CHAPTER 5

RIVER BASINS MANAGEMENT
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5.1. Introduction

A river basin is the portion of land drained by a river and its tributaries. It encompasses the entire land surface dissected and drained by many streams and creeks that flow downhill into one another, and eventually into one river. The final destination is an estuary or an ocean. As a bathtub catches all the water that falls within its sides, a river basin sends all the water falling on the surrounding land into a central river and out to the sea.

Fig. 5.1: Indian River Basin System
All regions are not uniform. Some are water sufficient, some have water stress situations. This is shown in Fig. 5.1. Depending upon basin area Indian rivers have been divided into three categories namely major, medium and minor.

**Categories of Indian River Basins**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>River Basin</th>
<th>Area (sq.Km)</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Major</td>
<td>Equal to or more than 20,000</td>
<td>13</td>
</tr>
<tr>
<td>2.</td>
<td>Medium</td>
<td>Between 2000 to 20,000</td>
<td>45</td>
</tr>
<tr>
<td>3.</td>
<td>Minor</td>
<td>Less than 2000</td>
<td>55</td>
</tr>
</tbody>
</table>

*Source: Central Pollution Control Board, Delhi.*

Of the total runoff of all the rivers in India, the major river system contribute 83% while the medium river basins occupy 8% of total basin area and about 119940 MCM water flows through them. The total area of minor basins is 9% of total basin area of Indian rivers while runoff is 127 MCM.

Restricted rainfall of three months in most parts of the country leads to drying of rain-fed rivers during summer and late winters and ultimately lowers streamflow and water scarcity as an emerging constraint. On the other hand this period of monsoon is also cause of floods and accumulation of sand, silt & other materials & hence siltation. Siltation rate in India is among the highest in the world. Indian rivers contribute 35% of the sediments to the ocean as compared to water flowing through the rivers of the world which is 5% only. It has been estimated that about 135 thousand million metric-tonnes of sediment load and 32 thousand million tones of soluble matter enter into ocean through
various rivers in our country which is 90% of the total solid waste going into the ocean and causing pollution.

Immediate actions are required to have balance between population growth & the water capacity of the hydrological basins to satisfy the water demand. This requires a proper river basin management system to have sustainable water availability. This could be achieved by proper planning, management and operations in river basin framework.

5.2. RIVER CHARACTERISTICS: DISCHARGES AND CHANGING SCENARIOS

The direct source of rivers is rain and the melting snow. Most of the rainfall of the country is received from the southwest monsoon, which lasts from June to September. The river characterization of both surface and groundwater is required. This will include an analysis of the characteristics of all aquatic systems, a review of the impact of human activity on the status of water bodies, an economic analysis of water use and a register of protected areas in each river basin together with their associated groundwater and coastal waters. From this characterization, appropriate environmental standards will be set with monitoring effort targeted towards those water bodies at the greatest risk of failing to meet their stated objectives, and a programme of measures will be established to ensure that water bodies reach the environmental objectives. This must be done using GIS with the
individual river basin making up each hydrological river basin. The following points should include

1. General Description of the characterization

2. Summary of the significant pressures and impact of human activity on the status of surface and ground waters.

3. Identification and mapping of protected areas

4. A map of monitoring stations and the results of the monitoring programmes, in map form, for all the surface waters (ecological and chemical), groundwaters (chemical and quantitative) and protected areas.

5. List of environmental objectives for all water bodies

6. A summary of economic analysis of water use

Fig.5.2: Showing the river in different stages
5.2.1. River Stage Definitions

First stage- A V-shaped gorge is caused by the vigorous erosion action of the river cutting downward. Waterfalls and rapids are caused by the river passing over harder beds of rocks.

Second stage- A floodplain is formed by the deposition sediments brought down from the first stage. Most deposition takes place during flood. The meander is the temporary river loop. Its position changes by erosion on the outside and deposition on the inside.

Third Stage- An ox-bow lake is formed which is a cut-off meander also sediment deposited along the river bed and sides (as shown in Fig.5.3).

