Chapter 1

Introduction

For centuries Bengalis have called their homeland Bangladesh (= land of the Bengalis). In the cultural context, this homeland stretches from Purulia (West Bengal : India) in the west to Cachar (Assam : India) in the east. Politically, however, it is fragmented between various Indian states and the People's Republic of Bangladesh.

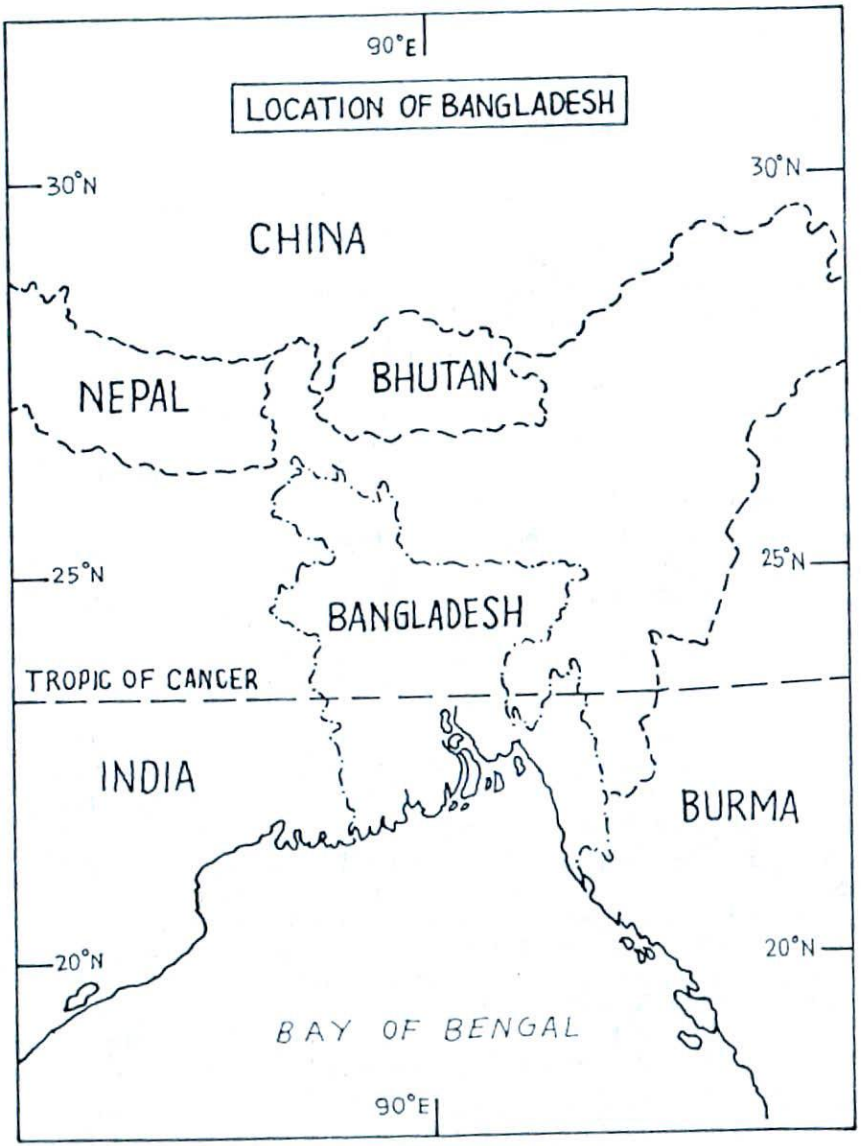
In this book we are concerned only with the People's Republic. It is a political creation, since its boundaries do not coincide with cultural or physical regions. However, it is the core of cultural Bangladesh, and being an independent country, it does form an economic region. To avoid confusion we will refer to cultural Bangladesh as Bengal, using the term Bangladesh only for the People's Republic.

Bengal is a transition zone between Southwest and Southeast Asia. Arabian, Persian and Turkish influences are noticeable in religious architecture, some art forms, ceremonial food, some of the clothing and in many words of the Bengali vocabulary. On the other hand, in common with Southeast Asia, rice and fish are the staple diet, betelnut and betel-leaf chewing is very common, the *lungi* (sarong) is the main dress for men, and there are similarities in the way many tropical articles, such as those made with bamboo, are used. Bengal belongs naturally more to humid, tropical Southeast Asia than to the very alien, arid western parts of Asia. The western orientation is due to centuries of immigration, reinforced by the conversion of the majority of the people to Islam.

Bengal forms the capstone of the arch formed by the Bay of Bengal, and because of the Tibetan massif to the north, it is a comparatively narrow land-bridge between the subcontinent of India and the subcontinent of Southeast Asia. It has, therefore, a strategic position in South Asia. More precisely, the People's Republic of Bangladesh stretches latitudinally between 20°34'N and 26°33'N, and longitudinally between 88°01'E and 92°41'E. It is one of the most crowded rural areas in the world, with 112 million people (1990) within only 143,999 sq. km.

Some of the biggest rivers in the world flow through the country and form the largest delta in the world. The Ganges-Brahmaputra river system forms in the Bengal Basin, a delta of 40,225 sq. km. extent. It is therefore quite obvious that the monsoon rains, the rise and fall of river levels, floods, alluvion and diluvion and changes in river courses form the substance of both cultural and physical geography of the area.

Map 1.1


90°E
LOCATION OF BANGLADESH
30°N
30°N
CHINA
NEPAL
BHUTAN
25°N
25°N
BANGLADESH
TROPIC OF CANCER
INDIA
BURMA
20°N
20°N
BAY OF BENGAL
90°E

Till early 1984, there used to be only 20 major administrative units known as Districts (Bengali = *Zila*). The Districts were divided into Sub-divisions (Bengali = *Mahakuma*). The next lower level of administration used to be the *Thana*, averaging about 256 sqkm. (100 sqm) in most districts. In 1983, the *Thanas* were renamed as *Upazilas* and a large number of new Upazilas were created by splitting one or more of the old ones. In mid-1985 there were 495 Upazilas. By February 1984, all Sub-divisions were upgraded to district level, so that by mid-1984 the number of districts had increased to 64. For revenue administration purpose there are 60,315 units known as *Mouza*, which contain the 85,650 villages of the country. For spatial distributions, Upazilas have been referred to frequently since they are the smallest unit which can be conveniently used in a statistical description of distribution. For political and administrative purposes each Upazila has several smaller units known as Union. In mid-1990 there were 4,401 Unions in Bangladesh.

Bangladesh is often treated as composed of four major regions : Northern, Southern, Central and Eastern. The Northern Region is the Ganges-Brahmaputra paradelta, and coincides with historical Varendra. The Southern Region lies between the Hoogly river and the Podda-Meghna. It coincides with historical Vanga, which gave its name to the whole country. The Central Region is between the Brahmaputra-Jamuna and the Surma-Meghna. It does not coincide with any of the historical regions, but may have been divided between Varendra and Samatata. The Eastern Region is the whole belt east of the Surma-Meghna rivers and to a large extent comprises of historical Samatata. These Regions are based primarily on the division of the country by the major rivers, but have also some basis in historical background.

The modern geographical study of Bengal may be said to have begun with James Renell's "Memoirs of a Map of Hindoostan" (Rennell 1792). However, almost a century passed before a properly compiled, statistically substantiated, detailed account of Bengal was published, in eight volumes, by W.W. Hunter (1875-77). This invaluable work has earned Hunter the right to be considered the first regional and historical geographer of modern Bengal. His big storehouse of information was generously mined when the Bengal District Gazzetteers were written between 1905 and 1925. These small Gazzetteers, in their turn, greatly added to the knowledge of the economy and industry of the people. The Gazzetteers of Jessore, Pabna and Rajshahi are outstanding in this respect. All three were written by L.S.S.O'Malley, whose contributions to human and historical geography of Bengal are important.

Census Reports are available for every decade from 1872 to 1981. Few places outside Europe and North America have such complete census records for over a century. These decennial reports contain not

only a survey of the human population, but in some instances accounts of livestock, handlooms, wells and tanks, boats, village markets, etc.

There has been a wealth of publications with geographical information by Government agencies and various consulting firms. Much of this rich source is not readily available. It is regrettable that a properly classified collection of these Feasibility Reports, Commission Reports, Surveys and Censuses are not available, even to those in the Government. This illustrates the difficulty of doing research in Bangladesh. Some of the main sources of research material are the libraries of the District Collectorates, the Secretariat in Dhaka, the Government Colleges in Dhaka, Chittagong and Rajshahi, the Murarichand College in Sylhet, the Carmichael College in Rangpur, the Universities of Dhaka and Rajshahi, and the Departments of Geography in Dhaka and Jahangirnagar Universities. Department of Geography of Dhaka University has the only collection of cadastral maps accessible to all research students. Their publication, the Oriental Geographer, is also a valuable source material.

