Vulnerability to Flood Hazard in Sant Kabir Nagar District of Rapti River Basin, Ganga Plain, India

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Abstract: ***Floods are the overflow of substantial amounts of water that are beyond the carrying capacity of the river. The Rapti River flows through Middle Ganga Plain, until meeting the Ghaghra river, making a total distance of about 560 kilometres in India. In the regions of Eastern Uttar Pradesh, it generates significant floods due to its shallow depth and extremely sinuous flow pattern. The river travels through Bahraich, Shrawasti, Balrampur, Siddharthnagar, Sant Kabir Nagar and Gorakhpur districts before joining the Ghaghara on its left bank close to Barhaj in Deoria district. The fact that the greatest number of marginal embankments have been built along Rapti in Uttar Pradesh and that 2, 65, 521 hectares have been safeguarded by the building of 1092 km of marginal embankments along Rapti and its tributaries further speaks to the severity of floods in the Rapti river. In addition to study the impact of the 2017 floods in the district of Sant Kabir Nagar, Rapti River basin, this paper will identify areas that are vulnerable to frequent flooding so that the machinery used in the process of rescue, relief, and rehabilitation can make the most effective use of the available human and physical resources.***

Keywords: Floods, Year 2017, Sant Kabir Nagar district, Rapti River Basin

1. Introduction

Floods have a significant impact on densely populated places, particularly when critical infrastructure is harmed. The vulnerability of a place to floods is influenced by a variety of human and territorial factors. Human causes include intensive agricultural activities and vast urbanised regions, while the soil's ability to absorb water is a crucial territorial component. Flood vulnerability can be quantified by integrating numerical indications for the numerous components into a single index value that decision makers can understand. GIS technologies make it simple to calculate these indicators from a variety of open geographic data sources, making vulnerability mapping a low - cost process. Climate change is increasing the risk of deadly floods by causing greater and more frequent rainfall as well as the removal of water - absorbing vegetation and soil. Flooding can destroy infrastructure and structures, resulting in human deaths and significant financial damages. Decision - makers must determine how vulnerable particular aspects are to water damage. This is referred to as "flood vulnerability. " Decision - making is aided by maps that depict the spatial distribution of at - risk items and quantify their susceptibility. Multiple human and geographical characteristics must be quantified in order to express flood vulnerability as a single index number. The number of people that reside in an area, the economic value of land, and the density of buildings, roads, and other infrastructure all influence the severity of flood damage. The human vulnerability index is created by combining these criteria. The risk of an area will be reduced if local protection volunteers or early warning systems, such as monitoring stations, are present. The geographical vulnerability index takes into account all of these criteria.

1.1 Location & Extent

Sant Kabir Nagar district (**Figure 1**) borders Siddharthangar on the north, Gorakhpur on the east, Ambedkarnagar on the south, and Basti on the west. On its southern border, the river Ghaghara separated this district from Ambedkarnagar. The district headquarters is in Khalilabad. There are three (3) tehsils and nine (9) blocks in the district. The district covers an area of around 1646 square kilometres, the rural area is 1620.0 square kilometres, whereas the urban area is 26.0 square kilometres and is located in the Survey of India Toposheet No.63 I & J, between latitudes 26 degree 30' and 27 degree 10' north and longitudes 82 degree 45' to 83 degree 15' east.

1.2 Administrative Setup

In September 1997, the district of Sant Kabir Nagar was created from the district of Basti. Khalilabad is the administrative centre of the district. To ensure effective administration, the district is divided into three tahsils: Mehdawal, Khalilabad, and Ghanghata. The district is divided into nine Development Blocks (**Fgure 2**) for the execution and monitoring of development schemes: Sotha, Mehdawal, Baghauli, Semariyawan, Khalilabad, Nath Nagar, Haisar Bazar, Belhar Kala, and Pauli. In the district, there are 794 Gram Panchayats and 1726 Revenue villages, including 1582 inhabited and 144 empty villages.

