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Significance of Rainfall in the Occurrences of Flood in Murshidabad district, West Bengal, India

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Abstract

There is a direct relationship between the intensity of rainfall and occurrence of flood in a place. However, there are certain factors which can accelerate or reduce the possibility of flood by controlling the surface run-off. The district of Murshidabad is located in the deltaic zone of West Bengal, India. All the spill channels are almost in decaying stage with reduced water retention capacity. Moreover, due to increasing population pressure in the district, almost all the run-off detention basins (or wetlands) have been encroached for cultivation, thereby affecting the storage capacity to a great extent. Therefore, an excess of rainfall has a flood-generating potential which often plays a major role in the occurrence of flood. The present paper aims to bring out the above in details in order to help the planners for formulation and implementation of appropriate flood management problems.

Introduction

An excessively sustained downpour during monsoon has been identified as the main cause of the eventual 2000-flood in Murshidabad district. According to the rainfall records in major hydrological stations along the main rivers and their tributaries, the total average rainfall received over the 5-day period from 18 September to 23 September, 2000 was about 470 mm. (with) The highest being 558 mm was recorded in the Bhairab-Jalangi basin and 332 mm in the Mayurakshi basin on 19th September. The significant issue about the rainfall in the district is that it received more than 1300 mm of rain in a spell of about 6 days. It may not be irrelevant to mention here that the earlier record of the heaviest rainfall in the district was 414 mm in the Bhairab-Jalangi basin on 16th October, 1874 (Office of the District Magistrate, 2000). The rainfall was characterized by high intensity and prolonged duration resulting in rapidly increasing river discharge eventually leading to the staggering immensity of calamity.

Such unprecedented rainfall caused the entire district to be waterlogged. A large region of Berhampore town was submerged for 5 to 6 days an incident that the oldest inhabitant of this town fails to recall any precedence. Simultaneously, incessant heavy downpour in the catchment areas of the major rivers led to immediate release of water from the D.V.C., Massanjore dam and Tilpara Barrage. As a result rivers in Kandi Sub-division ran in high spate. Release of water from Massanjore dam and Tilpara Barrage was at the rate of 100,000 cusec since 18 September, 2000 and at the rate of 230,000 cusecs from the morning of 21 September, 2000 (IWD, 2000). Magnitude of the grievous flood was best indicated by the instantaneous peak torrents rushing down the river, when the potential hazard was maximized.

Study Area

Murshidabad district is the northernmost district of the Presidency Division of West Bengal and is located at its north-eastern boundary (fig.1). It lies centrally in the lower Ganga valley. The geographical extension of the district is 24°50′20″ - 23°43′30″N and 88°46′00″ - 87°49′17″E with an area of 5324 km^2. The district is separated from Malda by the River Ganga (River) on its north. This pear-shaped district looks like an isosceles triangle with Farakka block in the north-west forming its apex. It is bounded in the north by the Malda district, on the west by the district of Birbhum, on the south by the districts of Burdwan and Nadia and on the east by Bangladesh. The Ganges forms the north and east boundaries of the district for some distance. The southern boundary is formed by the Jalangi river for a long stretch, forming a part of its southern boundary with the Nadia district. The district is primarily drained by the rivers of Bhairab-Jalangi, Pagla-Bansloi, Bhagirathi-Hooghly and Mayurakshi-Babla river basins. Besides, run-off is also contributed to this district from the neighbouring state of Jharkhand and the country of Bangladesh (fig. 1a and 1b).

Objectives

The main objectives of the present study are as follows:

1. To assess the relationship between rainfall and discharge of river Bhagirahi and occurrence of flood in Murshidabad
2. To calculate the probable rainfall in different return periods in the study area.
3. To explain the significance of hydrological characteristics of upstream areas in the occurrence of flood in Murshidbad.