Maps are usually very difficult to obtain. The Directorate of Land Records publishes a large number of village, upazila and mouza maps. They are useful for the study of land fragmentation, village groupings etc. The Survey of Bangladesh publishes topographical maps in various scales up to 1 : 15,840, but these most essential aids are very restricted in use, apparently for security reasons. A good set of maps of Bangladesh was published in December, 1971 by the World Bank. These were probably the first maps of the newly liberated Republic, and contained information on land use never previously published. A great amount of information about the country is now being gathered by SPARRSO through satellite imagery. It is a path-breaking method of cartography and resource inventory.

Despite the considerable amount of research material available in books, maps and other publications, so much of the country remains vaguely known, even to the development planner, that there is no substitute for actual travel to the areas being studied. Even satellite imagery needs 'ground truthing'. Most areas are difficult of access. Travel by four-wheeled vehicle or by boat is essential if any detailed study is to be made. Bullock carts and cycles have to be used frequently and walking is the only possibility in many areas.

Needless to say the scope for further research into every aspect of geography is very considerable. Statistics are often unreliable or misleading. A visit to the spot clarifies many things. The geographers and the development planners (and that includes development economists too) would be well advised not only to make full use of the printed material, but also to go out and see for themselves whether their plans and projects come close to the realities of the situation.

Chapter 2

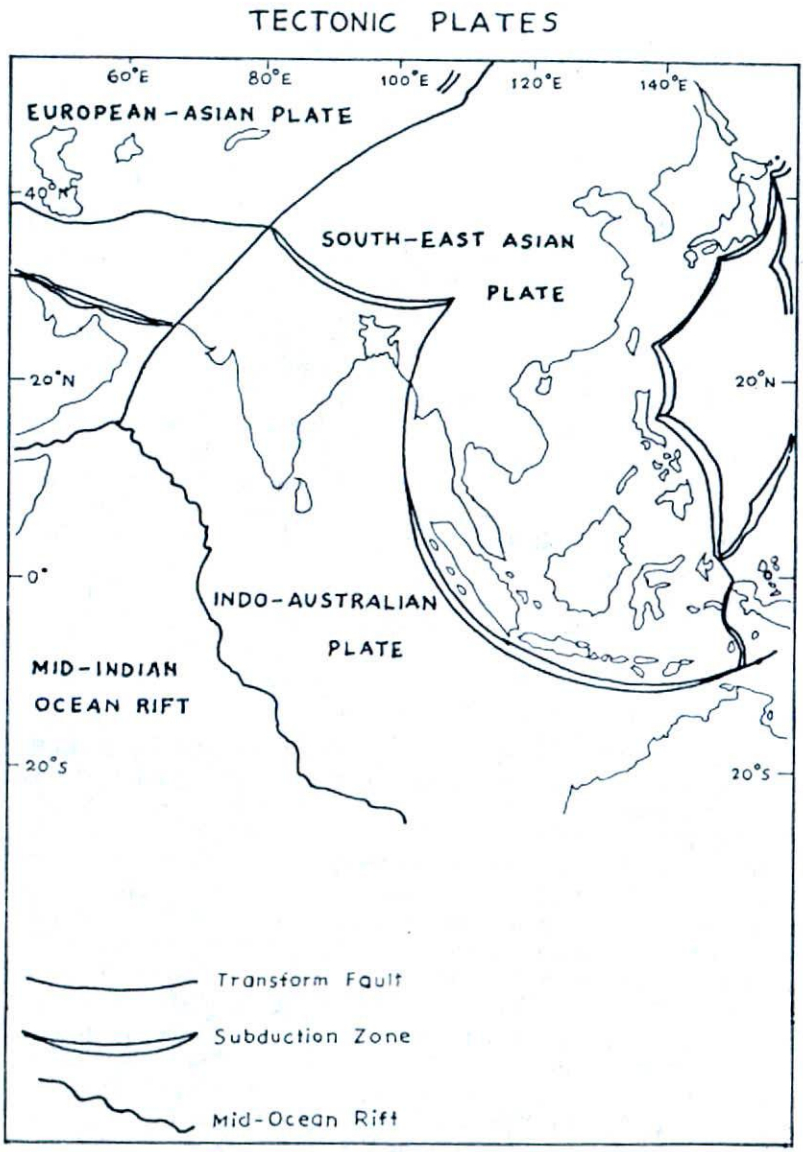
Physical Features

GEOLOGICAL BASIS

It is only within the last thirty years that a considerable amount of data essentially supporting Wegener's theory of the movement of the continents has been collected. The crust of the earth, according to the recently developed theory of plate tectonics, is thought to be divided into a number of plates, each of which is considered to behave as a relatively rigid unit (Clark 1971). These plates shift due to sea-floor spreading and subduction. It now seems that the continental masses collected together, broke up and re-formed several times during the four and a half billion years of earth history. In the early Triassic Period (225 to 190 million years ago) most of the earth's land formed a single continental mass, called Pangaea, and was surrounded by one ocean, called Panthalassa. The latest continental break up occurred about 200 million years ago (Gordon 1972), and the plates began moving in different directions. Pangaea split first into two masses, known as Laurasia and Gondwana. Laurasia later broke into three, the western-most forming North America and the eastern two forming most of the Asian-European land-mass. Most of the Asian mass, it is postulated, was carried on two plates, the Eurasian and the East Asian.

In the Jurassic Period (194 to 136 million years ago), the Indian portion of the Gondwana mass split off and began moving north towards Asia. The Indian and Australian portion of Gondwana were believed to be on the same plate, known as the Indo-Australian plate. However the movement in different directions of the two portions, and the obvious split in the plate along the 90 degree east longitude, makes it certain that the Indian and Australian portions are on separate plates since Late Cretaceous (circa 65-75 million years ago) (Molnar and Tapponier 1975; Carey 1976; Irving 1977; Norton and Sclater 1979). The Indian portion of the Gondwana moved north relatively fast and collided with the European-Asian (Hercynian) and East Asian (Cathaysian) plates in the Eocene period (54 to 38 million years ago). This collision was on such a tremendous scale that the Indian plate moved some 2000 km into the Cathaysian plate, which resulted in the uplift of the Himalayan System and the large Tibetan (Qinghai-Xizang) plateau, and very considerable faulting in China (Mattauer *et.al.* 1981). The Indian plate is subducted under the East

Map 2.1


TECTONIC PLATES
60°E
80°E
100°E
120°E
140°E
EUROPEAN-ASIAN PLATE
40°N
SOUTH-EAST ASIAN
PLATE
20°N
20°N
0°
INDO-AUSTRALIAN
PLATE
MID-INDIAN
OCEAN RIFT
20°S
20°S
Transform Fault
Subduction Zone
Mid-Ocean Rift

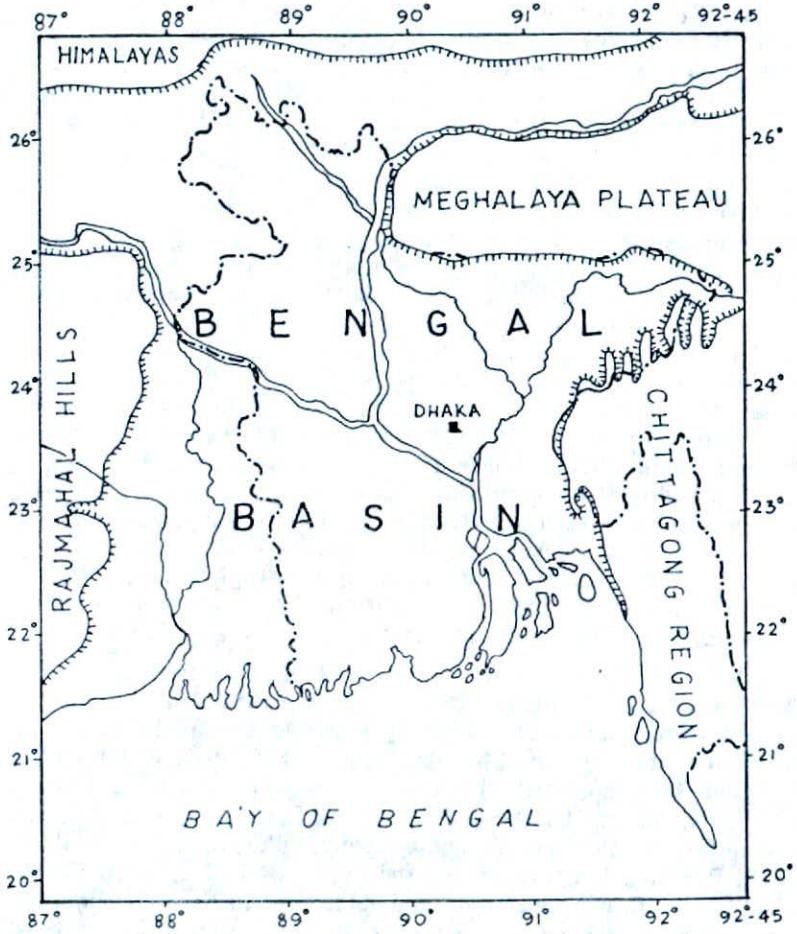
Asian plate along the line of the Himalayas, but under the Arakan Yomas the two plates are rubbing against each other along a transform fault (Map 2.1).