1.3 Land and Land Use Pattern

Because no agriculture census was conducted after the district was established in 1997, data on operating land holdings is not available separately. When District Sant Kabir Nagar was a part of District Basti in 1995 - 96, there were 516, 701 operational land holdings with a total area of 335, 550 hectares, according to the agriculture census. There were 419, 496 holdings, with 145, 300 hectares under 1.00 hectare size, indicating that up to 1.00 hectare size holdings accounted for around 81 percent of the total area and 43 percent of the total area.

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1.4 Land Use, Agriculture and Irrigation Practices:

The following are the key characteristics of the district's land use pattern, agricultural, and irrigation practises:

a) Total land use (cultivable area) - 174810 ha.
b) Forest area – 4374 ha.
c) Net area sown - 121297 ha.
d) Irrigation area (Net) - 101510 ha.

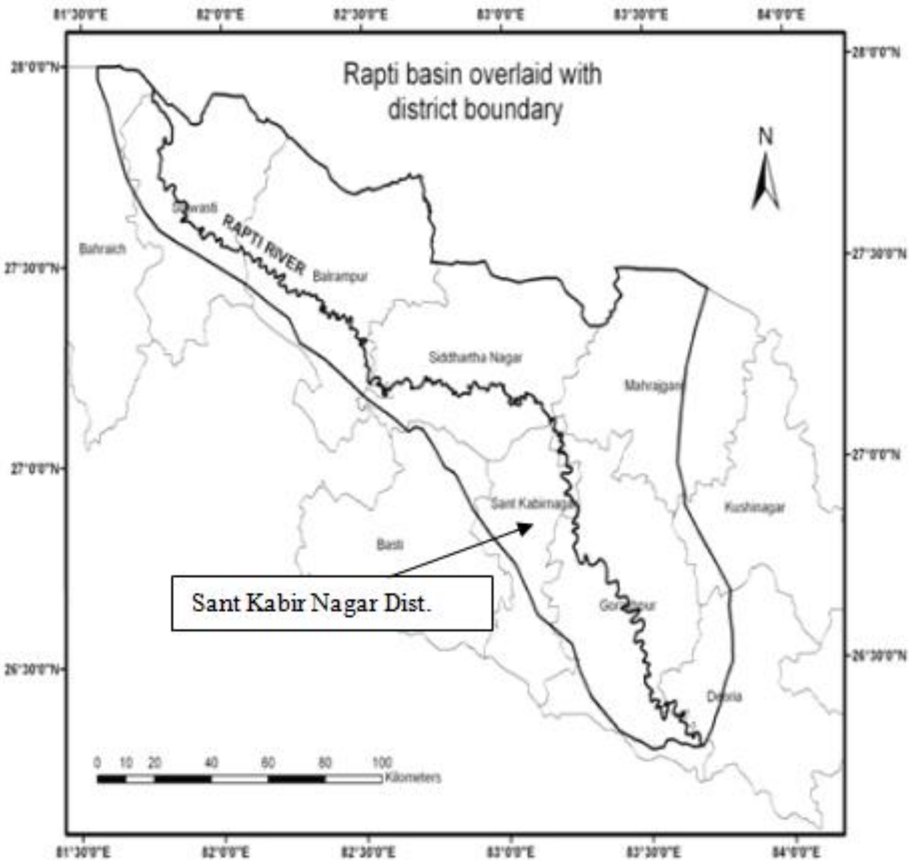

Figure 1: Location Map

Source: District Census Handbook, Census of India 2011

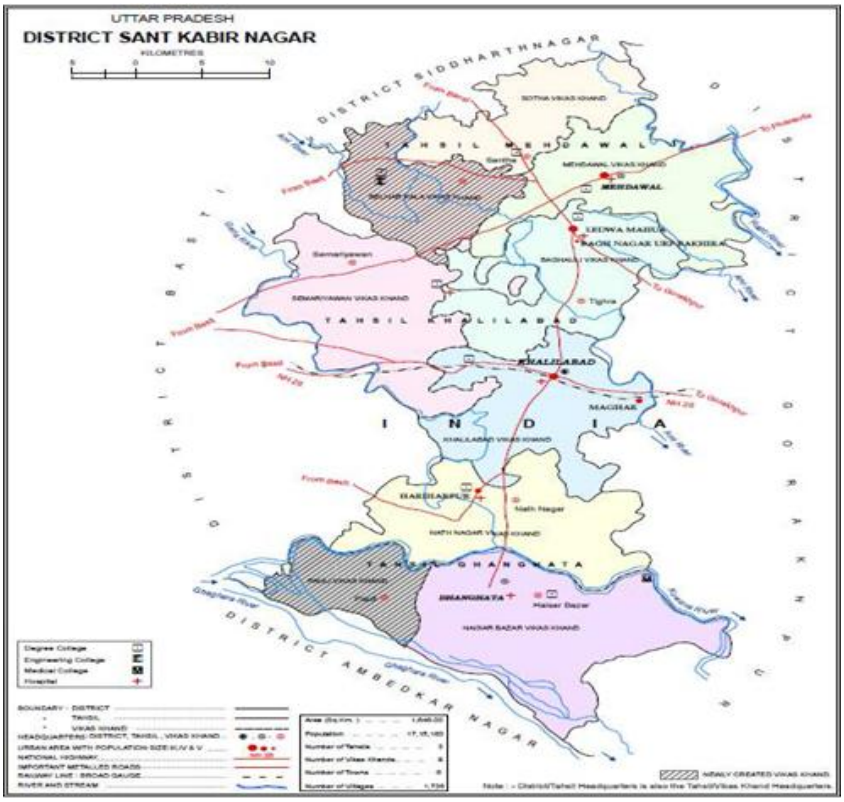

Figure 2: Administrative setup

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1.5 Agriculture and Crop Pattern

The district has two crop seasons, Rabi and Kharif. Another agricultural season, Zaid, is of minor importance, with just a small area sown under it. Sarson, Rai, and Sugarcane are the most important cash crops in the district. Wheat and sugarcane are the district's principal crops. Farmers in rural and urban areas sell their agricultural products at adjacent marketplaces and local markets (hats).