Methodology

The study is mainly based on the secondary sources of information. The hydrological data has been collected from the Office of the India Meteorological Department, Kolkata, Irrigation and Waterways Department, Govt. of West Bengal, District Statistical Handbook, Govt. of West Bengal and Annual Report of Central Water Commission, Govt. of India. For calculation of rainfall frequency Gumbel's method has been followed. Standard cartographic techniques have been used to represent the result.

Results and Discussion

(a) Rainfall and Discharge Pattern

Flood may be defined as the abnormal high stage of flow which overtops the natural or artificial river banks in any reach and causes immense socio-economic loss related to crops, houses and buildings, cattle and human life, transport and communication. Often, it is a natural event that results from excess runoff generated from a drainage basin due to favourable combination of critical hydrologic and meteorological conditions over the region.

The historical records of flood in Murshidabad shows that its occurrence is largely related to the amount, duration and intensity of rainfall. It has been assessed that the monsoon rainfall (June —October) accounts for about 80% of the annual rainfall in the catchment and consequent run-off in the district. Abnormally high spells of rain are generally followed by phases of depressions during this period. The catchments of the western tributaries of the Bhagirathi outside the state show almost similar type of hydro-meteorological response to the south-west monsoon activity. Thus, huge rainfall in a short period causes high flow in the rivers. One such example in Murshidabad is 1300 mm of rainfall in a spell of about 6 days only in 2000 causing devastating flood. High intensity of rainfall, prolonged duration, and large aerial extension of river catchment area outside the district together are responsible for high flow stage. The pattern of variation of annual rainfall from average during a period of 1905 - 2000 gives an idea of the occurrences of flood in terms of significant positive deviations (fig.2).

The annual average number of rainy days

and annual rainfall in Murshidabad are 79 and 1553 mm respectively. The district has only one meteorological station at Baharampur. The data recorded at this station does not represent the districts' scenario at all. Maximum rainfall occurs during June - September and minimum during November March (fig. 4a) and the average flow of the rivers has the following features

- The rivers flow at high water levels in the summer months and at low water levels in the winter months (fig. 4b).
- Most of the graphs document an extraordinary difference between the dry and the rainy season flow.
- The average flood flow of the Ganga depicts as much as 20 times greater quantity than its dry season flow.
- There is a positive relation between the discharges of river Bhagirathi with rainfall (fig. 3).

Thus, though rains are quite high in the first two monsoon months (June and July), it takes more time than expected for creating resultant high discharge. This may be due to a number of factors like, less soil moisture content, a higher evapo-transpiration rate and increased extraction of irrigation water. During AugustSeptember, the gradual accumulations of water raises the proportion of surface run-off as a result of full soil moisture content, a lower evapotranspiration rate and reduced extraction of irrigation water and direct discharge into the river channels. The probability and occurrence of heavy short-term precipitation events in these months generally produces a very high surface runoff, thereby accentuating the probability of occurrence of flood.

Although there lies a positive relationship between rainfall and discharge, it must be mentioned that the distribution of rainfall has been considered encompassing the whole district. Bhagirathi, one of the tributaries of the mighty Ganges accumulates water from the surface runoff in the upstream side, and also from the distributaries more after the burst of monsoon with the progress of time. For this reason though there is a tendency of steady rise of average rainfall from the month of April, it is from August that discharge starts accumulating from the upper catchment area.

The component of direct rainfall represents the lumped effect of number of processes including antecedent evaporation which initiates the occurrence of flood.

(b) Probability of Return of Rainfall

The frequency of rainfall can give a good idea regarding the occurrence of flood in Murshidabad as flood is directly related with the amount of rainfall in the district. So flood management requires calculation of rainfall frequency. To calculate the rainfall frequency in the district, Gumbel method has been adopted (Table 1). The probability of extreme value distribution of peak rainfall ≥ Q is given by,

$$P = 1 - e^{-e^{-y}}$$

The reduced variate y is given by,

$$y_T = -\left(0.834 + 2.303 \log\log \frac{T_r}{T_r - 1}\right)$$

Or $y_T = -(0.834 + 2.303 X_T)$

where $X_T = \log\log \dfrac{T_r}{T_r - 1}$

The reduced variate y is linear with the variate Q (annual rainfall) itself and is given by,

$$y_T = \frac{Q_T - \bar{Q}}{\sigma}\sigma_n + \bar{y}_n$$

Where (reduced standard deviation) and (reduced mean to mode) are function of sample size N.