Monitor - Flood - Danger Stages

Fig.5.3: Cross Section - Typical Non-Leveed Stream

Monitor Stage - The Stage at which initial action must be taken by concerned interests (livestock warning, removal of equipment from lowest overflow areas, or simply general
surveillance of the situation). This level may produce overbank flows sufficient to cause minor flooding of low-lying lands and local roads.

**Flood Stage** - The Stage at which overbank flows are of sufficient magnitude to cause considerable inundation of land and roads and/or threat of significant hazard to life and property (as shown in Fig.5.3).

![Fig.5.4: Cross Section-Typical Leveed Stream](image)

**Monitor Stage** - The Stage at which patrol of flood control project levees by the responsible levee maintaining agency becomes mandatory, or the Stage at which flow occurs into bypass areas from project overflow weirs.

**Project Flood Stage** - The Stage at which the flow in a flood control project is at maximum design capacity (U.S. Corps of Engineers "Project Flood Plane"). At this level there is a minimum freeboard of 3 feet to the top of levees.

**Danger Stage** - The Stage at which the flow in a flood control project is greater than maximum design capacity and where there is extreme danger with threat of significant hazard to life and property in the event of levee failure. This is generally 1 foot above project flood stage (as shown in Fig.5.4)
5.3. River Basin in Tripura

This is a list of rivers in India. Rivers that flow into the sea are sorted geographically, along the coast starting from the Bay of Bengal in the east moving along the Indian coast southward till Kanyakumari and moving northward along the Arabian Sea. Rivers that flow into other rivers are sorted by the proximity of their points of union to the sea (the lower in the list, the more upstream). To identify some river, names of districts or States are also given. The major rivers of India flow into the Bay of Bengal and Arabian Sea.

The major rivers of India are:

- flowing into the Bay of Bengal: Brahmaputra, Ganges (with its tributaries Yamuna, Gomti, Chambal), Mahanadi, Godavari, Krishna, Kaveri (and their main tributaries)
- flowing into the Arabian Sea: Indus, Narmada, Tapti (and their main tributaries)

The remaining rivers are:

- flowing into the inner part of India.
- coastal rivers which are arranged as per Indian States

The list has to be arranged as per above.

Rivers flowing into Bay of Bengal

- Karnaphuli River from Mizoram and Bangladesh
- Meghna River from India to Bangladesh
  - Titas River in Tripura
  - Haora River in Agartala
There are seven rivers in Tripura- Gumati, Muhri, Manu, Dhalai, Burima, Khowai and Haora (as shown in Fig.5.5).

The catchment area of Gumati within India Union is 2492 km² and it is the largest sub-basin among the rivers in Tripura. It is surrounded by Bangladesh on its east and west. It originates from the hill ranges connecting Atharamura and Langtarai on the north-east boundary of SouthTripura district and flows down across the Bangladesh border to outfall into the river Meghna.

At source, two chhara (rivulets) known as Kalyansing and Malyansing flows southward and meet at a place Kouticharanpara thereafter it flows down by the name Raima Chhra till it meets its major tributary Sarma Chhara near Ducharibari at an altitude of 86.87 m, after this point the river assumes the name of Gumti and flows down through deep gorges upto Dumbur Falls. The Gumti takes a westerly turn at this point and flows for about 10 km, where it turns northward upto Amarpur and again flows westward and enters into the plains near Maharani. After entering into the plains the river generally flows in west and south-west direction and it enters in the Bangladesh territory at Sonamura. The total length of the river from origin to Indo-Bangladesh border is 167 km. The river then flows through the plains of Bangladesh and meets the Meghna river system near Doudkandi. The length in this reach is about 77 km.
Fig.5.5: Haora River Basin in West Tripura
The maximum discharge observed at Sonamura was 992 m$^3$/s whereas the minimum was 2 m$^3$/s. The width of the river varies from 70 m to 100 m and depth available is more than 2 m except at few places. At present the river is navigable for 6-7 months in a year only at the lower reaches by country boats. A barrage for Gumti medium irrigation project was constructed across river Gumti at Maharani in 1987. A study of the water level for the lean period conducted by the Brahmaputra Board for a distance of 10 km downstream of Maharani reveals that there is no significant change in the river level from pre-barrage to post-barrage condition.