1.6 Population Distribution

The district's overall population is 1, 715, 183, with 1, 586, 652 living in rural areas (**Table 1**) and the remaining 128, 531 in urban areas. Mehdawal, Khalilabad, and Ghanghata are the three tahsils in the district. Khalilabad is the most populous tahsil, whereas Mehdawal is the least populous. The district's urban population is 7.49 percent. In the tahsil of Khalilabad, the urban population reaches a peak of 12.37 percent. Semariyawan is the most populous C. D. Block, with a population of 242, 616 people, and Nath Nagar has the most inhabited villages (232). About half of populous villages have populations of 500 to 999 people and 1000 to 1999 people, accounting for up to 57 percent of all populated villages. The district has a population density of 1042 people. The rural population density is 979, while the urban population density is 4944. The district has 04 Statutory towns and 02 Census towns (**Table 2**). There is one Nagar Palika Parishad and three Nagar Panchayats. With a total Urban population of 128, 531, Khalilabad Nagar Palika Parishad (NPP) has the highest population (47, 847), followed by Mehdawal Nagar Panchayat (NP) with a population of 27, 897. The 02 Census towns are Ledwa Mahua (CT) and Bagh Nagar Urf Bakhira (CT). At the time of the current territorial jurisdication, the district's population was 1, 715, 183 people, up from 1, 420, 226 in 2001. During the decade 2001 - 2011, it increased by 20.77 percent which was higher than the state's rate of 20.2 percent.

