Factors of Flood Hazard in the Study Area

The district of Murshidabad is a part of the lower Gangetic plain and is replete with rivers and stream channels. As of its geographical situation, physiographic conditions, climatological characteristics and socio-economic peculiarity it deserves a particular consideration in the matter of its susceptibility to flood. Rivers, channels and waterbodies command the drainage over the district, and play a very crucial role in shaping its prosperity, and misery by engendering the environmental hazard. Features of the surface of the locality, no doubt, give profile to floods in the district.

4.1 CAUSES OF AGGRAVATION OF RISK FROM FLOOD

The empirical analysis of the prevalent phenomena finds five fundamental parameters aggravating the severity of flood in the study area:

1. Storage capacity and nature of run-off;
2. Development Activities in the floodplain;
3. Topography and slope;
4. Frequent breaching of embankment.

4.1.1 Storage Capacity and Nature of Run-off

Rain is a meteorological event. A greater volume of annual rainfall does not necessarily mean the incidence of flood. Rainfalls well distributed over the year may not cause a flood. For an illustration, had the excessive rainfall in September 2000 been distributed over that year it might not spell out such a calamitous flood. Flood is natural event in that sense that it results from an overstepping of the stream flow generated by a severe combine of hydrologic and meteorological conditions over the drainage basin of an area. Records show that the incidence of flood in Murshidabad district is simply related to quantity, duration, intensity and temporal distribution of rainfall. Following the assessment, the catchments in the district receive 80 per cent of the annual rainfall in monsoon months only. Excesses of rain are usually associated with passage of depressions. 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. Thus combined rainfall over a short period causes high run-off and resultant flow in the rivers. The annual rainfall during the period of 1905-2000 depicts considerable deviations from the average rainfall in the district (Fig. 4.1.1a) and it also indicates the years with heavy rainfall bringing about flood in the district. The average annual number of rainy days and annual rainfall in Murshidabad district are 79 and 1333 mm respectively. Fig. 4.1.1e depicts the rainfall distribution in the study area. The district has only one meteorological station at Bahrampur. The data recorded at this station do not necessarily represent districts’ scenario. The rainfall pattern and resultant run-off have the following features.
Maximum rainfall is recorded from June to September and minimum precipitation from November to March (Fig. 4.1.1b).

The rivers flow at high water levels in the monsoon months and at low water levels in the winter months (Fig. 4.1.1b).

The hygraphs of all the rivers document an extraordinary difference between the dry and the monsoon season flow.

The average flood flow of the Ganga keeps as much as 20 times greater than its dry season flow.
There is a positive relationship between the discharges of river Bhagirathi (Fig. 4.1.1c), the main river in the study area, with rainfall (Fig. 4.1.1d).

**Figure 4.1.1c**: Annual discharge of River Bhagirathi in Murshidabad district; *Data Source*: Gauging station at Bahrampur, Murshidabad.

**Figure 4.1.1d**: Relationship with annual discharge of Bhagirathi and annual rainfall in Murshidabad district; *Source*: IMD-Gol, Kolkata.
Though rains are quite high in the first two monsoon months (June and July) but it takes more time than expected for creating resultant high discharge as a result of a less soil moisture content, a higher evapo-transpiration rate and more extraction of irrigation water. For August and September the gradual accumulations of water raises the proportion of surface run-off as a result of full soil moisture content, a lower evapo-transpiration rate and reduced extraction of irrigation water and the direct discharge into the river system. The probability and occurrence of heavy short-term rainfall in these months generally produce a very high surface runoff to accelerate occurrence of flood.

Data about the rivers associated with flood in Murshidabad district are given below in the following tables. Kalyan Rudra, the distinguished interpreter of riverine behaviours has denominated the river basins and their riparian tracts (Rudra, 2009). The district of Murshidabad encompasses five river systems. Of them the Mayurakshi and the Bhairab- Jalangi- Gobra river systems together cover 90.8 per cent of the district. Besides the contribution of the run-off over the district during the Monsoon, the hydrological characteristics of the areas outside the district over which the rivers outflow play a significant role. The districts that contribute to Murshidabad district’s run-off count the relevant data in the Table 4.1.1a-c. Such extraneous contributory areas measure 13056 km². The districts of Birbhum, Uttar Dinajpur and Malda account for the major
share of the contribution. On the contrary, the district derives a huge quantity of uncontrolled run-off from the neighbouring states Bihar, and Jharkhand and the neighbouring country Bangladesh. The total of these areas outside the state is estimated at 15736 km$^2$. It is worth pointing that these areas are characterised by varying physiography and culture, markedly in disagreement with that of the study area. Consequently, the areas surrounding the district have got the hydrological features, sometimes, altogether unlike to that in the Murshidabad district.

**Table 4.1.1a**: River Systems of Murshidabad district

<table>
<thead>
<tr>
<th>Name of the River Basin</th>
<th>% of district area</th>
<th>Sub-district area (km$^2$)</th>
<th>Name of the basin$^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pagla</td>
<td>3.6%</td>
<td>191</td>
<td>pM</td>
</tr>
<tr>
<td>Bansloi</td>
<td>1.5%</td>
<td>82</td>
<td>bM</td>
</tr>
<tr>
<td>Mayurakshi</td>
<td>36.4%</td>
<td>1938</td>
<td>yM</td>
</tr>
<tr>
<td>Bhairab-Gobra-Jalangi</td>
<td>54.4%</td>
<td>2895</td>
<td>gM</td>
</tr>
<tr>
<td>Bagmari Feeder Canal</td>
<td>4.1%</td>
<td>218</td>
<td>fM</td>
</tr>
<tr>
<td><strong>Total area</strong></td>
<td></td>
<td><strong>5324 km$^2$</strong></td>
<td></td>
</tr>
</tbody>
</table>

(* denotes names of river basins across Murshidabad, where pM = Pagla river basin, bM = Bansloi river basin, yM = Mayurakshi river basin, gM = Bhairab-Gobra-Jalangi river basin and fM = Bagmari basin); **Source:** CWC-GoI, 2002