In the Oligocene Period (38 to 26 million years ago), some time after the plates collided, a portion of the northeastern part of India fractured and sank below sea-level. This portion was gradually filled up to form the eastern part of the Bengal Basin (Map 2.2). The Gondwana rocks are close to the present surface of the land roughly west of a line drawn from Jamalpur to Kushtia. East of this line the sediments are very deep since they were formed on the Gondwana Tethys sea, which filled up only in the Tertiary era (6.5 to 1 million years ago) (Wen Shi-xuan 1981). Bangladesh is therefore formed on a mass of sediments underlain by the very old rocks of the Gondwana continent. On two sides of the Bengal Basin the old rocks crop up, in the east as the Meghalaya plateau and in the west as the Chhota Nagpur plateau. The narrow part of the Basin, in-between these two plateaux, is known as the Garo-Rajmahal gap. Along the line of this gap the old base rocks come closest to the surface in Dinajpur, Rangpur and Naogaon districts of Bangladesh. Due to its position, with one of the world's major subduction faults in the north and a major transform fault in the east, the Bengal Basin and its adjacent area is an active tectonic region. Large areas within Bangladesh have been uplifted in recent times and some areas are still sinking. It has been postulated that these tectonics may be due to the presence of a major fault at depth or a subsiding trough along the axis of the Jamuna-Podda-Meghna river system (Morgan and McIntire 1959). This subsiding structural zone may be the foredeep of the transform fault in the east.

The Bengal Basin has been filled by sediments washed down from the highlands on three sides of it, and especially from the Himalayas, where the slopes are steeper and the rocks less consolidated. The greater part of this land-building process must have been due to the Ganges and Brahmaputra rivers. The origin of the Ganges and Indus rivers is much debated. On the evidence of the Siwalik deposits (between 1 to 12 million years old) in the Indo-Gangetic Valley, E.H. Pascoe (1919) and G.E. Pilgrim (1919) advanced the hypothesis of an Indo-Brahm or Siwalik river flowing westward and southward to Sind and draining the vast plains. Post-Siwalik movements are said to have dismembered this river, which broke up into the Indus, Ganges and Brahmaputra. The latter two reversed their flow and found a new course to the sea through the Garo-Rajmahal gap. This theory has been challenged (Krishnan & Aiyengar : 1940), but not seriously shaken. If accepted, it means that much of the Bengal Basin formed on the reversal of the Indo-Brahm in the late Pliocene period (7 to 25 million years ago). The hills to the east—mostly the outer ranges of the Arakan Yomas—date from the middle Miocene to the Pleistocene. In this latter period much

Map 2.2

BENGAL BASIN



of the Bengal Basin was complete : large sections of the early deposits remain as the Barind Tract of the Northern Region and the Madhupur Tract of the Central Region. There are other scattered remnants such as the Tripura Hills Piedmont. Much of the Pleistocene deposits have either been eroded away or have sunk below recent alluvial deposits, which cover three-fourths of Bangladesh. Most of the deltaic southern part of the Bengal Basin is probably not more than 10,000 years old.

PHYSIOGRAPHIC SUB - REGIONS

Spate (1954) outlined five physiographic sub-regions in the Bengal Basin. Of these, three only (II, III and V) fall in Bangladesh. He further sub-divided the Delta (V) into three parts—Moribund, Mature and Active. His outline regions were elaborated upon by Johnson (1957), who divided Bangladesh into five regions, with twelve sub-divisions. The hillocks and mountains of Sylhet district and the Chittagong region were left out completely. He recognised the individuality of what he named the Noakhali-Tippera Clay Plain, which was changed to the Tippera Surface by Morgan and McIntire (1959). Johnson's map, however, contains several inaccuracies, especially in the distribution of the Barind and the lowlands to its south and south-east. Morgan and McIntire brought out the fourfold division of the Barind and the Piedmont nature of the alluvial plains to the north. The divisions and sub-divisions listed below are an attempt to refine the previous attempts. They are based mainly on topographical features, and partly on considerations of drainage patterns, soil associations, morphologies and land use patterns. As more information is gathered and analyzed the physiographic units will no doubt be even more clearly delineated.

Bangladesh can be divided into the following twenty-four sub-regions, with fifty-four units on the basis of physical features and drainage pattern (Map 2.3) :

I. Himalayan Piedmont Plains ;

II. Tista Floodplain ;

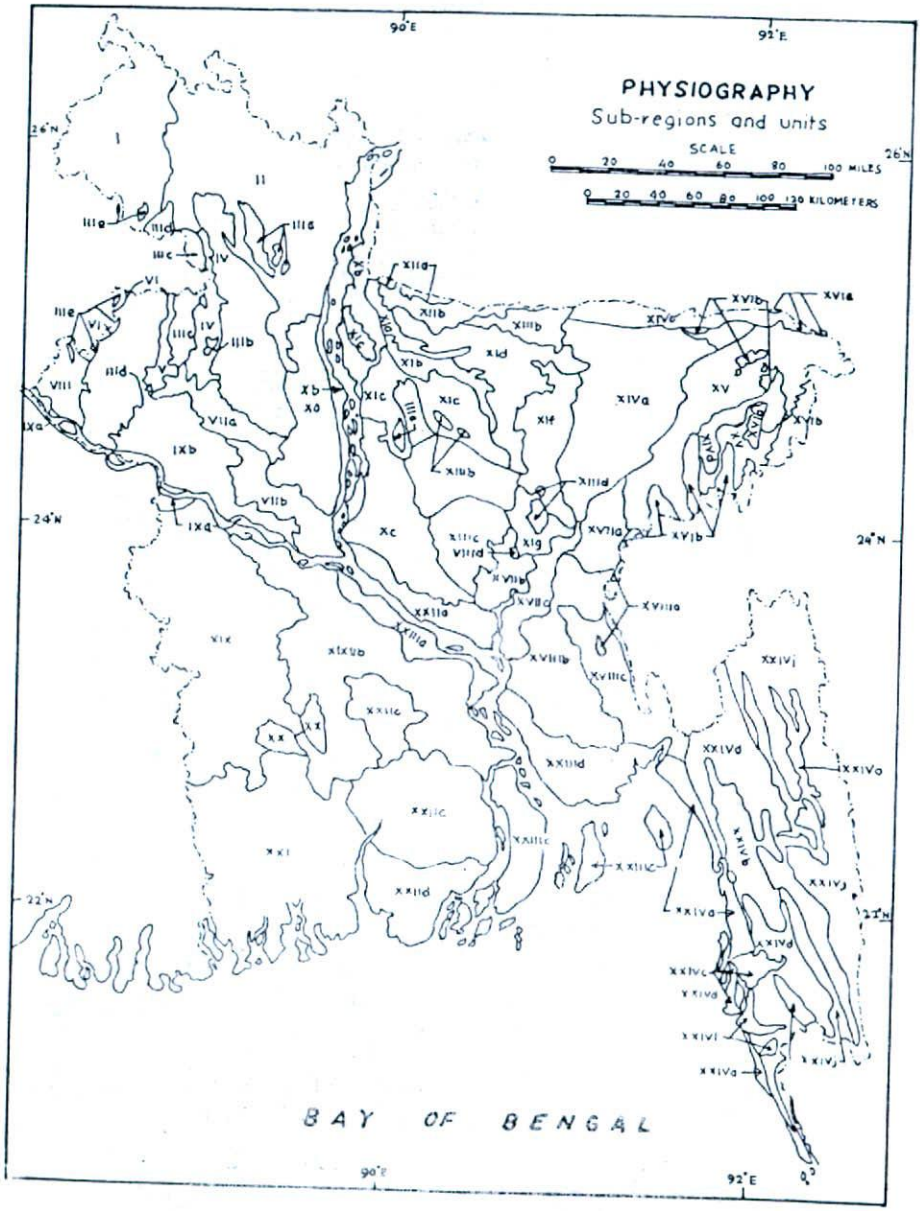
III. Barind Tract :
- (a) North-eastern Outliers
- (b) Eastern Barind
- (c) East-central Barind
- (d) West-central Barind
- (e) Western Barind