**Titas River** is a river in south-eastern **Bangladesh**. It originates from the state of Tripura in **India**, and enters Bangladesh near Agartala (India) and Akhaura (Brahmanbaria District, Bangladesh). The length of the river is about 98 km. It falls into the **Meghna River** near Ashuganj.

Many legends about Titas and Meghna traverse from generation to generation in world's largest deltaic country Bangladesh. One such legend says that Titas is the daughter of Meghna, who has been carrying her progeny to the **Bay of Bengal** since time immemorial. Amazingly enough, the two streams never commingle, and they keep a conspicuous demarcation line between them. While many hydrographers attribute this phenomenon to the difference in water properties of the two rivers, the people cherish to think of them as mother-daughter.
The **Haora River** flows through the city of Agartala, it is the major river which flows in the Sadar subdivision of the West District of Tripura. It is called Saidra in Kokborok by the original inhabitants of the state.

**Origin of Saidra**

The Saidra or the Haora originates from the Baramura hills in central Tripura and flowing through the foothills passing through important towns like Champaknagar, Jirania, Khumulwng, Khayerpur and the capital city Agartala it goes to merge with the famous Padma river of Bangladesh crossing the international border.

The geophysical characteristics of each of these river systems shape the socio-economic characteristics of the regions through which they flow. Any change in the climatic characteristics of the river basins is likely to have a profound impact on the economic and social character of the region. In order to study the changing climate variability due to global warming and their possible socio-economic impacts, the present study concentrates on important Haora river basin in Agartala.

**5.3.1. Haora River Basin**

Haora is a small river having a length of 46 km within the State of Tripura from its source at Baramura hill range to Indo-Bangladesh border. Its catchment area is only 414 km² in the Indian Territory. After flowing through the Indian Territory it enters into Bangladesh nearing Agartala town and falls into river Titas. The river is over flooded during high spate
period while during winter the depth is very less. Occasional country boats are being pleyed in this river for fishing activity and for carrying wood products, bamboo etc.

The lower stretch of the Haora river between Bangladesh border near Agartala and Jirania (25 km) appears to be made navigable by undertaking certain river conservancy measures like dredging at least for 6-7 months in a year. The maximum and minimum discharge observed at Bardowali was 233.5 m$^3$/s and 0.435 m$^3$/s respectively. The depth in this river varies between 0.3 m to 1.5 m.

5.3.1.1. STUDY AREA

The Haora river basin is situated between latitude 23$^o$49’ N and 24$^o$25’ N and longitude 91$^0$10’E and 91$^0$46’E located in the eastern part of India at Tripura which is surrounded by Bangladesh on the West, South and North. Its North Eastern and Eastern boundaries are demarcated by Assam and Mizoram respectively. The total basin area of Haora river is 414 km$^2$ and length of the river is 25 km (as shown in Fig.5.6).
Fig. 5.6: Haora River Basin
5.3.1.2. Soil Condition

The basin has mainly sandy soils followed by clay i.e. 30 to 43%. It has been tested in the North East Soil Testing Laboratory at Agartala. The soil consists of reddish brown clayey silt having maximum silt content i.e. 48 to 51 % with a cover of alluvial deposit somewhere upto a depth of 6 m from ground level. The depth is between 6m to 15 m which consists of brownish sandy silt with presence of mica. The sand content is 91-97%. The soil textures profiles have been analyzed in the laboratory and are discussed in the Chapter 3.

5.3.1.3. Climate

The basin is characterized by humid sub-tropical climate with three distinct seasons such as summer, monsoon and winter. The climate warms up generally from the middle of March and this condition persists up to May. Generally the average maximum temperature is 37°C whereas average minimum temperature is 5°C. The average annual rainfall recorder is about 2543 mm. Humidity is generally high throughout the year. In the summer season, relative humidity is between 50 to 74% whereas in the rainy season it is over 85%.
5.3.1.4. Drainage

The flow in a river helps in dilution of effluents and in self purification. The drains are divided into three categories- high, medium and low. This is done to differentiate the different drains according to their dilution capacity which may be based on the flow characteristics in a particular river basin.