**Table 4.1.1b**: List of the River Basins and the Area that Feed Run-off to Murshidabad District in W.B

<table>
<thead>
<tr>
<th>Name of the River Basin</th>
<th>District</th>
<th>Area (km$^2$)</th>
<th>Name of the basin$^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahananda</td>
<td>Darjeeling</td>
<td>1233</td>
<td>mD</td>
</tr>
<tr>
<td></td>
<td>Jalpaiguri</td>
<td>28</td>
<td>mJ</td>
</tr>
<tr>
<td></td>
<td>Uttar Dinajpur</td>
<td>3140</td>
<td>mU</td>
</tr>
<tr>
<td></td>
<td>Dakshin Dinajpur</td>
<td>1260</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>Malda</td>
<td>3733</td>
<td>mL</td>
</tr>
<tr>
<td>Bagmari Feeder Canal</td>
<td>Birbhum</td>
<td>28</td>
<td>fF</td>
</tr>
<tr>
<td>Bansloi</td>
<td>Birbhum</td>
<td>277</td>
<td>bF</td>
</tr>
<tr>
<td>Pagla</td>
<td>Birbhum</td>
<td>166</td>
<td>pF</td>
</tr>
<tr>
<td>Mayurakshi</td>
<td>Birbhum</td>
<td>3132</td>
<td>yF</td>
</tr>
<tr>
<td></td>
<td>Burdwan</td>
<td>59</td>
<td>yB</td>
</tr>
<tr>
<td><strong>Total area</strong></td>
<td></td>
<td><strong>13056 km$^2$</strong></td>
<td></td>
</tr>
</tbody>
</table>

(Notes: * denotes district-wise river basins, where mD = Mahananda river basin in Darjeeling, mJ = Mahananda river basin in Jalpaiguri, mU = Mahananda river basin in U.Dinajpur, mA = Mahananda river basin in D.Dinajpur, mL = Mahananda river basin in Malda, fF = Bagmari river basin in Birbhum, bF = Bansloi river basin in Birbhum, pF = Pagla river basin in Birbhum, yF = Mayurakshi river basin in Birbhum and yB = Mayurakshi river basin in Burdwan); **Source:** CWC-GoI, 2002

A comparative profile of the rainfall characteristics of the areas including the study area is shown in the Fig. 4.1.1f. Of these the Mahananda basin receives the highest degree of rainfall and
delivers a corresponding quantum of run-off (Fig. 4.1.1g). So, it can be inferred that the floods in the district is governed largely by the physiographic traits of the upstream segments of the region.

**Table 4.1.1c:** List of the River Basins and the Area outside WB that Feed Run-off to Murshidabad District

<table>
<thead>
<tr>
<th>Name of the River Basin</th>
<th>State/Country</th>
<th>Area (sq.km.)</th>
<th>Name of basin*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahananda</td>
<td>Bihar</td>
<td>6662</td>
<td>mY</td>
</tr>
<tr>
<td></td>
<td>Bangladesh</td>
<td>1505</td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td>Bangladesh</td>
<td>2082</td>
<td>mX</td>
</tr>
<tr>
<td></td>
<td>Bihar</td>
<td>1638</td>
<td>mZ</td>
</tr>
<tr>
<td>Bagmari Feeder Canal</td>
<td>Jharkhand</td>
<td>204</td>
<td>fO</td>
</tr>
<tr>
<td>Bansloi</td>
<td>Jharkhand</td>
<td>531</td>
<td>bO</td>
</tr>
<tr>
<td>Pagla</td>
<td>Jharkhand</td>
<td>914</td>
<td>pO</td>
</tr>
<tr>
<td>Mayurakshi</td>
<td>Jharkhand</td>
<td>2200</td>
<td>yO</td>
</tr>
<tr>
<td><strong>Total area</strong></td>
<td></td>
<td><strong>15736 km²</strong></td>
<td></td>
</tr>
</tbody>
</table>

(Note: * denotes state-wise river basins, where mY = Mahananda river basin in Bihar-U.Dinajpur, mV = Mahananda river basin in Bangladesh-U.Dinajpur, mX = Mahananda river basin in Bangladesh-D.Dinajpur, mZ = Mahananda river basin in Bihar-Malda, fO = Bagmari river basin in Jharkhand, bO = Bansloi river basin in Jharkhand, pO = Pagla river basin in Jharkhand and yO = Mayurakshi river basin in Jharkhand); *Source: CWC-Gol, 2002*

The storage capacity of an area plays a very 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, on the other hand it provides for irrigating fields during non-monsoon season. The storage capacity of the sub-district surrounding Murshidabad district is shown in Table 4.1.1d. The sub-districts contributing run-off to the river systems in the study area do not have any large reservoir such that they can keep immune from floods; the few small ones hardly having adequate storage capacity for taking on comparatively large mass of run-off, are estimated at barely 2.6 per cent of the volume of the run-off, while the capacity of the study area alone measures 11.4 per cent of the total volume of run-off produced.

**Table 4.1.1d:** Storage Capacity (in mcm) of Small River Basins within Murshidabad district

<table>
<thead>
<tr>
<th>Name of the River Basin</th>
<th>Capacity of small reservoirs (mcm)</th>
<th>Capacity of large reservoirs (mcm)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pagla</td>
<td>10.3</td>
<td>00</td>
<td>10.3</td>
</tr>
<tr>
<td>Bansloi</td>
<td>4.4</td>
<td>00</td>
<td>4.4</td>
</tr>
<tr>
<td>Mayurakshi</td>
<td>104.4</td>
<td>00</td>
<td>104.4</td>
</tr>
<tr>
<td>Bhairab-Gobra-Jalangi</td>
<td>155.9</td>
<td>00</td>
<td>155.9</td>
</tr>
<tr>
<td>Bagmari Feeder Canal</td>
<td>11.8</td>
<td>00</td>
<td>11.8</td>
</tr>
<tr>
<td><strong>Total Capacity</strong></td>
<td></td>
<td></td>
<td><strong>286.8 mcm</strong></td>
</tr>
</tbody>
</table>

*Source: CWC-Gol, 2002*

The storage capacity of the sub-district surrounding Murshidabad and the river basin-wise storage capacity of the study area are shown in the Fig. 4.1.1h-i. The volume of run-off over the
district measures meager 1 per cent against the rest 99 per cent coming from the outer upstream areas lying in the other districts of the state and the adjacent states afore mentioned (Fig. 4.1.1i).