Thus, $Q_T = \bar{Q} + \dfrac{y_T - \bar{y}_n}{\sigma_n}\sigma$

Or $Q_T = \bar{Q} + K\sigma$

where $K = \dfrac{y_T - \bar{y}_n}{\sigma_n}$

It is very difficult to model flood analytically as it is the outcome of many component parameters. Therefore, estimation of peak flood is a complex problem leading to many approaches. Probability of return of rainfall can help estimation of flood frequency analysis. Flood occurring in the river are treated as statistical events and may be considered to constitute function of occurrence of rainfall.

Average rainfall of the district is about 1332 mm. From Table 1, it is found that in every 10, 20, 25 years interval the quantity of probable rainfall is 1880.88 mm, 2103.93 mm and 2174.61 mm respectively. These amounts of rainfall must be considered during planning any structure for protection from flood.

(c) Rainfall-Runoff Pattern

The district of Murshidabad encompasses five river systems. Of these, the Mayurakshi and the Bhairab-Jalangi- Gobra systems together cover 90.8% of the district. Besides the monsoon run-off of the district and the hydrological characteristics of the areas lying outside the district (over which the rivers outflow) play a significant role (Table 2a-c). The extraneous contributory areas measure about 13056 km^2, which includes Birbhum, Uttar Dinajpur and Malda accounting for the major share of the contribution. On the contrary, the district derives a huge quantity of uncontrolled run-off from the neighbouring states of Bihar and Jharkhand and also from the neighbouring country Bangladesh. The total landspace of these areas outside West Bengal (WB) is estimated to be 15736 km^2.

The area under study is characterized by varying physiography and morphology. Hence, areas surrounding the district have got their own respective hydrological features. Sometimes, its altogether unlike to that in the district. A comparative profile of the rainfall characteristics of the areas including Murshidabad shows that the Mahananda basin receives the highest degree of rainfall and delivers a corresponding quantum of run-off (Fig. 5).

The storage capacity of an area plays a dominant potential role in shaping up and controlling the hydrological regime of that area.(for) It dominates the run-off to reduce the risk and intensity of flood and also provides water for irrigating fields during non-monsoon season. The sub-districts spreading over the river systems (in the district) do not have any large reservoir so that they can keep themselves immuned from floods. The few small ones, hardly having an adequate storage capacity for taking on comparatively large mass of run-off are estimated at barely 2.6% of the volume of the run-off, while the capacity of the district alone is 11.8% percent (CWC, 2010). The volume of run-off over the district measures a meager 1% against the rest 99% coming from the outer upstream areas lying in the other districts of the state and the adjacent states. Consequently, the floods in the district owes largely to the physiographic traits of the upstream segments of the region.

Conclusion

Flood is a natural event that results from excess runoff generated from a drainage basin due to severe combination of critical hydrologic and meteorological conditions over the region. In view of heavy losses due to occurrence of flood, its proper measurement or estimation is very much essential for its control and design of different hydraulic structures. Since 1954 the state of West Bengal like all other states of India has taken different flood protection projects to cope with unprecedented rainfall. Engineers have constructed permanent leeves, flood walls, drainage channels for controlling flood in the district. But no structure in the district has been designed properly based on probability calculation. So these structures have proved futile for controlling flood in the district. Engineers or planners must actually take into consideration the probability calculation, incorporating floodplain management practices not only for the district itself but for the adjoining district also. Murshidabad is a part of lower Ganga basin that covers an area of about 10, 52,769 km^2 including its catchment in the other states of India also on its eastern side. The western part is feed by the Mayurakshi and Pagla river basins. All rain waters of this vast catchment area flow over Malda, Murshidabad and ultimately into Bay of Bengal. The chance of the lower catchment area being flooded cannot be ruled out if the rivers in the upper catchment are in spate due to rainfall.

