentage of vulnerable population is around 17182. Gaur, Dubaulia, block is at moderate risk to flood and vulnerability stand between at 1.00 to 2.00 % and the number of population at risk to flooding is 4138. Ramnagar, Saltaua Gopal Pur, Paras Rampur, Harraiya Vikram Jot, Kaptanganj, Rudhauli, Sau Ghat, Bankati, Kudaraha blocks are least affected by flood with vulnerability percentage ranges from 0% to 1.00%.

Risk in terms of population is 3176. From the inundation map it can well be seen Ami river, the right bank tributary of Rapti river flows from the left flank of Ramnagar, Rudhauli and Saughat block. Kuwano flows through Gaur, Basti, Bahadurpur and Kudrana blocks and River Ghaghra flows through the right flank of Vikramjot, Dubaulia, Bhadurpur and Kudrana. Out of total 2076.7 ha. of inundated area, Saltaua Gopal Pur, Gaur, Dubaulia, Basti and Bahadurpur blocks together constitutes 1897.48 ha of land which is around 90.50% and 22711 number of people out of 2326367 which is 0.98 percent of the total rural population.

IX. FLOOD MITIGATION MEASURES AND CONCLUSION

The Flood Risk Assessment Study of Basti District, Uttar Pradesh, underscores the region's high vulnerability to recurrent flooding, primarily driven by the Ami, Ghaghra and Kuwano rivers. Intensive monsoon rainfall, coupled with low-lying topography and inadequate drainage systems, exacerbates the frequency and severity of these inundations. The study reveals that agricultural lands and rural settlements along the river basins face the highest risk, leading to substantial economic losses, crop damage, and displacement of communities annually. To mitigate these risks, the study recommends a shift from reactive disaster response to proactive risk management. Key strategic interventions include: Structural Measures: Strengthening embankments, constructing guide bunds, and desilting major river channels to improve carrying capacity. Non-Structural Measures: Implementing advanced early warning systems, mapping precise flood zones, and enforcing strict land-use regulations. Community Resilience: Conducting local awareness campaigns and establishing community-led emergency response teams. Ultimately, integrating these flood mitigation strategies into the district's long-term developmental planning is essential to safeguarding lives, protecting livelihoods, and ensuring sustainable socio-economic growth in Basti.

The flood risk assessment for Basti District, Uttar Pradesh, concludes that the region faces severe, recurring threats by the Rapti and Ghaghara River system, low-lying topography, and intense monsoon surges. High-risk zones are heavily concentrated in riparian tracts, threatening vulnerable agriculture and riverside habitations. Key Vulnerabilities and Findings; Geographical Exposure: Flat terrain and low north-south gradients cause massive surface sheet flows and prolonged waterlogging near river confluences. Erosion and Channel Shifting: Alterations in main river streams exponentially increase bank erosion and endanger local embankments like the BD bund. Agricultural and Livelihood Impact: Submergence during peak monsoon months heavily damages Kharif crops in riparian. Strategic Recommendations; Embankment Monitoring: Continuous round-the-clock surveillance of vulnerable regulatory points and vulnerable spurs during high-discharge cycles. Integrated Spatial Planning: Utilizing geospatial data via the Uttar Pradesh State Disaster Management Authority to update micro-regional zoning. Community Preparedness: Strengthening local flood posts and early warning communication channels for last-mile evacuation readiness.

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