![Figure 4.1.1f: Average rainfall of sub-districts surrounding Murshidabad district; Data Source: CWC-GoI, 2002](image)

![Figure 4.1.1g: Estimated run-off and storage capacity of sub-district surrounding Murshidabad district; Data Source: CWC-GoI, 2002](image)
The reservoirs under the multipurpose Damodar Valley Project were built aiming at controlling floods, generation of power, and irrigation, whereas the Massanjore and the Kansabati Projects precluded flood control plan. DVC project indirectly affects the flood situation of the study area as the run-off from surrounding area also determines the hydrograph of these rivers. An alarming order of siltation over five decades has cut down the capacity of those staggeringly huge reservoirs considerably enough. Having three step water storage structures— the dead, the live and the flood storages— the sum total flood storage capacity of four DVC reservoirs is 1,270 million m$^3$. This capacity has proved to be miserably inadequate to provide for the massive quantum of
run-off during the monsoon that brings vastly torrential rains around. The Fig. 4.1.1k presents the loss of capacity of the reservoirs, Maithon and Panchet- two major structures under DVC Project.

**Figure 4.1.1k:** Loss of capacity of Maithon (upper) and Panchet (lower) reservoirs; Source: IWD-GoWB, 2008

Allegedly, the DVC, putting it at risk, reserves an excess of water upto the flood storage during July-August to provide for irrigating boro paddy fields later, for rainfall in September is uncertain. Now, when a larger scale torrential rainfall occurs in September it compels the dam authority to release water in bulk letting flush flood in lower floodplains (as in the years 1999, 2000). Here it is noteworthy that the different committees on flood in India observed that the construction of dams has moderated the level of water but increased the duration of flood. As a result the chances of synchronisation of floods from upper and lower valleys and also from adjoining river basins have been enhanced.

The Kangsabati and the Massanjore reservoirs do not have flood storage. The Kangsabati reservoir and the Massanjore reservoir can hold $123.35 \times 10^7$ m$^3$ and $61.67 \times 10^7$ m$^3$ respectively. According to the report of the IWD, the dead storage and the live storage Massanjore Reservoir have dwindled by about 48 per cent and 15 per cent respectively. Average reduction of the
storage capacity of the Massanjore reservoir is estimated as 28 per cent over the last five decades. The details are given in the Table 4.1.1.e.

**Table 4.1.1.e: Storage Capacity of Massanjore Dam (Capacity in mcm)**

<table>
<thead>
<tr>
<th>Original LS (mcm)</th>
<th>Reassessed LS Capacity (mcm)</th>
<th>Loss (mcm)</th>
<th>Span (Year)</th>
<th>Loss (%)</th>
<th>Annual Loss (%)</th>
<th>Rate of Siltation (mcm/yr)</th>
<th>Capacity Loss Anticipated till 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>547.59</td>
<td>474.82</td>
<td>72.77</td>
<td>45</td>
<td>13.29</td>
<td>0.295</td>
<td>1.617</td>
<td>82.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15.045</td>
</tr>
</tbody>
</table>

*Source: IWD-GoWB, 2004*

4.1.2 Development Activities in Floodplain

The flood in a certain area has a very significal association with the ecological settings and natural regime of hydraulics in that area. Flooding is a natural incidence and human’s living with it is just decreed by nature; transgression of such decree can not be welcome. An unscrupulous encounter by man can only be probable to make humanity vulnerable to natural hazards further. As for floods, there could be no exception of this in Murshidabad district. The floodplains in the district have been largely occupied and thereby constringed by human settlements. As is generally the other district of West Bengal, Murshidabad district has faced a huge increase in population since 1901; the number of people in 2001 was more than four times higher than the number in 1901.

Between 1901 and 2001 the increase was gradual and constant, leading to a doubling of the population over a period of 80 years. From 1951 to 2001 the increase was drastic and resulted in a tripling of the population in only 40 years (Fig.4.1.2.a). The increase in population, particularly during the second part of the twentieth century, has led to a significant increase in the population density in the floodplains of Murshidabad district and a decrease in per capita land availability. The average size of land holding per household and availability of cultivable land per agricultural worker are 0.75 hectare and 0.73 hectare respectively (BAES-GoWB, 2008).

Consequent on an inordinate rise in population and human infiltration, the inhabitants from the riparian tracts encroach even on the river islands, just adding to the risk of inundation of lands. Across the southern parts of West Bengal human interference with the hydrological regime come in along with the extension project of the railways commencing fifties and sixties of the last century. Since the railways and roads in the region have been aligned usually in the north-south direction, they have intercepted the eastward flows of run-off. The result is: the pools of stagnant waterbody alongside the structures making up the common feature in the district. The riparian tracts in Murshidabad district are highly fertile with the river-borne silt. There are so many *beels* that are, in fact, abandoned stream channels. Alongside these wetlands lie the fertile strips of alluvial plains; naturally people choose these plains for cropping. As a result, the loose soil mass slides down into the wetlands, getting them silted up. This causes the reduction of storage capacity of the natural flood cushions aggravating the risk of flood during heavy rain.

4.1.3 Nature of Topography and Slope

To consider the variants of physical characteristics of the district, Murshidabad district can be divided into six physiographic sub-units (Fig 4.1.3).
Each of these physiographic sub-units has distinct physiographic character influencing the occurrence of flood in the district. These sub-units are:

- The Padma Riverine Tract
- The Bhagirathi-Dwarka Interfluve
- The Rangamati Upland and
- The Mayurakshi-Dwarka Plain.
- The Padma-Bhairab-Bhagirathi Tract and
- The Kalantar Low Tract.
Plate 4.1: Human Intervention in hydrological Regime (*Clockwise from upper left*) ■ Agriculture practice in Ahiron Beel; ■ Natural Siltation of Khairamari beel; ■ Obstruction on the Chhoto Bhairab; ■ Embanking the Padma; ■ Human encroachment in the Chhoto Bhairab; ■ Obstruction on the Gobra nala; **Source:** Field Survey, 2011

**The Padma Riverine Tract:** This physiographic unit represents the narrow belt along the river Ganga/Padma with 32 kms length extending from north to south and about 4 - 16 kms width, representing an almost flat-surfaced tract. The proximity to the river Padma is primarily responsible for a distinct character of this area. The right bank of the Ganga/Padma stands conspicuously 6.71 metre high and suffers from lateral erosion. The Ganga/Padma has, however,
has altered its course a number of times over the area, the abandoned beds and depressions indicate this fact.