IV. Little Jamuna Floodplain ;

V. Middle Atrai Floodplain ;

VI. Lower Purnabhaba Valley ;

Map 2.3


PHYSIOGRAPHY
Sub-regions and units
SCALE
0 20 40 60 80 100 MILES
0 20 40 60 80 100 120 KILOMETERS
90°E
92°E
26°N
24°N
22°N
BAY OF BENGAL

VII. Lower Atrai Basin : (a) Western
(b) Eastern

VIII. Lower Mahananda Floodplain :

IX. Ganges Floodplain :
(a) Diaras and Chars;
(b) North Ganges old floodplain

X. Brahmaputra-Jamuna Floodplain :
(a) Bangali - Karatoa floodplain;
(b) Diaras and Chars,
(c) Jamuna - Kaliganga floodplain;

XI. Old Brahmaputra Floodplain :
(a) High ridges
(b) Floodplain complex
(c) Western plain
(d) Northern plain
(e) Southern plain
(f) Eastern plain
(g) South eastern plain

XII. Susang Hills and Piedmont :
(a) Susang hills
(b) Piedmont plains

XIII. Madhupur Tract :
(a) Northern tract
(b) Central tract
(c) Southern tract
(d) Eastern tract

XIV. Haor Basin :
(a) Central basin
(b) Susang Piedmont basins
(c) Meghalaya Piedmont depression
(d) Central Sylhet lowland

XV. Sylhet High Plains ;

XVI. Sylhet Hills :
(a) Meghalaya foot - hills
(b) Tila ranges

XVII. Meghna Floodplain :
(a) Titas basin
(b) Meghna - Lakkha Doab
(c) Middle Meghna floodplain

XVIII. Tippera Surface :
(a) Eastern Piedmont strip and Lalmai range
(b) Low floodplain
(c) High floodplain

XIX. Moribund Delta :

XX. Central Delta Basins :

XXI. Immature Delta :

XXII. Mature Delta :

(a) Old Ganges floodplain
(b) Podda - Madhumati floodplain
(c) Non - saline tidal floodplain
(d) Saline tidal floodplain

XXIII. Active Delta :

(a) Active Podda floodplain
(b) Mehendiganj islands
(c) Meghna estuary islands and Chars
(d) Meghna estuarine floodplain

XXIV. Chittagong Sub-Region :

(a) Northern coastal plains
(b) Central valley
(c) Matamori delta and coastal islands
(d) Western hills
(e) Middle Karnafuli system valleys
(f) Bakkhali river valley
(g) Southern beach plain
(h) Nhila - Teknaf plains
(i) Jinjira islets and reefs
(j) Mountain ranges and eastern hills

I. *Himalayan Piedmont Plains*

These plains, rolling in parts, are the alluvial cones of the many rivers issuing from the terai region at the foot of the Himalayan ranges. The interflows of the rivers are slightly dome shaped. This sub-region is bounded by the Mahananda river in the west and Dinajpur-Karatoa in the east. In the north, it merges with the sub-montane terai, known here as the Duars (Spate's Region 1). The rivers in this sub-region are entrenched in the recent alluvial deposits, mostly sandy silt. They flow towards the south, for the land slopes from a height of 97m[1] at Tetulia Upazila to 34m. at Dinajpur. The gradient is considerable, being 0.91 m. per km. In the south, deposits overlie the pleistocene clays of the Barind Tract. The plain is undulating in parts being most marked on either bank of the Kulik river.

II *Tista Floodplain*

This big sub-region stretches from the high sandy levees of the Dinajpur-Karatoa to the right bank of the Brahmaputra. In the south a long outlier

1. All heights, unless otherwise mentioned, are above mean sea-level, as calculated in the General Triangulation Survey (G.T.S.).

reaches down to Sherpur (Bogra) along the course of the ancient Tista. The relief is that of medium level ridges and shallow basins. Most of the land is shallowly flooded. There is a slight depression along the Ghaghat river, where flooding is of medium depth. The big river courses of the Tista, the Dharla and the Dudkumar cut through the plain. The active floodplain of these rivers, with their sandbanks and diaras, is usually less than six kilometres wide."

III. *Barind Tract*

The Barind Tract is one of the several terraces of Pleistocene age within the Bengal Basin. The contours of the tract suggest that there may be two terrace levels - one at 39.7m and the other between 19.8 and 22.9m. It is cut through by several rivers, of which three have carved valleys wide enough to separate it into four parts. This tract is characterised by its comparatively high elevation, reddish and yellowish clay soils (Khiyar in local terminology), entrenched dedritic stream pattern and a relative paucity of vegetation.

(a) *North-eastern Outliers* : Three separate sections of the Barind Tract are surrounded by Tista deposits. These outliers differ from the main tract in having deep red-brown soils. The relief is that of an almost level highland, except around Ahshula Bil, where it is irregular. The sharp edges of parts of these outliers suggests some block faulting.

(b) *Eastern Barind* : In the north, the eastern and east-central parts of the Barind are nearly joined together, for the dividing line between them, the Western Jamuna river is very narrow from Hili northwards. From this place southwards, the valley of this river is much wider. In the north this part of the Barind extends up to Darwani and Badarganj. The north-eastern boundary is roughly a line drawn from a point between Badarganj and Shampur to Gobindaganj. From there, the tract is bounded on the east by the Bogra-Karatoa river down to Taras Upazila. The southern margin cuts to the north-west till the Western Jamuna river. The area thus enclosed is roughly 1930.90 km. and cover the whole or parts of the Upazila of Taras, Singra, Nandigram, Raninagar, Adamdighi, Kahaloo, Khetlal, Sherpur, Bogra, Dupchanchia, Shibganj, Panchbibi, Joypurhat, Gobindaganj, Palashbari, Pirganj, Mithapukar, Badarganj, Saidpur, Parbatipur, Nawabganj (R), Ghoraghat and Hakimpur. This part of the Barind is mainly a level plain, with few undulations. One portion of this terrace in the north-east is cut off from the rest by the Karatoa fault. The height of the plain varies because of two faults. The northern one is over 65 km. long, in a northwest to southeast direction, and upthrown to the southwest by about 5m. This has greatly affected the Karatoa river, which used to flow in a north-south direction across the present fault, down to the

Hurasagar river in Pabna district. In 1820, during a big flood, this river broke through to the Bangali river by the narrow Katakhali channel (Gupta 1910) and the portion below Gobindaganj has since then progressively dried up. The flood alone could not have changed the course so suddenly; the existence of the Karatoa fault confirms that there were tectonic movements which favoured the sudden shift of the channel. This fault was probably the result of the 1812 earthquake, for Buchanan-Hamilton wrote that even in 1810 the Karatoa was 'a very considerable river' (Buchanan-Hamilton 1833). Another fault, 16 km. long, is 16 km. to the north-west of Bogra town. Its direction is east-west and it is upthrown to the south. This has resulted in the drying up of the source of the Nagor river. There are moreover, two other fault traces to the south-west of this portion of the tract. The height of this block varies from 36 m. near Parbatipur to about 28 m. in the south.

(c) *The East-Central Barind* : The East-central Barind is narrowest of the four parts, being only twelve kilometers in average width. Its length is 97 km. from Chirirbandar Upazila to Mahadebpur Upazila. Out of its 676 sq. km. about 507 sq. km. are in Bangladesh. Between Chirirbandar and Parbatipur in Dinajpur District. There is no distinct break between II (a) and II (c); the tiny western Jamuna in its upper reaches is the partition. The whole of the western side of this section of the Barind is bounded by the Atrai river valley. In the south, it ends abrupily in the low Bhar Basin. Between Parbatipur and Chirirbandar in the north, the height is 39m. There are some undulations in this stretch of the Barind. The stream pattern is entrenched dendritic, as in all these raised terraces of Pleistocene alluvium. A 32 km. long fault can be traced north-west to south-east across the centre of this part of the terrace. It is upthrown to the south-west.