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Table – 1: Rainfall Frequency and Probable Rainfall in Murshidabad

Frequency (Years)	$X_T \quad \log\log \frac{T_r}{T_r \quad 1}$	$y_T \quad 0.834 \quad 2.303X_T$	$K \quad \frac{y_T \quad y_n}{n}$	Probable Rainfall $Q_T \quad \bar{Q} \quad \_K$
10	-1.34	2.25	1.79	1880.88
15	-1.52	2.67	2.21	2012.05
20	-1.65	2.97	2.51	2103.93
25	-1.75	3.20	2.74	2174.61
30	-1.83	3.39	2.92	2232.17
40	-1.96	3.68	3.21	2322.62
50	-2.06	3.90	3.44	2392.52
60	-2.14	4.09	3.62	2449.51
75	-2.23	4.31	3.85	2519.20
80	-2.26	4.38	3.91	2539.32
100	*-2.36*	*4.60*	*4.14*	*2608.79*

Source: Calculated by the authors

Table - 2a: River Systems of Murshidabad district, West Bengal

River Basin	District's Area (%)	Sub-district area (sq.km)	Districtwise basin*
Pagla	3.6	191	pM(1)
Bansloi	1.5	82	bM(2)
Mayurakshi	36.4	1938	yM(3)
Bhairab-Gobra-Jalangi	54.4	2895	gM(4)
Bagmari Feeder Canal	4.1	218	fM(5)
Total Area =		5324 km²	

Source: CWC-GoI, 2010

Table - 2b: River Basins and the area in West Bengal that feed run-off to Murshidabad district

River Basin	District	Area (sq.km.)	Districtwise basin*
Mahananda	Darjeeling	1233	mD(1)
	Jalpaiguri	28	mJ(2)
	Uttar Dinajpur	3140	mU(3)
	Dakshin Dinajpur	1260	mA(4)
	Malda	3733	mL(5)
Bagmari Feeder Canal	Birbhum	28	fF(6)
Bansloi	Birbhum	277	bF(7)
Pagla	Birbhum	166	pF(8)
Mayurakshi	Birbhum	3132	yF(9)
	Burdwan	59	yB(10)
Total Area =		13056 km²	

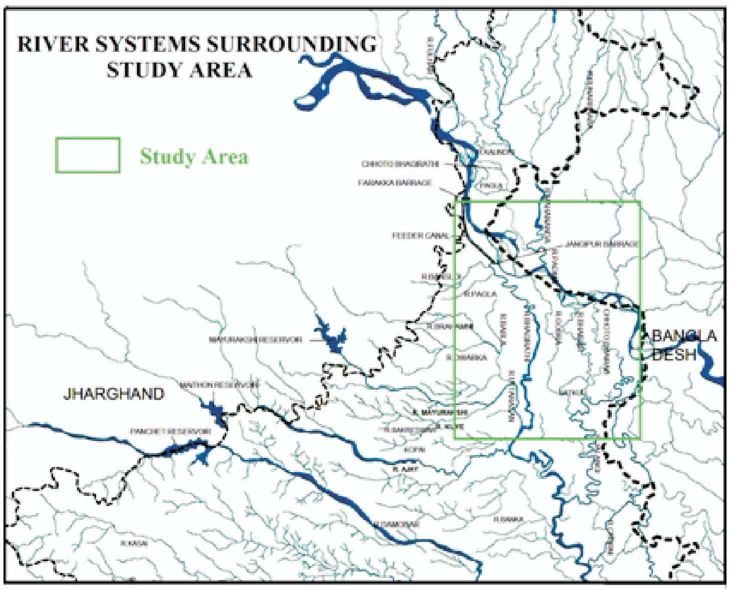
Source: CWC-GoI, 2010

Table - 2c: River Basins and the area outside West Bengal that feed run-off to Murshidabad district