**The Bhagirathi-Dwarka Interfluve:** This vast tract with its distinctive characteristics of undulation and eastward sloping, composed of laterites or older alluvium which are built up as well as scarred by the Dwarka, the Gambhira, the Brahmani, and other right bank tributaries of the Bhagirathi. The central part of this tract is relatively higher and has not been inundated in the recent past.

**The Rangamati Upland:** A narrow strip of tract lying between the Bhagirathi and the Babla, it provides a set of particular physiographic trait. Lying about more than 9 metre above the average level of the Bhagirathi, a layer of reddish soil mixed with lime and oxide of iron features the uplands of Rangamati. The huge red bluffs, after which the locality is named as Rangamati, are considerably reduced in recent years due to weathering and erosions.

**The Mayurakshi-Dwarka Plain:** This plain is drained by the Dwarka and the Mayurakshi along with their tributaries – all flowing down in the south-east direction. Both the rivers meet near the Hijal and the confluent flows towards the south. There are several prominent and permanently marshy depressions of various shapes and sizes. Some of them, such as Hijal, Patan, Belun, Langolhata, Karul etc., are mostly abandoned beds of the rivers. The Hijal, a saucer-shaped depression, near the confluence of the Mayurakshi and the Dwarka, covering about 130 km², presents a very different topographic aspect. Recently, the Mayurakshi and Hijal Beel have lost their carrying capacity and storage capacity. Estimated volume of sand deposition of the river Mayurakshi is about 0.786×10^6 m³ over the last 54 years. Ability to carry discharges of all the rivers collectively has descended to about 0.786×10^6 m³. Storage capacity of the Hijal Beel area has got reduced to about 1.90×10^6 to 1.56×10^6 m³ over the last five decades (Mukhopadhyay and Pal, 2011). An outflow of such a huge volume of extra water from Hijal Beel and loss of carrying capacity of the rivers are only too responsible for flood severity in the Kandi block, in particular.

**The Padma-Bhairab-Bhagirathi Tract:** This riverine plain is completely different from the Rarh in respect of topography, soils and hydrology. It covers more than half of the Bagri which is composed of very recent alluvium accumulated by the Ganga/Padma and its distributaries i.e., the Jalangi, the Bhairab, the Chhoto-Bhairab, the Sialmari etc. The most characteristic features of these distributaries are that they flow southwards and during the summer season they are almost disconnected from their headwaters. It has been observed that the upper parts of these distributaries are completely dried up and the river beds are often cultivated. From Nurpur, where the Bhagirathi takes off, to Jalangi, the land slopes gradually towards the east. The Padma continuously shifts its course causing bank erosion and resulting in emergence of a number of chars. This area is frequently inundated by floods which cause havoc to the local people. The Bhairab, a spill channel of the Padma, divides this area into almost two equal parts. The eastern part is comparatively lower than the west and slopes towards the south-southeast direction.

Another important feature of this tract is Bhagirathi levee. This long and narrow tract differs much in terms of material from the general alluvial plains of the Bagri. The area bounded by the Bhagirathi on the west and the Gobra Nala on the east, has been formed by the deposition of sands and silts brought by the flood water. The land varying 4 to 9 kms in breadth, maximum
height being 19.51 metres recorded at MSD-Jiaganj block with slope towards the Gobra Nala. A number of horse-shoe lakes viz., Motijhil, Bishnupur Beel, Chaltia Beel etc., been some evidences of the changing river beds of the Bhagirathi.

**The Kalantar Low Tract:** It is a vast saucer-shaped depression of dark clay and hence it is locally known as Kalantar; it lies between the rivers - Bhagirathi and Jalangi. A striking feature of the surface of the Bagri, particularly of this southern part, is the abundance of *beels* or depressions, which terms a large area replete with swamps and marshes. During dry season, these marginal marshes and *beels* i.e., Salmara, Pat, Dhandar, Harma, Kumri etc., get parched up considerably. But as soon as the monsoon sets in they are transformed into a huge watery expanse. The whole area lies below 15 metres above sea-level (WBDG-GoWB, 2003).

![Physiographic Divisions of Murshidabad District](image)

**Figure 4.1.3:** Broad physiographic divisions of Murshidabad district; Source: SWID-GoI, 1998
Physiographic features of the study area favour generation of flood. The Hijal, a saucer-shaped depression, near the confluence of the Mayurakshi and the Dwarka, covering about 130 km², persuade the occurrence of flood. Due to its topography the area becomes a huge sheet of water during monsoon season; in some places the depth of water being about 6 metres. Besides, due to its topographic feature it takes a long period to recede the flood water from the area. In the Bagri region the eastern part is comparatively lower than the west and slopes towards the south-southeast direction. As a result the local run-off runs towards the Jalangi instead of the Padma or the Bhagirathi. This run-off aggravates the flood risk of the south-east part of the Bagri region. In respect of topography the Kalantar tract is a vast saucer-shaped depression; it lies between the rivers - Bhagirathi and Jalangi. The whole area lies below 15 metres above sea-level. Therefore, as soon as the monsoon sets in they are transformed into a huge watery expanse accelerating the magnitude of flood risk.

Figure 4.1.3a: Slope pattern in the Northern Rangamati Upland Tract; AB: Max slope- 30.1; Average slope- 3.5; CD: Max slope- 14.6; Average slope- 1.5; Source: Google Earth, 2012

The region west to the Bhagirathi forms the part of the south-east fringe of the foothills of the Rajmahal hills. The parts, by and large, are undulating and full with marshes and abandoned
riverine courses. This region is drained by the streams originating from Rajmahal hills and they fall into the Bhagirathi. These are, according to geologists, even older than the Bhagirathi. In this region the slope is comparatively as high as 30.1 and average slope is 3.5 in the northern part. In the southern part of the feeder canal the slope reduces to 14.6 and the average slope to 1.5 (Fig. 4.1.3a). Consequently the rivers like the Bansloi, the Pagla, and the Brahmani etc. result rapid flow of run-off in the region.