(d) *West-Central Barind* : This large section of the terrace is 145 km. long, and varies from 16 km. to 37 km. in breadth. About 1770 sq. km. of it is in Bangladesh. It slopes up through the recent alluvial deposits of the Piedmont plains just south of Dinajpur, and continues in an unbroken mass to the Ganges river, where it appears as a stiff high northern (left) bank for about eight kilometers. A bit of it appears east of Dinajpur town between the Kankra and Atrai rivers. This part of the terrace covers almost the whole of Godagari, Tanor, Niamatpur, Nachole and Porsha Upazila, and parts of Dinajpur, Mahadebpur, Gomastapur, Chapai-Nawabganj and Paba Upazilas. Its northern end is flat and so is the north-eastern margin for about ten kilometers. The rest of it is undulating and broken up by many gullies (known as Khary). These undulations reach their maximum in the centre, near Porsha, where elevations of over 19m. are common. The simulation of hill scenery is enhanced by the entrenched streams which have cut deep. Undulations of similar amplitude continue south to the Ganges. The level of the northern end is about 31m. it gradually goes up to a maximum of 46m.

in the centre and then slopes down to 36m. at Mahadebpur in the south-west. West to east also, this section is slightly dome-shaped, with the west tilted higher. The southern half of this part of the Barind is locally called Katal, which means 'thorn jungle'. Distinction is sometimes made between the flat and the undulating part of the terrace, the former areas being Khiyar and the latter Barind. Sometimes only the central part of this west-central part is referred to as the 'true' Barind. The Sanskrit name Varendra (Borendro in Bengali) has, however, always referred to the whole of this distinct group of older alluvial deposits. Barind, therefore, refers to all parts of this terrace. Khiyar refers to a type of soil and should not be confused with Barind, which is the name of a tract of land.

(e) *Western Barind :* Four small sections (in all comprising 81 sq. km.) of the Western Barind projects into Bangladesh, in Gomastapur and Porsha Upazila, along the Purnabhaba and Tangon rivers. Though the Tangon does form a small part of the boundary between India and Bangladesh, its valley ends in the Mahananda river flood-plain within India.

IV. *Little Jamuna Floodplain*

The Little Jamuna was once a large river, being one of the former channels of the Tista. Its valley is very narrow in Dinajpur district, but south of Hili it is from 8 to 16 km. wide. The recent alluvial soil is a greyish sandy-silt and greatly contrasts with the clays of the Barind. It is 3 to 5m. thick, underneath which the reddish clays appear. The valley terminates in the Bils (depressions, mostly water filled) in south Naogaon Upazila. It covers all, or parts of Upazila Phulbari, Joypurhat, Panchbibi, Adamdighi, Dhamoirhat, Patnitola, Badalgachhi, Mahadebpur and Naogaon. It reaches its widest extent in Badalgachhi, Joypurhat and Panchbibi Upazila. In Naogaon it covers only the northern half. In the other Upazila, it covers only a strip to the east or west. Part of the valley is in India. The area of the valley is about 644 sq. km. of which 531 sq. km. is in Bangladesh.

V. *Middle Atrai Floodplain*

This is a 81 km. long valley stretching from Chirirbandar to Mahadebpur, with the Barind Tract rising on both sides. Only half of the valley is in Bangladesh. The relief is that of low ridges and shallow basins. The ridges usually remain above flood level, but the lower areas are subject to flash floods. The river is to some extent entrenched, its bed being the Khiyar soil of the Barind. Flash floods bring down considerable amounts of sand and much of the floodplain has sandy soils.

VI. *Lower Purnabhaba Valley*

This valley, separating the West-central Barind from the Western Barind begins 26 km. south of Dinajpur town, in Indian Dinajpur district. It ends at Rohanpur in Gomastapur Upazila where the Purnabhaba river joins the Mahananda river. It is 81 km. long and 3 to 8 km. broad. The Barind on either side of it is higher than the terraces to the east, with the result that this valley looks more entrenched than the Atrai valley. Locally the valley is known as Duba, i.e., swampy. Near Porsha, there is a re-entrant into the East-central Barind, occupied by the Bara Mirzapur or Jabai Bill. Due to imperfect drainage this valley is not so fertile as those to the east of it.

VII. *Lower Atrai (Bhar) Basin*

Strictly speaking the Bhar (which means 'lowland') is the very low land in Atrai Upazila. This basin is sometimes also called the Chalan Bil Depression. It is now generally referred to as the Lower Atrai Basin in the growing literature on floods and water ressurces.

This basin or depression has its 40 km. long base along the eastern side of the West-central Barind, and its apex is nearly 161 km. away where the Hurasagar river flows into the Jamuna river. This 3120 sq. km. basin can be divided into two parts on the basis of their relative height, and thus the normal depth to which they are inundated. The area is covered during the rainy season (June to October) by a sheet of water, varying from 0.61 to 3.7m. in depth. It does not look like a lake however, for it is dotted with homesteads on raised mounds, and covered with long-stemmed rice or reeds and grasses.

(a) *Western* : The drainage of its western half collects around the large Chalan Bil, from where it passes through the broad sheet of water, known as the Failam, into several other water bodies and finally flows into the Jamuna river through the Hurasagar river (Chapter 3 : Hydrography). Much of this basin is silting up, for here the many north-south streams coming through the Barind are checked and turned south-east. Due to the rapid change in course, these rivers and streams deposit much of their silt here, and as they choke, they change course only to silt up elsewhere. The continual changing of these water courses and their consequent silt deposits is raising the level of the basin slowly. This part of the basin floods deeply and often quickly. Near Manda, where the Atrai turns towards the south-east, there is an area of very irregular relief, with almost circular, deep basins. The soil here is mainly clay.

(b) *Eastern :* This part of the basin has more ridges. However, most of the land is deeply flooded in the rainy season. There is some influx of water from the Ganges when it is in flood. Lower areas drain slowly in the dry season.

VIII. *Lower Mahananda Floodplain*

The Mahananda river forms the western boundary of Bangladesh in two places along the Piedmont Plain in Dinajpur district. Further south, it flows along the northern side of Bholahat Upazila and enters Bangladesh in Gomastapur Upazila and winding through Chapai-Nawabganj district, it falls into the Ganges south of Chapai-Nawabganj town. The course below Chapai-Nawabganj is in the Ganges floodplain. Above it, the Mahananda floodplain varies in breadth from 8 to 11 km. west of the river and 1.60 to 5 km. east of it. This 402 sq. km. floodplain lies between the Barind and the Ganges floodplain. The river is slightly entrenched.

IX. *Ganges Floodplain*

Throughout this work that stretch of the Ganges river, below its confluence with the Brahmaputra, is referred to as Podda, as is the practice in Bengal. Moreover those areas which could be included in the floodplain but are better treated as part of the delta, XVI(a) and XVII (a), have been left out.

(a) *Diaras and Chars :* By *Diara*, generally means, the low bank of a river. Here it is used for any alluvial accretion on the banks of any water body. *Char*, usually means, any accretion in a river. Here it is used only for islets in the rivers. In such a large river as the Ganges, Diaras and Chars are plentiful. These accretions are, however very rarely permanent, for courses of rivers in low alluvial plains are very liable to shift across their flood-plains. These Diaras and Chars often first appear as thin slivers of sand. On this is deposited layers of silt till a low bank is consolidated. Tamarisk bushes, a spiny grass, establish a foot-hold and accelerates deposition. The people from either bank settle these accretions as soon as the river recedes in winter; the river flows being considerably seasonal. For several years the Diara or Char may be cultivable only in winter, till with a fresh flood either the level is raised above the normal flood level or the accretion is diluvated completely. Certain Chars and Diaras appear very substantial while others appear to be mere sand or mud-banks. Some are very flat, while others are undulating. There are three types of these accretions, according to the principal composition of their soil. The clay or mud Chars and Diaras are not easily cultivated, so they are generally used as pastures during winter. The sandy Chars and Diaras

are infertile, but landless cultivators often try to raise a millet or pulse crop on them. These are also favoured for pastures. Those with silty soils are obviously the most prized, on some of them crops can be grown with practically no tillage. As a general rule, the accretions in the upper courses of the rivers within Bangladesh are sandy, those in the middle courses are silty, and those in the lower courses have a high proportion of clay. The Ganges Diaras and Chars within Bangladesh stretch from the south-west of Shibganj Upazila to the south of Bera Upazila, a distance of 261 km. The Ganges here fluctuates between its high levees on either side, which are from 5 km. to 19 km. apart. There are large Diaras south-west and south-east of Shibpur Upazila, north of Daulatpur Upazila and south of Charghat, Ishurdi, Pabna and Shujanagar Upazila. Chars are numerous and shifting very often. The principal ones are south of Rajshahi and Shujanagar Upazilas.