In Tripura, there are no rivers having high flow. The state is drained by as many as 10 rivers which originates in the hill ranges and flow either in a northerly or westerly direction through the narrow valleys. These rivers are Longi, Juri, Deo, Manu, Dhalai, Khowai, Haora, Gomti, Muhuri and Feny. However, all the rivers are rainfed and ephemeral in nature, their flow is directly related to rainfall.

5.3.2. Water Demand Scenario

Haora river is the lifeline of Agartala city because it fulfils the major demand of drinking water as well as water for other purposes for most of the population of Agartala city. It also fulfils the total demand of the families who reside near the banks of the river from Champaknagar to Bangladesh boarder area. Haora is one of the ten major rivers of Tripura. The river originating from the eastern side of the Baramura range flows Westerly through the alluvial plains and passes by the southern embankment of the capital city of Agartala before finally flowing down into Bangladesh. The flow length of the river is 50 km in Indian Territory and basin area is 414 Km². The annual flow of this river is 364
MCM out of which the monsoonal flow is 288 MCM. Agartala Municipal Corporation and Public Health Engineering Department uses the water of this river daily for community uses and for minor irrigation. The intake wells are situated near Badarghat and Collegetilla. The average annual surface water availability in the basin is approximately 317 MCM while the annual groundwater available is estimated at 341 MCM out of which the total utilisable groundwater resource is 334 MCM and domestic groundwater requirement is 24 MCM. The three water treatment plants namely Collegetilla, Badarghat and Jirania have already supplied the water to the community of 3 MGD, 4 MGD and 0.1 MGD respectively. The new water treatment plant is to be started with capacity of 0.55 MGD at Assam Para which is at Ranir Bazar.

The water demand from Champaknagar to Khyerpur in the upper basin of Haora river is 47.3425 MCM whereas the lower basin up to Agratala is 21.525 MCM by using the different specification of pumps as 35,000 m³/year/HP as shown in Table 5.1 and 5.2.
5.4. Water Quality Scenario

Water quality assessment is critical for pollution control and the protection of surface water and groundwater. Water quality rarely remains static, so quality data are needed specifically because

(a) Quality varies in space and time

(b) Waste loads vary at different points in the system.

(c) For effluent description

(d) For setting consents, mass balance calculation and river modeling

**Water Quality**

- Both surface water and ground water should be regularly monitored for quality. A phased programme should be undertaken for improvements in water quality.
- Effluents should be treated to acceptable levels and standards before discharging them into natural streams.
- Minimum flow should be ensured in the perennial streams for maintaining ecology and social considerations.
- Principle of ‘polluter pays’ should be followed in management of polluted water.
- Necessary legislation is to be made for preservation of existing water bodies by preventing encroachment and deterioration of water quality.
5.4.1. Surface Water Quality Scenario

Surface waters originate from a combination of sources:

- Surface run-off: rainfall which has fallen onto the surrounding land and that flows directly over the surface into the water body
- Direct precipitation: rainfall which falls directly into the water body
- Interflow: excess soil moisture which is constantly draining into the water body
- Water table discharge: where there is an aquifer below the water body and the water table is high enough, the water will discharge directly from the aquifer into the water body.

The quality of surface water depends on a climatic and geologic factor. However, in Haora river where the water is in a dynamic state of constant movement, the volume of water is very much dependent on the preceding weather conditions. Generally in rivers the flow is greater in the winter than the summer due to greater amount and longer duration of rainfall. Short fluctuations in flow, however, are more dependent on the geology of the catchments. In Haora river, turbidity is high ranges from 80 to 2400 NTU during entire period that may be caused by fine particles, both inorganic and organic in origin, which are too small to readily settle out of suspension and so the water becomes cloudy.
5.4.2. Ground Water Quality - Regional scenario:

Apart from collection and analysis of ground water samples as a part of various scientific studies and exploration of fresh water aquifers, ground water samples are collected once a year from the observation wells and analyzed to create a background database and assess regional ground water quality changes. Brief findings of these studies are as follows.