**Figure 4.1.3b:** Slope pattern in the Mayurakshi-Dwarka plain; **AB:** Max slope- 24.3, Average slope- 1.6; **CD:** Max slope- 4.0; Average slope- 0.6; Source: Google Earth, 2012

Again if we notice the slope pattern in further south in the Mayurakshi – Dwarka plain the maximum slope is 24.3 and the average slope is 1.6 in the northern part of the plain. Below that the slope reduces to only 4.0 and average slope to 0.6 (Fig. 4.1.3b). This also causes rapid flow of waters coming down in the study area. To the east of Kandi town there lies a vast depression named Hijal where the Dwarka meets the Mayurakshi. It covers about an area of 130 km². The area goes under water in the wet season due to huge run-off coming from the western hilly
region. At places water stands 6.10 metre deep. During the rains this region turns out to be a vast lake.

![Map showing slope pattern of Northern Padma-Bhairab-Bhagirathi tract](image)

**Figure 4.1.3c**: Slope pattern of the Northern Padma-Bhairab-Bhagirathi tract; **AB**: Max slope- 3.0; Average slope – 0.4; **CD**: Max slope- 1.9, Average slope- 0.4; **Source**: Google earth, 2012

The region east to the Bhagirathi is characterised by lesser slope of surface. In the northern part the maximum slope is 3.0 and the average slope is only 0.4. Further south in the kalantar tract the maximum slope reduces to mere 1.9 and the average slope is 0.4 (Fig. 4.1.3c). Thus in region the drainage becomes sluggish and waterlogging occurs during heavy rain. The change in topography from north to southern part of the district aggravates the flood situation in the study area.

### 4.1.4 Construction of Embankments and Their Frequent Breach

West Bengal has got around 16,370 km embankment for flood control and one-fourth of its area is protected against flood (IWD-GoWB, 2008). But these embankments ultimately expedite siltation of the stream channels and this may have the river-beds raised even above the ground in the banks, which is an obvious condition inducing the flood hazard. Besides, recently it has been
a wider practice to raise the earthen bunds to intercept the channel-flow for irrigating lands of the boro paddy during the dry season or to use them as fair-weather bridge across the channels. These noxious practices by the local people cause the rivers to degenerate further in an un-natural way altogether.

In the past, when rivers had been free from embankments, the waters used to overflow the banks of the river and impinge upon the floodplains where they left alluvium to settle down. The main stream down the channel carried the rest of the mass to the sea. Thus the capacity of stream channels in the area remained intact. In recent days the channels are profusely walled by embankments to prevent the floodflows in the riparian tract causing alluvial deposits in the river beds to warp the stream channels and thus impair them. As a result, these channels are no longer capable of carrying water in the time of even moderate floods and during flood cause havoc to the floodplains. In the context, P.C.Mahalnabis marked the words of caution in (1927:86) “Embankments in the riparian tract may for a time prevent overflow from the rivers, but would tend to raise the bed of rivers still further, and they make situation much worse in long run”. At places in the district where the sluggish flows of the river have developed large islands, the rate of its discharge decreases. Besides, here the rivers carry a very large mass of silt during the wet season down the channels when a considerable portion of the silt settle down on the river-beds, getting them raised and choked up the channels. Consequently, rivers become moribund and the head water supply gets diminished, further worsening the potential of stream flow down the channels of the district.

Murshidanad district has about 530 km long embankment along the different rivers; most of the embankments are 4.26 m. to 6.40 m. high and were built in zamindari period. Almost every 2-3 years interval, elevation of the embankment is getting rise in parity with rising flood height. Most of the embankments were constructed during the 1950s and 1960s when reliable hydrologic data were not available; later on, they were found to offer inadequate protection. After studies in depth, the following deficiencies were found in river embankments:

The magnitude of flood of different return periods has not been taken under consideration during designing height of embankments. As a result the embankments are frequently overtopped. Hydraulic gradients adopted are not based on actual tests. Drainage sluices provided in the embankments are inadequate resulting in drainage congestion behind the embankments. Embankments are not aligned through a suitable foundation, resulting in seepage through the seat of the embankment. Embankments are constructed close to the riverbanks to protect as many villages and towns as possible and thus costly anti-erosion works has to be undertaken subsequently to protect them. Spurs constructed to protect the embankments have an adverse effect on the opposite bank.

Besides, materials used for construction of river embankment – often very loose sand or sandy soil. Moreover, soil used for embankment is just collected from base of the bundh as a result a deep scour has been developed alongside the outer margin of embankment basement. These scours contain water like marshy land almost all through the years as well as weaken the basement. Ramps are cut along embankments to allow crossing by tractors and bullock carts transporting farm produce, or soil and sand for house construction. Even the earth from the slopes of the embankments is dug to build houses with. If embankment is the ultimatum its base should be much wider than apex to resist huge water pressure. The people in protected areas have developed a sense of security and river courses have been stabilised. The embankments are now the best means of communication in the flood-prone areas and are being recklessly used for
transportation of materials by tractors and other heavy vehicles. During floods, people shift to the embankments for temporary shelter and often settle down there permanently. This is a very common feature in the district. It messes up proper maintenance, and embankments become susceptible to breaches during floods. These breaches result in unexpected flood causing huge loss which may not be if there is no embankment.

Another aspect is that entire length of the river is not embanked thus quantum of flood water reaching the un-embanked reaches will be more and the time of travel will be less. Rainwater and the flood water that spill in the country side will not drain back quickly into the river due to embankments resulting in inundation of the areas for longer periods and disruption of communication and transportation links for longer periods increasing agony of the inhabitants. One example of extent of breach in the embankment in the study area is shown in the Fig. 4.1.4.