(b) *North Ganges old floodplain* : This broad high floodplain stretches from Premtali in Godagari Upazila to Shujanagar Upazila where it slopes into the Jamuna floodplain. The southern part of this floodplain is a levee. The northern part is lower. Because of the fluctuations in the course of the Ganges, the levee is not everywhere beside the river. In the south of Charghat Upazila, the levee is far from the present course of the river, the intervening ground containing point bars, swales, and Diara accretions. Formerly the north Bengal rivers used to flow directly south into the Ganges, but during the eighteenth and nineteenth centuries the levee has built itself up rapidly. The starting point of this rapid built-up seems to have been the damming up of the Ganges by the first onrush of the newly formed Jamuna branch of the Brahmaputra in the late eighteenth century. Since then, the levee has built itself up through the depositions of the Ganges and the Atrai and its tributaries. It varies in width from 3 km. to 19 km. and its total area is about 274 sq. km. Heights vary from 21 to 27m. The southern side presents an abrupt face where the Ganges cuts past it, but in the north it slopes gently into the backswamp of the Bhar Basin.

The southern part covers Bagatipara, eastern Paba, northern Puthia, Durgapur, Mohanpur and southern Bagmara Upazilas. The land here is a succession of saucer-shaped basins, rimmed by old river levees and point bars. It was once the backswamp of the Ganges, but as that river built up its left rank levee, this area has become progressively drier. The small basins are silting up.

X. *Brahmaputra-Jamuna Floodplain*

A dual name is used for the mighty Brahmaputra river, because the Jamuna channel is comparatively new and this course must be clearly distinguished from that of the older Brahmaputra (Region XI).

Before 1787, the Brahmaputra's course swung east to follow the course of the present Old Brahmaputra (Map 2.4). In that year, apparently, a severe flood had the effect of turning the course southwards along the Jenai and Konai rivers to form the broad, braided Jamuna channel. The change in course seems to have been completed by 1830. Fergusson (1863) suggested that the diversion may have been due to the uplift of the Madhupur Tract (called 'Madhupur Jungle, in most of the earlier writings). La Touche (1919) disagreed, and suggested that the change in course was directly due to an increase in the volume of water carried, when the Dihang tributary of the Brahmaputra cut back and beheaded the Tsangpo of river of Tibet and thereby received an 'enormous accession of water'. That the Tsangpo, which flows through a dry plateau, is a small river by the standard of those in the Indian sub-continent, does not seem to have occurred to him. The accession of even two or three hundred thousand cusecs could not have made such a difference to a river which was even then well over a kilometer broad in its course through Mymensingh.

Hirst (1916) advanced the more plausible concept of a zone of subsidence between the two large Pleistocene blocks of the Barind and Madhupur. He suggested that these two blocks had been elevated 'as compensation to a line of subsidence passing approximately from Jalpaiguri to the sea, down the alignment of the present Meghna river. Hayden and Pascoe (1919) strongly attacked this concept and accepted the 'rational' explanation of La Touche, which since then was not seriously challenged till the findings of Morgan and McIntire (1959). In their stimulating paper, they put forward four points as evidence that there is most likely a zone of subsidence between the two large Pleistocene blocks. Firstly, the change in the course of the Brahmaputra is in response to a steeper gradient along the course of the present Jamuna. This gradient must have increased sufficiently by the 1780s to need only the trigger action of a single flood to divert the river. Secondly, there are faults on both sides of the hypothetical zone ; there are six echelon faults west of the Madhupur Tract and a large fault north-east of the Barind Tract. Thirdly, the hypothetical garo-Rajmahal gap stretched across the Northern Region, and sank only in the Oligocene period, and is quite possibly an unstable mass. Fourthly, the vast amount of sediment carried to sea by the Meghna river (the main mouth of the combined Ganges-Brahmaputra-Meghna rivers) for the last 200 years, at the least, has not built out the deltaic front appreciably. Subsidence in the estuary of the Meghna possibly hinders the rapid building of islands and Diaras. On the evidence available, Morgan and McIntire accept and elaborate upon the theory of a zone of subsidence between the Barind and the Madhupur Tracts, which in turn elevates the two tracts on either side. On these, and other evidence, Haq (1988) refers to this unit as a rift valley.

(a) *Bangali-Karatoa floodplain* : This plain was once a part of the Tista floodplain, and now through the Bangali distributary of the Jamuna it is part of a bigger floodplain. The relief is that of broad ridges and basins. Some of the ridges are shallowly flooded but most the ridges and all the basins are flooded more than 0.91m. deep for about four months (mid-June - mid-October) during the monsoons.

(b) *Diaras and Chars* : Along the Brahmaputra-Jamuna, as along the Ganges, there are many Diaras and Chars. In fact, there are more of them along this channel than in any other river in Bangladesh. There is a continuous line of Chars from where this river enters Bangladesh to the off-take point of the Dhaleshwari river. Both banks are punctuated by a profusion of Diaras. The largest of these are in Rahumari Upazila where they form most of the land between the river and the abrupt faulted western end of the Meghalaya Plateau. There are other large Diaras on the opposite bank in Chilmari Upazila. Chars are profuse: there are so many of them where the river turns past the Meghalaya Plateau that the banks are 16 km. apart with several dozen semi-permanent Chars in-between. This extremely breaded course of the river is about 81 km. long. Below Fulchari Ghat[2] there are several stretches with no Chars. There are however, considerable Chars between Sirajganj and Jagannathganj Ghat. As in the Ganges the soil and topography of the Chars and Diaras varies considerably. Some of the larger ones have point bars and swales. The elevation between the lowest and highest points of these accretions may be as much as 5 meters. The difference between them and the higher levees on either bank can be up to 6 meters.

(c) *Jamuna-Dhaleswari floodplain* : This is the left bank floodplain of the Brahmaputra-Jamuna. Several distributaries of the Jamuna flow through here, of which the Dhaleswari is by far the largest. The southern part of this sub-region was once a part of the Ganges floodplain. Most of this area is flooded more than 0.91m. deep during the monsoons.

XI. *Old Brahmaputra Floodplain*

When the Brahmaputra turned south and adopted the Jamuna as an main channel, the old course between Bahadurabad and Bhairab shrank through silting into a small seasonal channel only two kilometer broad (Chapter 3). The old river had already built up fair high levees on either side over which the present river rarely spills. The levees slope away to lower ground ; in the north there is a long depression parallel to the alignment of the Meghalaya Plateau, and only a few kilometers from it ; in the south the plain is more uniform in level,

2. Ghat means a landing place

possibly because the Madhupur tract dips beneath it just where a backswamp would have been. There is however, a very conspicuous depression in the south of Ghaffargaon Upazila between the Old Brahmaputra river and the Madhupur Tract.

(a) *High ridges* : This sub-region begins at the foot of the Garo hills and curves along the old course of the Brahmaputra to end near Nakla. The relief here is of broad and narrow, high flood-plain ridges, with lower ridges and inter-ridge depressions between them.

(b) *Floodplain complex* : This long and narrow sub-region follows the course of the Old Brahmaputra and has a relief of irregular ridges and depressions with some extensive areas of smooth ridges and basins. The higher ridges are on the northern side.

(c) *Western plain* : This part of the plains is cut off from the southern section by an arm of the old Brahmaputra. The active floodplain all around floods fairly deep but most of this plain is only shallowly flooded within the rice field bunds.

(d) *Northern plain* : This large sub-region is roughly in the shape of a broad T, the east-west arm extending 113 km. from Mohanganj to Sherpur, and the north-south arm extending 97 km. from Purbadhala to Katiadi. This plain also has a relief of broad ridges and basins, locally irregular along old channels. Basins are usually flooded more than 0.91m. deep, but the ridges are only shallowly flooded.

(e) *Southern plain* : This large section extends from the Brahmaputra-Jamuna to Old Brahmaputra and almost encloses the northern part of the Madhupur Tract. Three outliers of the tract are within the plain. The relief is that of broad ridges and basins, except along the Modhupur Tract where it is often undulating. The plain is almost divided in half just east of Jamalpur, where seven broad undulations of the floodplain complex (b) almost join the northern-most spur of the Madhupur Tract. There are a few fairly deep basins within the plain, of which the one at Moshakhali is most prominent.

(f) *Eastern plain* : This sub-region has the broad ridges of the Northern plain, but the basins are deeper. The higher ridges are only shallowly flooded but all the basins are flooded more than 0.91m. deep. Most soils have a strongly developed ploughpan impeding internal drainage.

(g) *South-eastern plain* : This section is a continuation of Northern plain across the Old Brahmaputra. It is cut off from the Southern plain by an extension of the Madhupur Tract. There are numerous small sandy patches on the ridges. Most of the area is only very shallowly flooded within the field punds. This plain contains several outliers of the Madhupur Tract, including the Eastern Sub-region (XIII. d).