River Basin	State/Country	Area (sq.km.)	Districtwise basin*
Mahananda	Bihar	6662	mY(1)
	Bangaladesh	1505	mV(2)
	Bangaladesh	2082	mX(3)
	Bihar	1638	mZ(4)
Bagmari Feeder Canal	Jharkhand	204	fO(5)
Bansloi	Jharkhand	531	bO(6)
Pagla	Jharkhand	914	pO(7)
Mayurakshi	Jharkhand	2200	yO(8)
Total Area =	15736 km²		

Source: CWC-GoI, 2010

* denotes district-wise river basins, where 1= Mahananda basin in *Darjeeling*, 2= Mahananda basin in *Jalpaiguri*, 3= Mahananda basin in *U. Dinajpur*, 4= Mahananda basin in *D. Dinajpur*, 5= Mahananda basin in *Malda*, 6= Bagmari basin in *Birbhum*, 7= Bansloi basin in *Birbhum*, 8= Pagla basin in *Birbhum*, 9= Mayurakshi basin in *Birbhum* and 10= Mayurakshi basin in *Burdwan*



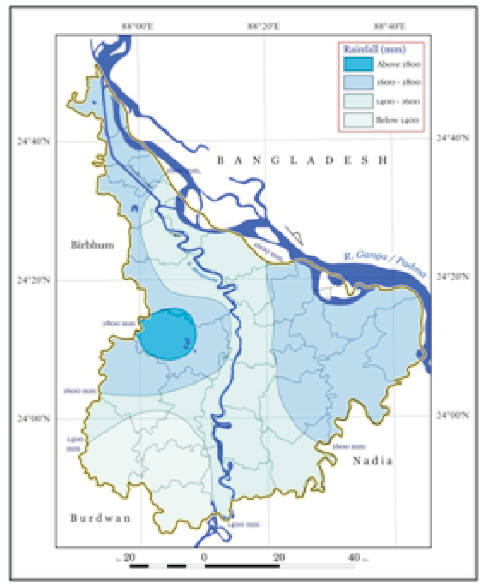


Fig. 1a (left): Networks of drainage in Murshidabad and its surrounding; 1b (right): Rainfall Distribution in Murshidabad

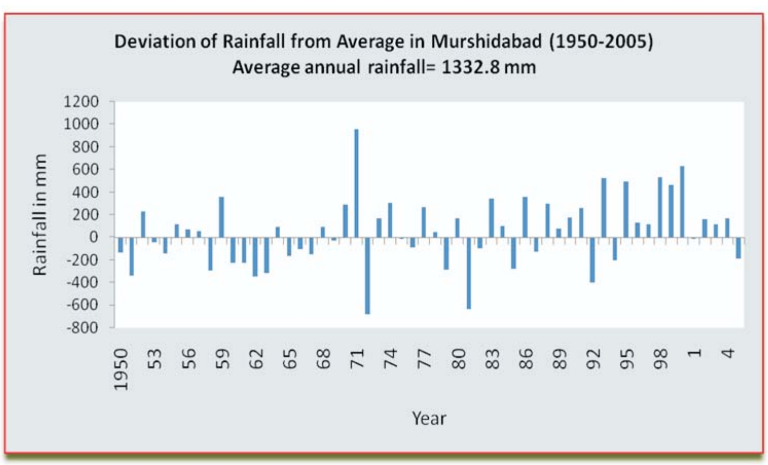


fig. 2: Annual Rainfall Pattern of Murshidabad (1905 -2000)

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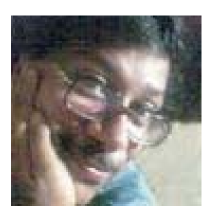

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