![Breaching of Embankment during Sept-Oct., 2000 in Murshidaabd District](image)

**Figure 4.1.4**: Breaching of embankment in 2000 flood; Source: IWD-GoWB, 2000

4.2 **FLOOD HAZARD IN MURSHIDABAD DISTRICT: A RIVER BASIN APPROACH**

Murshidabad district is bounded by the Bhagirathi River on the east, the Ajoy river basin on the south and the State boundary of Jharkhhand on the west. The western part of the district is drained by two river systems viz. (i) the Bagmari, the Bansloi and the Pagla and (ii) the Mayurakshi- Kuye- Babla system both of which have their upper catchments in the hilly tracts of Santhal Parganas in Jharkhhand. These river courses have steep gradients in upper reaches and are very flat in lower reaches where they pass through natural depressions before out falling into the Bhagirathi. Problems of these rivers are more or less of a similar nature. The low depression pockets in their lower reaches are separated by high banks from the Bhagirathi and ground levels of these depressions are generally lower than the average flood levels prevalent in the Bhagirathi during August and September. Besides a number of beels, which are perhaps abandoned river
courses, exist in these low areas. Large areas thus remain waterlogged for considerable period of the time during monsoon season. The problem worsens when heavy rainfall in the local catchment synchronises, with high flood levels in the Bhagirathi, when additional areas also get submerged affecting habitations, crops and communications. The eastern part of the district is drained by the Jalangi-Bhairab-Gobra basin. This part of the district is relatively flat with very gentle slope. The characteristic of flood in this region is governed by the decaying carrying capacity of the spill channels and physiography of the area. The areas drained by the different river systems in the district and its surrounding areas is shown in the Fig. 4.2.1a and Fig. 4.2.1b represents the areas of the district under different river basins.

Figure 4.2.1a: River Systems Surrounding Murshidabad district; Source: Adapted from Rudra, 2008
4.2.2 Flood Hazard in Mayurakshi Basin

In the Mayurakshi river system, the upper catchment lying in Jharkhand state is free from flood menace. Actual flood problem starts in the state of West Bengal from downstream of Tilpara Barrage. The core problem area is the Kandi area comprising broadly 2,764 km$^2$ of low or flat lands bounded by Sahibganj loop railway line on the west, Nalhati- Azimgunge railway line on the north, Katwa- Azimgang railway line on the east and Ahmedpur- Katwa railway line on the south. High floods in 1956, 1959, 1971, 1978, 1995, 1999 and 2000 inundated some 1000 km$^2$ of this region. However, flood in 2004 and 2006 hit the areas to a moderate intensity. The areas are subject to sustained submergence almost annually.

Figure 4.2.1b: Areas of Murshidabad district under the different river Basin; Source: IWD-GoWB, 2008
The Kandi area is traversed by the rivers Mayurakshi, the Kuye (combined flow of the river Kopai & Bakreswar), the Dwarka, the Brahmani and the spill channels viz. the Manikarnika, the Kana Mor and the Gambhira. The Mayurakshi meets with its major tributaries namely, the Dwarka- Brahmani system and the Kopai- Bakreswar system in Hijal Beel, where from the river Babla takes off to ultimately outfall into the Bhagirathi, through two-outfall channels viz. the Babla and the Uttarasan (Fig. 4.2.1b). For the sake of better understanding of the nature of problem, the Mayurakshi-Babla basin should be segmented into two zones. The areas with steeper slope having the level of grounds fairly above the flood-level of the Bhagirathi are to be considered in the 1st zone, while the areas having lowlying beels and swamps with relatively flat grounds below the high flood-level of the Bhagirathi around the countryside can taken in the 2nd zone (Fig. 4.2.2c in Appendix M1)

![Map of Mayurakshi Basin](image)

**Figure 4.2.2a:** The river systems of Mayurakshi Basin; *Source:* Prepared from SRTM data, 2010

**4.2.2.1 Zone- I**

Fig 4.2.2a shows the different rivers comprising the Mayurakshi River Basin. The Zone- I comprises broadly areas below the Tilpara barrage on the Mayurakshi and other barrages on the tributaries extending up to Badsahi road. The flood problem in this area is mainly due to deteriorated condition of the river channel, being shallow, starts spilling over their banks even at
low flood stages. The Mayurakshi river below the Tilpara Barrage, however, been mostly embanked on either side in the zamindari period. These embankments appear to have been constructed arbitrarily quite close to the river channel in certain reaches without much technical planning, consequent to which the channel capacities are greatly reduced at many places. Due to population pressure the local beneficiaries tried to save the Hijal Beel area from flood for Kharif cultivation by compartmentalisation of some areas by construction of several Gher Bundhs called as ex-zamindari embankment. The embankments on account of their unplanned and faulty alignment encroach upon the spill areas considerably so much so that they quite often get breached during high floods. Further, as the general slope of the country is not always towards the river, some portion of the spill waters do not return back to the river but flows across the countryside along depressions and ultimately collects into Hijal Beel area. The rivers Manikarnika and Kana Mor are two such important spill channels which, although remain practically dry during low floods, carry large volume of spill waters during high floods, creating additional problems on the left bank of Mayurakshi by flooding large areas all along. In fact, the whole area surrounded by the river Manikarnika, Kana Mor and Mayurakshi gets flooded. Quite often, the Mayurakshi flood spills enter into the Manikarnika from above the Burdwan- Murarai railway line through gaps in the existing embankment on its left bank.

The rivers Dwarka and Brahmani before their confluence near Sankoghat get absorbed in the Jhilli Beel area measuring 36 km$^2$. After confluence the river is called Dwarka and again the flood volume is absorbed in the Basia Beel area with a surface area of 101 km$^2$. After Basia Beel there is a constriction on the river Dwarka at Gantlaghat which acts as a natural regulator of the flow of the river Dwarka and desynchronise and moderate the flood volume. The spills of river Dwarka, though moderate below the railway line, increase substantially from near Sankoghat. From Sankoghat downstream, the terrain becomes flat and low-lying. On the right side of Mayurakshi, the problem is, more or less, concentrated near Langolhata Beel and Panchthupi Beel due to spilling of Mayurakshi and floods in Kuye River.