XII. *Susang Hills and Piedmont*

(a) *Susang hills* : This region extends in a thin line of some 161 km. length from the north of Jamalpur district to the north of Sunamganj district. It includes the hillocks at the base of the Meghalaya Plateau, which are within Bangladesh and the land in between and around them, which is high and sloping. Beds and outcrops of rocks of the Jaintia series, of the Eocene age, occur (Wadia 1953). They are mainly sandstones and shales. Recently limestone (of the Sylhet limestone stage) has been found in north Sunamganj district. There are small quarries of nummulitic limestone in the north of Jamalpur district. Large deposits of white clay have also been found here. The highest of the hillocks within Bangladesh are over 92m. The valleys are at a height of over 31m. Many entrenched mountain streams cut through this region, depositing sand plentifully. Over much of its length this narrow belt gives way very rapidly to low waterlogged land. In the eastern part of this region, the Meghalaya Plateau ends abruptly in a series of gigantic faults, over 610m. in height, and the narrow gravelly ledge at its base sinks down to the very low Haor Basin.

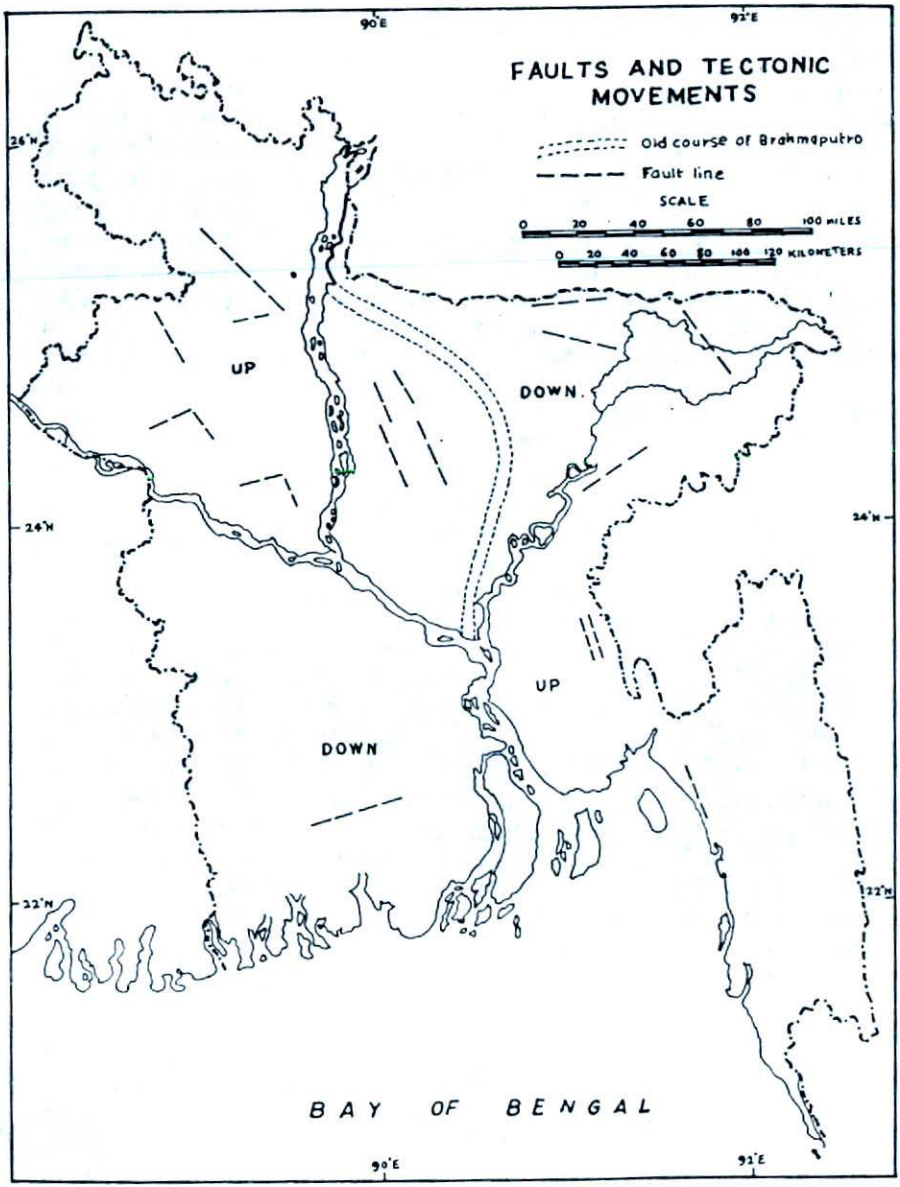
(b) *Piedmont plains* : This sub-region covers most of Nalitabari, Haluaghat and Kalmakanda Upazila and part of Durgapur Upazila. It has a gently sloping relief, with a line of extensive basins in the south. Most of the area is only very shallowly flooded in the monsoons, and that too due to field bunds to retain the rain water. A few basins in the south are deeply flooded. Occasional flash floods affect the whole area.

XIII. *Madhupur Tract*

Like the Barind, this is another large Pleistocene inlier within the Bengal Basin, with an area of about 2558 sq. km. It is tilted towards the south-east. This elevated tract is probably the result of the very interesting tectonic movements to which the Bengal Basin is being subjected. The problem will be discussed further on.

(a) *Northern tract* : The northern end of the tract (Map 2.3) is characterised by its large plateau like hillocks, known as Chala. They are 9 to 18m. in elevation and have slightly dome-shaped tops. Between them are narrow winding valleys (mostly flattened and terraced for rice cultivation) known as Baid. The drainage pattern is dendritic. Morgan and McIntire (1959) found two faults on its western face, and five faults traces in it. The two faults are each some 20 kilometer long and upthrown to the east. Their elevation varies from 9 to 18m. The southern fault is the western face of a block slightly detached from the main one by a valley of recent deposits.

Map 2.4


FAULTS AND TECTONIC MOVEMENTS
Old course of Brahmaputra
Fault line
SCALE
0 20 40 60 80 100 MILES
0 20 40 60 80 100 120 KILOMETERS
90°E
92°E
26°N
24°N
22°N
UP
DOWN
UP
DOWN
BAY OF BENGAL

The north-eastern side of this sub-region slopes into the overlapping recent sediments with a slight fault, and the south-east is largely bounded by a fault. From the northern end of the tract five spurs reach out to the Old Brahmaputra river. They divide and sub-divide into a number of undulating ridges, with comparatively low flat land in between them. The area covered by these spurs and the land between them is about sixty five square kilometers in area.

(b) *Central tract* : This area can be divided into two parts. The eastern part of the block, about 241 sq. km. in area is bounded on its west by a fault downthrown on the eastern wide. It is characterised by chains of Chalas, with not very broad tops and deep circular Baids, most of which are not connected with each other. The western part is highly dissected, being characterised by small Chalas and a profusion of winding Baids. The western side has four faults, downthrown to the west, and presenting an elevation from 6 to 15m. The drainage pattern is, of course, dendritic.

(c) *Southern tract* : The large southern part has a topography different from that of the other three parts. Here, most of the terrace is almost flat in relief, except where streams have cut across it. The levelling for rice fields has gone a long way towards making the relief uniform. Besides the streams and especially along the Lakkha (Sitalakhaya) river, the terrace presents a marked elevation because of the entrenched drainage pattern and the dissected nature of the tract. In the south, the tract reaches the Buriganga and a small bit of it has been traced on the other bank. The level here (in and around Dhaka City) is uniform mainly due to artificial levelling. There are extensive waterlogged Baids in the eastern part.

(d) *Eastern tract* : Three bits of the terrace are detached from the main tract by the Old Brahmaputra and Lakkha rivers. The southernmost, at Sonargaon, is very small. The northernmost at Egaro Shindur, is also small. South-east of the latter area is the third, fairly large, block in Monohardi and Shibpur Upazilas. The drainage in this sub-region is not markedly dendritic, but definitely entrenched.

XIV. *Haor Basin*

This large basin takes its name from the multitude of large lake-like bodies, known as *Haor*, with which it is dotted. This sub-region stretches from the Mahadeo and Mogra rivers to the plain of central Sylhet. Its greatest length, both east-west and north-south, is just over 113 km. The area covered by the basin is about 4505.20 sq. km. The sinking of this large area into its present saucer-shape seems to be intimately connected with the rise of the Madhupur Tract. Local tradition has it that the land sank 9 to 12m. in the last 200 years.

Areas which used to grow floating rice fifty years ago cannot do so now due to the depth of flooding. Indications are that these areas sank at least 0.91 - 1.5m. in this period. Morgan and McIntire (1959) also considered that this basin has sunk at least 9 - 12m. within the last several hundred years. Could it be that the earthquake of 1762 began the diastrophic sinking which is still going on?