Ground water in most of the areas in the country is fresh. However, in some areas, ground water quality has been found to be contaminated due to hydrogeological reasons.

**Iron contamination in ground water**

High concentration of iron (in excess of 1 mg/l) in ground water has been observed in more than 1.1 lakh habitations in the country. In the eastern parts of Brahmaputra basin, the iron content is in the range of 0.4 to 4.0 mg/l while in the northwestern parts of the basin, iron is in the range of 0.3 to 3.0 mg/l in ground water. In Tripura, there is widespread occurrence of ground water with iron in the range of 0.3 to 1.2 mg/l.

| Fig.5.8 : Water samples collected from Haora river | Fig.5.9: Water quality scenario in Haora river basin |
The main factors affecting variation in quality for Haora River Basin are dilution, water temperature causing variation in biological activity and oxygen solubility and seasonal changes in waste inputs. The selection of parameters for water quality assessment is dependent on the type of receiving water, the nature of the discharges into the receiving water, water use and legal designation relating to the system. The key parameters for physico-chemical and biological assessment of a selection of different system and effluents are BOD, COD, DO, Turbidity, Temperature, pH, Ammonia Nitrogen, Nitrate, Phosphate, Sulphate, Chloride and Coliform and Faecal Coliform etc.
### Table 5.1: Scheme Status of Water Resource from Haora River Basin Champaknagar to Khayerpur (November to February and running times 15hr/day)

<table>
<thead>
<tr>
<th>SL NO.</th>
<th>Name of Scheme</th>
<th>River</th>
<th>Pump Set</th>
<th>Covered Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>L. I. Biswamani Para -I</td>
<td>Haora</td>
<td>3EX20HP</td>
<td>40</td>
</tr>
<tr>
<td>2.</td>
<td>L. I Biswamoni Para-II</td>
<td>Haora</td>
<td>1Ex20HP 1Ex25HP</td>
<td>40</td>
</tr>
<tr>
<td>3.</td>
<td>L. I. Chandra Sadhupara</td>
<td>Haora</td>
<td>2Ex20HP</td>
<td>15</td>
</tr>
<tr>
<td>4.</td>
<td>Purba Debendranagar</td>
<td>Haora</td>
<td>3EX20 HP</td>
<td>40</td>
</tr>
<tr>
<td>5.</td>
<td>Parchim Debendranagar</td>
<td>Haora</td>
<td>3E X 20 HP</td>
<td>40</td>
</tr>
<tr>
<td>6.</td>
<td>Jangalia</td>
<td>Haora</td>
<td>3E X 20 HP</td>
<td>40</td>
</tr>
<tr>
<td>7.</td>
<td>Rabi Charan Thkur Para</td>
<td>Haora</td>
<td>2E X 20 HP</td>
<td>35</td>
</tr>
<tr>
<td>8.</td>
<td>Kuthamara</td>
<td>Haora</td>
<td>3E X 20 HP</td>
<td>-</td>
</tr>
<tr>
<td>9.</td>
<td>Jirania Khala</td>
<td>Haora</td>
<td>2E X 20 HP</td>
<td>36</td>
</tr>
<tr>
<td>10.</td>
<td>Harinath Sardar Para</td>
<td>Haora</td>
<td>1E X 20 HP 1E X 25 HP 1E X 15 HP</td>
<td>37</td>
</tr>
<tr>
<td>11.</td>
<td>Jirania</td>
<td>Haora</td>
<td>1E X 25 HP 2E X 20 HP</td>
<td>45</td>
</tr>
<tr>
<td>12.</td>
<td>Barjala Binapani</td>
<td>Haora</td>
<td>2E X 25 HP</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Radhanagar Para</td>
<td>Haora</td>
<td>2E X 20 HP</td>
<td>35</td>
</tr>
<tr>
<td>14.</td>
<td>Radhamohan Para</td>
<td>Haora</td>
<td>2E X 20 HP 2E X 25 HP</td>
<td>53</td>
</tr>
<tr>
<td>15.</td>
<td>South Majlishpur</td>
<td>Haora</td>
<td>2E X 25 HP</td>
<td>30</td>
</tr>
<tr>
<td>16.</td>
<td>Dudpatil East</td>
<td>Haora</td>
<td>2E X 20 HP 2E X 25 HP</td>
<td>72</td>
</tr>
<tr>
<td>17.</td>
<td>Dudipatil West</td>
<td>Haora</td>
<td>3E X 20 HP 1E X 25 HP</td>
<td>48</td>
</tr>
<tr>
<td>18.</td>
<td>Ranir Goan</td>
<td>Haora</td>
<td>2E X 25 HP 3E X 20 HP</td>
<td>70</td>
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<td>19.</td>
<td>Purba Noagoan</td>
<td>Haora</td>
<td>2E X 25 HP 2E X 20 HP</td>
<td>47</td>
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<tr>
<td>20.</td>
<td>Pachim Noagoan</td>
<td>Haora</td>
<td>2E X 20 HP</td>
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<td>21.</td>
<td>Assam Para</td>
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<td>40</td>
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<td>22.</td>
<td>Madhya Assam Para</td>
<td>Haora</td>
<td>2E X 20 HP</td>
<td>40</td>
</tr>
<tr>
<td>23.</td>
<td>Deota Bari</td>
<td>Haora</td>
<td>2E X 20 HP</td>
<td>35</td>
</tr>
<tr>
<td>24.</td>
<td>Balda Khal</td>
<td>Haora</td>
<td>2E X 20 HP</td>
<td>35</td>
</tr>
</tbody>
</table>