Though the flooding period is not very prolonged, it causes acute drainage congestion, as the drainage from these beels is rather slow. The problem of this zone can now be summarised as follows:

- Flooding in the left bank of the Mayurakshi across this zone owing to spill over out of the three channels- the Mayurakshi, the Manikarnika and the Kana Mor.
- Inundation of the areas in the right bank of the Mayurakshi and the drainage congestion in Langalhata and Panchthupi areas due to the spate in the Mayurakshi and the Kuye.
- Floods in the Dwarka and the Brahmani subscribing to the moderate spilling over the both banks of the rivers.
- Unscientific alignment of the embankments without berms and constringed river-channels across the zone.

### 4.2.2.2 Zone – II

The lower catchment of the Mayurakshi river system below the Badsahi road upto confluence with the Bhagirathi constitutes the zone II. With a steep slope in the upper reaches the river rapidly flow in the low lying Hijal Beel area measuring 126 km$^2$, get absorbed and thereafter gradually discharge into the river Bhagirathi through the river Babla at Kalyanpur and the river Uttarasan at Uttarabad. The Hijal Beel thus serves as a natural detention basin, which gets gradually drained off when the water levels in Bhagirathi subside after the monsoon season. But
the drainage channels, Babla and Uttarasan practically do not function as drainage channels. These have deteriorated to such an extent that carry reverse flow from Bhagirathi for a long period, during monsoon months, thus, aggravating the congestion in the Hijal Beel areas (Fig. 4.2.2.b). The bank full capacity of the Bhagirathi is about 2,550 cumecs at the outfall point of the Babla confluence. With the river already flowing almost full due to discharges coming down from upstream areas, the capacity is rather inadequate to take any significant additional flow from the Mayurakshi system. Therefore, a considerable volume of flood inflow gets stored as valley storage in the Hijal Beel area with the result that the beel area remains submerged for a considerable period of time till the Bhagirathi levels fall. The Bhagirathi level near the Babla outfall is also influenced by the floods in the Ajoy River which has its outfall about 14 km downstream of the Babla outfall point. Moreover, floods in the Mayurakshi and Ajoy basins synchronise most of the times because of their similar meteorological characteristics.

![Schematic Diagram of Mayurakshi Basin in Murshidabad](image)

**Figure 4.2.2b:** Schematic diagram of part of Mayurakshi Basin in Murshidabad; *Source: Adapted from IWD-GoWB, 2000*

The problem area in this zone is mainly below Kandi Bharatpur road along the Mayurakshi and the Kuye rivers and extends right upto Sankoghat and further downstream along the Dwarka. Another low depression extends along the Jibanti Khal, a small drainage channel to Telkar Beel, and goes almost up to Azimganj. Originally, these low areas were not being cultivated as they
used to remain submerged under floodwaters. Due to growing influx of population, however, the low areas, which were basically natural detention basins, have progressively been reclaimed by construction of ring bunds. These bunds afford protection only during low floods but get overtopped or breached quite often during high floods submerging large areas. The flood problems in the Zone- II can mainly be attributed to the followings:

- Floodwaters stranded in the depressions over the zone by the high and sustained flood level in the Bhagirathi, following the commissioning of the Farakka Barrage in particular,
- Widespread incidence of downpour entirely over the zonal catchment.
- The back-water effect on account of synchronisation of floods in the Ajay catchment.
- Inadequate release through some of the railway bridges.

**Fig. 4.2.2:** Backwater effects at the river Babla and Uttarasan outfalls; Source: Prepared from IRS-P6 LISS-3 image, 01.10.2010

### 4.2.3 Flood Hazard in Pagla- Bansloi Basin

The discharges from the Bagmari, Pagla and Bansloi make this area suffer from inundation. The catchments of these rivers being minor, adjoining and compact these three rivers together rise in spate in response to rainfall in the catchment areas (Fig. 4.2.3). Now the Bagmari, instead of
outfalling straightway into the Bhagirathi, has got its passage through a siphon buried under the Feeder Canal. Due to the structure getting choked, the area gets inundated as it rains even moderately. Following the Farakka Barrage commissioning the flow-level of the Bhagirathi remains considerably higher. Consequently, the drainages of the rivers Bansloi and the Pagla gets blocked during monsoon, which leaves the area under waterlogging extending from Ahiron Beel to Bansabati Beel area, the rivers occasionally facing the back-flow from the Bhagirathi during high flood. Apart from this, the Bangsabati Beel getting silted-up the water spreads over about 100 km² compared to 64 km² earlier.

Thus, the flood problems in this zone can mainly be attributed to the followings:

- Inadequacy of waterways provided in some of the railway bridges.
- Inadequacy of inlet structures on the Farakka Feeder Canal to inlet some of the rivers during high flood and choking of Bagmari Siphon to allow the river Bagmari to outfall into the Ganga.
- Drainage blockage due to obstruction from Feeder Canal.

![Figure 4.2.3: Pagla-Bansloi-Bagmari river basin; Source: Prepared from SRTM data, 2010](image)

4.2.4 **Flood Hazard in Jalangi Basin**

The Jalangi from its off-take from the Padma flows only in the monsoon period as this point got heavily silted up until it meets the Bhairab at Muktarpur, which also brings discharge from the Padma. Earlier during peak monsoon, it used to run in full channel capacity. It used to spill the both banks at Muktarpur in the years of high rainfall. Naturally when the Bhairab flows high, the
upper part of the Jalangi experienced complete drainage blockage. The Jalangi cannot drain freely and backwater from the Bhairab extends up to considerable distance upstream up to confluence of the Sialmari causing submersion of large area measuring 480 km\(^2\) approximately. But along this reach, there are several flood cushions (beels/swamps etc.), which admit to store water due to river spill or heavy rainfall and the depth of inundation hardly exceeds 0.3 m in this region.