Table 1: Rural population distribution

S. N.	Block Name	Population (Rural)
1	Pauli	107, 277
2	Mehdawal	161, 145
3	Belhar Kala	117, 826
4	Sotha	151, 716
5	Khalilabad	204, 131
6	Baghauli	202, 881
7	Nath Nagar	202, 513
8	Semaryawan	242, 616
9	Haisar Bazar	196, 547
	Total	1, 586, 652

Source: Census of India 2011

Table 2: Urban population distribution

S. N.	Nagar Palika Parishad/Nagar Panchayat	Population (Urban)
1	Khalilabad (NPP)	47, 847
2	Mehdawal (NP)	27, 897
3	Maghar (NP)	19, 181
4	Hariharpur (NP)	11, 285
5	Ledwa Mahua (CT)	13.844
6	Bagh Nagar Urf Bakhira (CT)	8477
	Total	128, 531

Source: Census of India 2011

1.7 Geomorphology and Soil Types

The district can be divided into two broad sections based on geomorphology, the younger alluvium plains and the older alluvium plains. The younger alluvial plain is a moderately undulated, flat to gently sloping land surface formed by significant deposition of unconsolidated sand, silt, and clays next to the river's flood plain. The depression of the Ghaghra in the south, extending to its tributary Kuwana between Hainsar and Nathnagar blocks region, and the Rapti river in the north - east of the district in Gorakhpur, are examples of older alluvial plains. Sant Kabir Nagar is located in the Central Ganga Plain, between the Ghaghra River's fluvial area in the south and the Rapti River in the northeast. It is made up of various amounts of sand, gravel, clay, and kankar. It is quaternary alluvium transported in from the Himalayas by southerly running rivers. The elevation of the Sant Kabir Nagar district area ranges from 73 to 97 metres above sea level. The district's soils are mostly transported, i. e. alluvial soil with various concentrations of sand, silt, and clay. The district's alluvial soils are classified into two types: older alluvial soil and younger alluvial soil. The older alluvial soil occupies high ground whereby the younger soils are constrained to marginal tract of the Ghaghra and Rapti rivers.

1.8 Drainage

The district's drainage system is mostly influenced by the rivers Ghaghara, Rapti, and Ami. Sant Kabir Nagar and Ambedkar Nagar are separated by the River Ghaghra, which flows in the south of the district. The Rapti river originates in this district's Mehdawal tahsil and meets the river Ghaghra in Deoria district. The river Ami flows from the north of Khalilabad tahsil to the east, defining the district Gorakhpur's boundary. The district's lone lake is Vakhira, which is located in the north - western portion of Khalilabad tahsil. The Gorakhpur boundary is defined by this lake, which is located in the district's east. During the summer, there is enough water in this lake.

1.9 Rainfall and Climate

The annual rainfall averages 1166 mm. With the exception of the cold and summer seasons, the climate is sub - humid and mimics the eastern region of the United States, being wet and soothing. Between June and September, 90 percent of the rain falls occur. During the monsoon, there is enough water for deep percolation to ground water. There is a meteorological observatory station, whose records can be used to determine representative weather conditions. May is the hottest month, with a mean daily maximum temperature of 41.50°C and maximum temperatures reaching 47°C on rare occasions. The temperature begins to decline as the monsoon approaches, but night temperatures remain high; January is the coldest month, with a temperature of 9.70°C. The average monthly maximum temperature is 32.20 degrees Celsius, and the average monthly minimum temperature is 19.90 degrees Celsius. The air is very dry during the cold season and the first half of the hot season. Between June and November, the air is wet, with a relative humidity of around 75%. The monthly mean relative humidity in the morning is 66 percent, and the monthly