**Total No. of pumps = 1355 HP**

**Water Demand for upper Haora river = 1355 X 35000 m³/year**

= 47425000 m³/year

= 47.425 MCM/year
Table 5.2: Scheme Status of Water Resource from Lower Haora River
Khayerpur to Bangladesh Border
(November to February and running times 15hr/day)

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Name of Scheme</th>
<th>Length of pipe line</th>
<th>Pump &amp; Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>L.I. Scheme at Kashipur</td>
<td>3300</td>
<td>2×20H.P.</td>
</tr>
<tr>
<td>2.</td>
<td>L.I. Scheme at Rajdhar Nagar</td>
<td>0.00</td>
<td>2×20H.P.</td>
</tr>
<tr>
<td>3.</td>
<td>L.I. Scheme at Ichamuya-I</td>
<td>3220</td>
<td>3×20H.P.</td>
</tr>
<tr>
<td>4.</td>
<td>L.I. Scheme at Ichamuya-II</td>
<td>4880</td>
<td>2×20H.P.</td>
</tr>
<tr>
<td>5.</td>
<td>L. I. Scheme at Rajnagar-I</td>
<td>5000</td>
<td>3×25H.P. 1×20H.P.</td>
</tr>
<tr>
<td>6.</td>
<td>L. I. Scheme at Rajnagar-II</td>
<td>2000</td>
<td>2×20H.P.</td>
</tr>
<tr>
<td>7.</td>
<td>L. I. Scheme at Joypur</td>
<td>5000</td>
<td>2×25H.P. 2×20H.P.</td>
</tr>
<tr>
<td>8.</td>
<td>Diversion Scheme at Debtachera</td>
<td>800</td>
<td>B.L.C</td>
</tr>
<tr>
<td>9.</td>
<td>L. I. Scheme at Gajaria</td>
<td>5500</td>
<td>2×25H.P. 2×20H.P.</td>
</tr>
<tr>
<td>10.</td>
<td>L. I. Scheme at Dukli-I</td>
<td>2000</td>
<td>3×20H.P.</td>
</tr>
<tr>
<td>11.</td>
<td>L. I. Scheme at Dukli-II</td>
<td>2000</td>
<td>3×20H.P.</td>
</tr>
</tbody>
</table>

**Total no. of pumps = 615 (in H.P),**

**Water Demand in lower Haora = 615 X 35000 m³/year = 21525000 m³/year**

= 21.525 MCM