The overspill from the Padma scouring down the Bhairab falls into the Jalangi and causes it to overflow the both banks along its lower reach. A wide spread bank erosion at Akheriganj has resulted in changes morphology and channel course around this reach of the Padma. The Suti, the confluent of the Jalangi and the Suti (the lower reach of the Gobra Nala) means to drain about 840 km\(^2\) and the Kalma Khal about 300 km\(^2\) just below the Suti. But they fail to discharge the drainage accumulation into the Jalangi and the consequent congestion leads to inundation around. The left bank lying lower than the right, the drainage down the upstream reach of the Chhoto Bhairab makes the Bhandardaha Beel spill gets reinforced by the water from the Chhoto Bhairab and flood the tract in between the Gobra Nala and the Bhairab. A part of Jalangi-Bhairab basin is shown in the Fig. 4.2.4.

![Figure 4.2.4: Jalangi-Bhairab river basin; Source: Prepared from IRS-P6 LISS-3 image, 01.10.2010](image_url)
At many places drainage canals in the region have been dug in order to effect the quick removal of flood water due to river spill for sowing rabi crops or *boro* variety of paddy. It just has attracted backlashes, such as loss of waterbodies that maintain groundwater storage, the baseflow to the rivers and above all a severe damage to ecosystem. The problem is, however, different for the reach of the Jalangi bounded by the Beldanga-Amtala road in the north and the Bethuadahari-Birpurghat road in the south. In this region, the level of water of the Jalangi flows high and prevents flow through the Suti and Kalma Khal. It causes inundation in the whole area in the north bounded by the Beldanga-Amtala road in the north and the Palasi-Palasipara road in the south. In some area spilled water reaches the level of two roads.

![Diagram](image_url)

**Figure 4.2.4a:** Drainage blockage at the outfall points of R.Gobra Nala and R.Bhairab; Source: Prepared from IRS-P6 LISS-3 image, 01.10.2010

The problem of the other reaches of the Jalangi is not so acute, though backflow through Kalma Khal engulfs a vast area under submergence in the vicinity of the Kumari Beel. The reach of the Jalangi further lower suffers from bank overspill, which is more on the left bank than on the right. The *beel* areas are sparse in this reach. A number of isolated embankments have been constructed along the left bank mostly by ex-zamindars and/or through test relief measures to prevent flood spill. The embankments are so aligned that about 400 ha berm land between river
channel and embankment has been kept for the river to spill. At the outfall of the Jalangi, drainage congestion due to high water level is often experienced. Such blockages when occur inundate the entire area. About 9 per cent of the basin floods result from the drainage congestion due to very gentle slope and physiography of beel areas. It causes flood affecting an area of 5,609 km². The maximum area flooded in a single year was 3,090 ha in 1971. So far the poor drainage is concerned, the points of the Jalangi where it receives the Bhairab, Suti and Kalma Khal and where it outfalls into the Bhagirathi are very significant (Fig. 4.2.4a). The Bhagirathi is embanked on the left bank but during exceptionally high floods, as recorded in the years of 1978 and 2000, this embankment breach and flood water escapes towards east, flooding vast areas in the Jalangi- Bhairab basin. The detailed description of this river basin is given in the Fig. 4.2.4b (in Appendix M2).

4.3 PROBABILITY OF RETURN PERIOD OF RAINFALL AND DISCHARGE

Regarding the fact that occurrence of floods in the district brings heavy losses, it stands essential to estimate the proportion and intensity of it in its proper bearing on the design of hydraulic structures concerning mechanism of mitigation. Flood frequency estimate is multipurpose: it serves not only the effective planning of measures to save lives and properties in the areas prone to flood, but also management of land, water resources and eco-conservation. It being the outcome of a host of component parameters it is pretty difficult to analytically model floods. Obviously, it is an intricate job to carry out estimation of a peak flood, for the problem leads to several approaches. For plotting a flood frequency analysis is the most expedient approach. Incidence of flood in rivers counts as a statistical event- that constitutes a discrete function of random variables. In the study area no such attempts has been yet taken for construction of any flood control structures. Here probability of flood and rainfall in different return periods has been calculated using Gumbel’s method (Das and Saika, 2009).

![Figure 4.3a: Rainfall graph in different return period; Data source: IMD-GoI](image)

<table>
<thead>
<tr>
<th>Probable Rainfall in Different Return period with trend in Murshidbaad district (Bahrampur)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall in mm</td>
</tr>
<tr>
<td>Years</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>50</td>
</tr>
</tbody>
</table>

Mean= 1327.50  
Std.Dev= 309.72  
N= 100

Flood frequency analysis makes use of annuals of peak floods to afford forecasting the probable courses of future flooding. The two primary utilisations of the flood frequency analysis:
1. To give profile to possible magnitude of floods over a period.
2. Determining the frequency of occurrence of flood with a certain magnitude

The analysis provides for awareness of flood potentials based on conditions current or conjectured beforehand. Besides, it utilises information about previous incidences of flood in order to update the statistical presentation of the probability of future occurrence of flood.

**Figure 4.3b**: Discharge graph of R. Bhagirathi in different return period; *Data source*: Bahrampur discharge record station

**Figure 4.3c**: Discharge graph of R. Mayurakshi in different return period; *Data source*: Bazarsau discharge record station
The graphs (Fig. 4.3a-c: Source Tables 1-3 in Appendix A) reveal the probable peak discharges and probable rainfall in different return periods in Murshidabad district. The probable rainfall in 25 years and 100 years return periods are 2174.61 mm and 2608.79 mm respectively. The probable peak discharges of Bhagirathi for 25 and 100 years return periods are estimated as 3465.89 cumec and 4262.64 cumec respectively. For the river Mayurakshi the probable peak discharges for the same return periods are 1305.88 cumec and 1608.02 cumec respectively.

The pattern of high flood level (HFL) can be made out on the basis of the flood frequency analysis, provided the hydrological data observed are available. As recommended by the NCF (1980), for the area predominantly agrarian the embankment schemes should be purported for the flood having 25-year frequency, while for the safeguard of the township, industrial belt or the like they should be for the flood having 100-year frequency. The Bhagirathi and the Mayurakshi are the two rivers that mainly cause floods in their respective basins in the district. The Fig. 4.3b-c show their PPD based on 25-year and 100-year return period. These can be of practical use to lay down the design of embankment in the corresponding basin of the study area. Flood frequency analysis is actually a form of risk analysis; however, the risk analysis of activity has been yet to be undertaken in this district.