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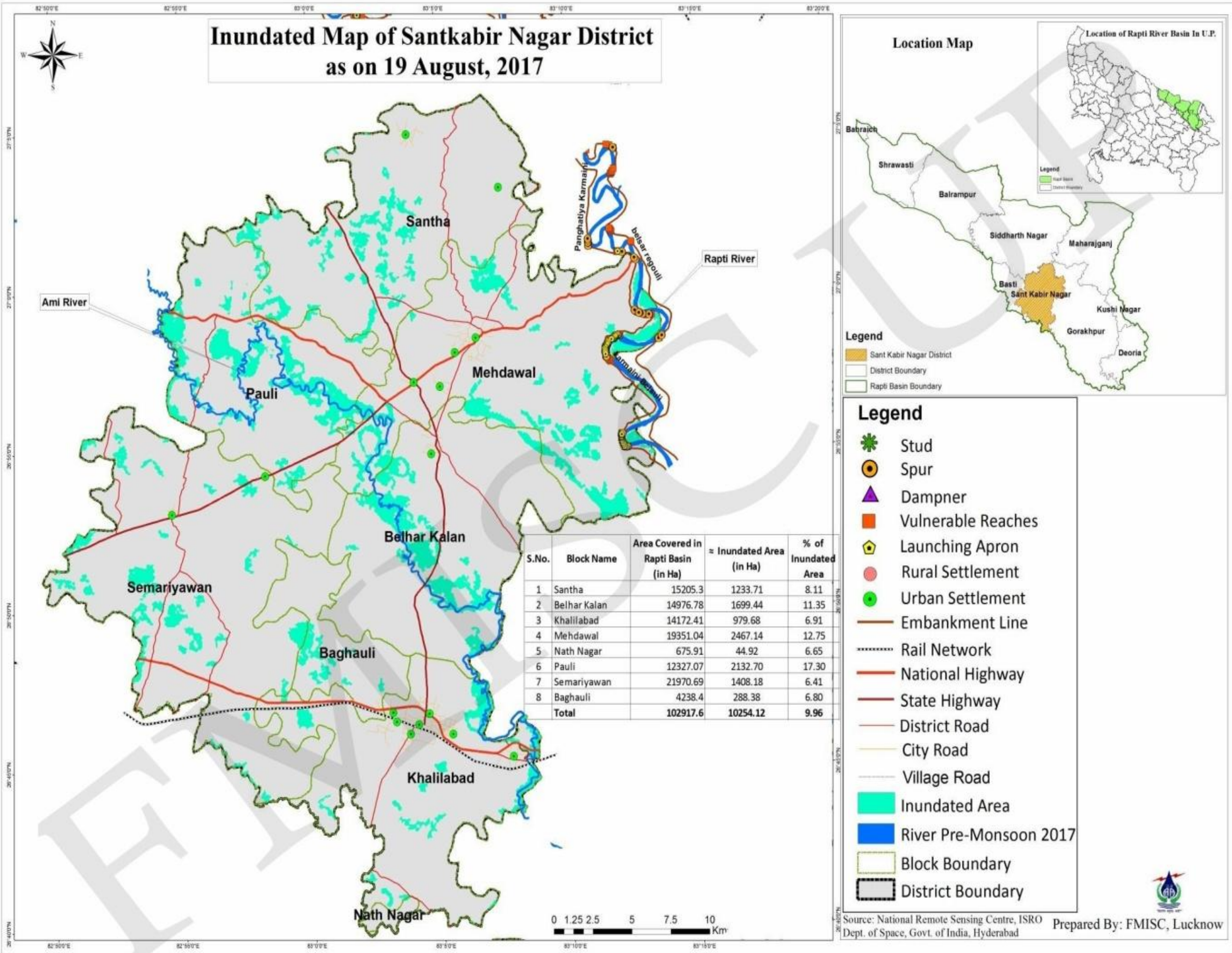
mean relative humidity in the evening is 50 percent. In the winter, the average temperature is 4.5°C, while in the summer, it is 44°C. The average rainfall in the district is 1166 mm, but there is still a significant variance between the north and south. Rainfall ranges from 1200 to 1800 mm in the north and middle, and 1100 to 1300 mm in the south.

The district's climate is generally pleasant. The winter season lasts from November to February, while the summer season lasts from March to June, with the rainy season lasting from July to October. The wind speed in the district ranges from 2 to 7 kilometres per hour. Normally, the wind blows from east to west. Between the last week of June and the first week of October, the district receives the most rainfall (about 90%). The next eight months of the year see very little rain.

1.10 Flood map and Observations

During the monsoon, the district receives an abundance of rain, which is on the rise. One of the main causes of flooding in the district is heavy rainfall during the monsoon season. Rainfall with a relatively high intensity produces major flooding and water logging issues. The area is mostly flat. During heavy rains, the main stream is unable to transport all of the water, thus offshoots emerge from it and eventually join the main stream. When it rains, the water flows in a sheet rather than a gully. Excessive rainfall during the rainy season joins the entire area's drainage system, which grows and pushes the rivers to overflow, wreaking misery & disaster in the region. Flood maps prepared by FMISC, Lucknow (**Figure 3**) based on the analysis of satellite data Radarsat - 2 SAR on August 19, 2017 (NRSC, Hyderabad) shows major inundated areas, water accumulated in low lying areas, wet areas, rainfall induced floods and isolated patches of waterlogged areas of the Sant Kabir Nagar district. On studying the flood map 9.96 % of the area was found inundated (FMISC, Lucknow). The extent of total inundated area is 10254.12 ha. Maximum inundation in terms of percentages is found in Pauli block which is to the extent 17.30 %. Next most affected block is Mehdawal (12.75 %) followed by Belhar Kala (11.35%), (**Table 3**). Maximum inundation in terms of area is found in Mehdawal block which is found to be 2467.14 ha. followed by Pauli (2132.70 ha.) and Belhar Kala block (1699.44 ha.). Haisar Bazar block does not under Rapti river basin and as such it has not been taken into consideration while preparing the table.



S.No.	Block Name	Area Covered in Rapti Basin (in Ha)	≈ Inundated Area (in Ha)	% of Inundated Area
1	Santha	15205.3	1233.71	8.11
2	Belhar Kalan	14976.78	1699.44	11.35
3	Khalilabad	14172.41	979.68	6.91
4	Mehdawal	19351.04	2467.14	12.75
5	Nath Nagar	675.91	44.92	6.65
6	Pauli	12327.07	2132.70	17.30
7	Semariyawan	21970.69	1408.18	6.41
8	Baghauli	4238.4	288.38	6.80
	Total	**102917.6**	**10254.12**	**9.96**

Figure 3: Inundated map of Sant Kabir Nagar district as on 19 August, 2017
Source: FMISC, Lucknow

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Table 3: Blocks covered with Rapti river basin

S. N.	Block Name	Area covered in Rapti Basin (Ha) (In Ha)	Inundated Area (In Ha)	% of Inundated Area	Population (Rural)	% of corresponding Population
1	Pauli	12327.07	2132.70	17.30%	107, 277	18, 559
2	Mehdawal	19351.04	2467.14	12.75%	161, 145	20, 546
3	Belhar Kala	14976.78	1699.44	11.35%	117, 826	13, 373
4	Sotha	15205.03	1233.71	8.11%	151, 716	12, 304
5	Khalilabad	14172.41	979.68	6.91%	204, 131	14, 105
6	Baghauli	4238.40	288.38	6.80%	202, 881	13, 796
7	Nath Nagar	675.91	44.92	6.65%	202, 513	13, 467
8	Semaryawan	21970.69	1408.18	6.41%	242, 616	15, 552
9	Haisar Bazar	Nil	-	-	196, 547	-
	TOTAL	102917.60	10254.12	9.96%	1, 586, 652	121, 702

Source: FMISC, Lucknow and Census of India 2011

1.11 Risk and Vulnerability Assessment:

In Rapti river basin of Sant Kabir Nagar district Pauli, Mehdawal and Belhar Kala blocks are at highest risk in terms of damage and losses (**Table 4**). Vulnerability in terms of percentage of inundated area ranges from 11% to 18%. At the same time percentage of vulnerable population is around 52, 478. Sotha block is at moderate risk to flood and vulnerability stand around at 8.11% and the number of population vulnerable to flood is 12, 304. Khalilabad, Baghauli, Nath Nagar, Semaryawan and Haisar Bazarblocks are least affected by flood with vulnerability percentage ranges from 0% to 7%. Vulnerability in terms of population is 56, 920. From the inundation map it can well be seen Ami river, the right bank tributary of Rapti river flows right from the middle of the Pauli and Belhar Kala blocks and Rapti river forms the boundary between Medhawal block of Sant Kabir Nagar and Gorakhpur district. Out of total 10254.12 ha. of inundated area, these 3 blocks together constitutes 6299.28 ha of land which is around 61.43%.

Table 4: Risk and vulnerability assessment

Blocks of district at risk (in terms of damage and losses -)	Vulnerability in terms of (Percentage of inundated area)	Vulnerability in terms of (Population)
Khalilabad, Baghauli, Nath Nagar, Semaryawan and Haisar Bazar	(0-< 7) % - low	56, 920
Sotha	(8 - <11) % - medium	12, 304
Pauli, Mehdawal, and Belhar Kala	(11 - <18) % - high	52, 478

Table 5: List of embankment in Rapti river basin of Sant Kabir Nagar district

Sr. No.	Name of Embankment	River/Bank	Total Length in (K. M.)	Benefited area (in Hectare)
1	Karmaini Belauli Embankment	Rapti/Right	19.200	8753.00
2	Dharauli Ring Embankment	Rapti/Right	0.580	50.00
3	Belauli Ring Embankment	Rapti/Right	1.300	125.00
4	Maghar Embankment	Ami/Right	1.300	10.00

Source: Irrigation and Water Resources Department, Ministry of Jal Shakti, Govt of Uttar Pradesh

1.12 Flood mitigation measures and conclusions

In India, as well as many other countries, embankments (**Table 5**) are the most common form of flood control. To most people, erecting tall walls alongside rivers to prevent floodwaters from entering homes appears to be the most obvious method of flood management. Despite this, the area endangered by floods in India has risen as a result of the construction of massive embankments. Surely, this should prompt us to re - examine the role and effectiveness of flood embankments, especially in light of the enormous sums of money spent on their construction and maintenance, a considerable portion of which is claimed to have gone down the corruption drain. Will the wall guard against floods, or will it simply redirect the flood? Will it be at the expense of other communities, where the flood is pushed or diverted, if the new wall protects some habitations, rural or urban, possibly where more prominent people live? Will it exacerbate the eroding impacts of the flow further downstream if a river's flow is confined for a length of time by barriers, especially if the flow has a natural tendency to meander? Will the river's silt, which is now constrained to a narrow embanked length, cause the river bed to rise? This elevation could exceed the height of the embankment within a few years, necessitating the need to raise the embankment, failing which the water could spill over and breach it. Will the flood be significantly more damaging than a normal flood if and when the embankment fails? Certainly, because the water will be delivered with greater force and from a smaller place than before. The destruction can be enormous if the riverbed has risen much in the meanwhile and the water flows from a higher to a lower plain. All of this isn't to say that embankments don't play a part in flood management. In a multi - faceted flood - control endeavour, embankments play a role in particular areas and situations, but their role must be studied while keeping all of their limits in mind, as well as the alternatives available. India is not alone in witnessing the paradox of more places becoming vulnerable to floods as flood - prevention spending continues to rise. These can be checked to a large extent by taking the right steps. While preventing more destructive and long - lasting floods, we must also learn to live with the natural process of rivers overflowing their banks during heavy rains. There are methods to make this coexistence a lot more comfortable, and even to put the floodwaters to good use. To begin, the catchment areas'

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forests and green cover should be adequately conserved. Natural thick mixed forests and artificial plantings have significant differences. We require natural mixed forests with a high proportion of dense, broadleaf species, as well as a diverse range of other indigenous growths that can efficiently protect soil and retain water. In watershed areas, we also require well - planned soil and water conservation activities. We must avoid costly infrastructure and crops that are readily devastated by floods on the floodplains closest to the river. This is the spot for water conservation, grass fodder, and fruit orchards or other sources of income trees that can absorb and tolerate a lot of water and moisture.

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