(a) *Central basin :* In the basin there are two very low areas : one near Sulla, more or less in the centre of the basin and the other along the north-central rim. The low area near Sulla and Khaliajuri has large tracts below 3m. level. Most of the basin on all sides gradually rises higher. The basin itself is a succession of Bils and Haors of various sizes, interspersed with river cutoffs, scours, swales and long higher levees known as Kandha. The Kandhas in this central area are around 6m. level. For seven months of the year the aspect is that of vast lake, then all but the higher Kandhas go under water. This central area covers much of Khaliajuri, Sulla, Dirai, northern Baniachang and Jamalganj Upazilas. The second very low area contains the Tangua Haor, directly to the north of the centre, at the foot of the Meghalaya Plateau. This area is as low as the centre, but the rim lands are higher (9m. level). From the central very low area, the basin rises on all sides but imperceptibly. On the west the rise is fairly sharp at the edge of the Old Brahmaputra floodplain. In the north there is a fairly high rim of land between 9 and 14m. level separating the two lowest areas. Around Gohala it rises over 15m. (This may be the remnant of low hills). In the east the basin rises very gradually. In the southeast the rise is gradual at first and then fairly steep. There are broad levees at Ajmiriganj and Bangalpara. The rim lands drain out earlier and fill later than the centre in winter when the water-level falls the streams have the appearance of being entrenched.

(b) *Susang Piedmont basins :* There is a line of deep basins between the Susang piedmont plains (XIIb) and the Northern plains of the Old Brahmaputra (XI d). These basins merge into the deeper Haor areas to the east. Most of this area is seasonally deeply flooded.

(c) *Meghalaya Piedmont depression* : This long depression stretches from the Rongra river in the west to the Lubha river in the east. A large fault along the southern edge of the Meghalaya Plateau is the cause of this long low strip of land : parts of it may still be sinking. The lowest part is the Tangua Haor area, which is at the foot of the tremendous fault scarp that extends from the Mahadeo river to the Jadukata river. The part of the depression to west of it averages about 6m. on the Kandhas. In the east, the land gets higher and Kandhas are generally between 9 to 12m. above mean sea level.

(d) *Central Sylhet lowland* : This depression contains the Hakaluki Haors and the low-lands to its north-west and south east. The heavily silt-laden Juri and Kushiara rivers are filling up the low areas and in a couple of decades the water area will be greatly reduced.

XV. *Sylhet High Plains*

This region is in large measure the higher land between the three major sub-divisions of the Haor Basin. Over much of its length it is above 9m. and the streams are fairly entrenched. In some parts there are Haor and Bils, but their level is higher than those of the Haor Basin and most of them drain out in early winter.

XVI. *Sylhet Hills*

Small areas of the Meghalaya Plateau foot-hills fall within Bangladesh. To the south of them there are four small hilly tracts and five hill ranges. The hilly tracts could be remnants of pleistocene terraces. The hill ranges are anticlinally folded and continue south into the Chittagong Region.

(a) *Meghalaya foot-hills* : Along the northern border of Sylhet district some of the foot-hills of the Meghalaya Plateau (the Khasi and Jaintia hills part) are within Bangladesh. Very small bit are within the border to the north of Tahirpur. North-east of Sunamganj there is an area of scattered hills both west and east of the Khasimara river. The Chhatak hills to the south-east are actually a continuation of these. Further east there are two hills, one reaching 52m. close to Bholaganj. Near Bholaganj the alluvial fans yield a large amount of boulders and shingles. To the east of the Piyain river there is a 8 km. long hill area known as Jaflong. Here heights reach over 61m. To the south-east, there is a continuous hilly area from Jaintiapur down to the point where the Surma river forms the border with India. Here the main hill groups are Jaintiapur (up to 54m), Shari (Dupi Tila 91.2m), Lalakhal (Kesara Pahar 153m), Bariyal (81m), Sonatan Pahar (90m), Numchara (over 61m), Lubhachara (over 92m), Mulagul (Khasia Tila, 100m) and Chatal Tila (over 122m), Dawkergul (80m) and Dona (over 76m).

These foot-hills are composed of the Jaintia series of sandstones and nummulitic lime-stones, and the Surma series of sandstones, sandy shales, mudstones and thin conglomerates, nummulitic lime-stone an pebble beds of the Pliocene. Dihing series are found in the gravelly alluvial fans.

(b) *Tila ranges* : Tila is the name given to small hillocks. There are four main groups of hillocks in northern Sylhet district. The group

at Chhatak has an area of 40 sq. km. It reaches heights of 45 and 44m. (Taramun Tila). This group has a north-west to south-east trend and is actually a continuation of the foot-hills along the Khasimara river. The group of Tilas at Sylhet form fairly well defined ranges with a north-east to south-west trend. South of the Surma river the highest point is Orthoki Tila (29m). North of the river the main heights are Abangi Tila (77m). Barutni Tila (79m) and Cherragong (92m). This group has an area of 115.8 sq. km. A few kilometers to the south-east is the 48 sq. km. Dhakadakhin group of Tilas which reaches up to 64m. at Kailash Tila and over 61m. north of the Surma river. A few miles to the east of this group are the Tilas of Beani Bazaar which cover 32 sq. km. and reach over 31m. in places. These Tilas are actually an arm of the Patharia range to the east. Similarly, the Dhakadhakin group seems to be an isolated remnant of a range that formerly joined the Ita range in the south to the Lalakhal foot-hills in the north. The Sylhet group may have once been joined to the Bhanugach range in the south and the Jaflong foot-hills in the north. The high plain of central Sylhet, with its entrenched streams may possibly be the remnant of these denuded ranges.

These Tilas have Pleistocene clays and sands over coarse ferruginous sandstones, mottled sandy clays and shales of middle Miocene age (Dupi Tila series). Petroliferous beds have been found in them, near Dwara Bazaar in the Chhatak Tilas, at Panircherra in the Sylhet Tilas, and near Golapganj in the Dhakadakhin group.

Six hill ranges project into the south of Sylhet district from the Indian State of Tripura. These ranges are in a sense, the continuation of those which traverse the Chittagong Region in the south-east. These six ranges, which project into the plains from the south are, from east to west, the Patearia, Harargaj, Rajkandi-Ita, Bhanugach, Tarap and Raghunandan. The Paharia forms the eastern border for 40 km and reaches heights of over 183m. (Kuleral Tila 208m.). The Harargaj is, in a sense, its continuation to the south-west. Twenty six kilometres of this range is in Bangladesh : the central ridge reaches 337m. at Harargaj Peak. Almost 19 km. to the south-west is the Rajkandi-Ita range. In its 65 km. length within Bangladesh a height of 133m. is reached. At the border there are higher peaks, such as Hiara (158m) and Parwatang (278m). The Rajkandi range terminates at the valley of the Manu river, but re-appears on the northern side as the Ita range which has a length of 23km. and reaches a height of 66m. The broad Doloi valley to the west of the Rajkandi range is fairly high, the height at Patrakhola being 35m. West of this valley is the Bhanugach or Balisira range. It is 44 km. long, and reaches a maximum height of over 168m. in the south, where this range join the Tarap range to the west, which is 48 km. long and reaches upto 61m. height at only a few places. The western-most range, the Raghunandan or Laskarpur, is 26 km.

long and reaches heights of over 122m. in the south, but is mostly below 46m. The valleys between these ranges slope up from 50 to 150m. height. The Raghunandan and Tarap ranges appear to be thickly mantled by Pleistocene deposits. The other ranges have a thinner mantle. Their origin and composition is more or less similar to the ranges of the Chittagong Region, which will be discussed later.

XVII. *Meghna Flood-Plain*

Much of the flood-plain of the Meghna was built up by the Old Brahmaputra river, when that carried the main stream. The Meghna continues to fill in the depressions left since then but is not building up any more north of its confluence with the Dholeshwari.

(a) *Titas basin* : Titas plain is flooded by the Titas distributary of the Meghna, which leaves it near Chatlapur and re-joins it near Nabinagar. The low ground is in a sense the continuation of the Haor Basin Ram, but it does not slope toward the centre of that basin. It is studded with point-bars.

(b) *Meghna-Lakkha Doab* : This large piece of land includes part of the Lakkha-Bangshi Doab to the west. This Doab is low and very fertile.

(c) *Middle Meghna floodplain* : Along the middle Meghna river, as is to be expected, there are many large Chars and Diaras, separated from those to the south because the latter are part of the Delta while the former are not. There are several wide Chars between Bhairab Bazaar and Daudkandi - which is opposite the Dholeshwari confluence. Whereas the Chars in the lower course of the Meghna river are liable to sudden changes, most of those in its upper course are fairly stable.

XVIII. *Tippera Surface*

The Tippera surface (named by Morgan and McIntire) or the Tippera-Noakhali Clay Plain (according to B.L.C. Johnson), is a distinctive physiographic unit. It has a rectangular drainage pattern in contrast to the braided and meandering pattern of the floodplain (Chapter 3 : Hydrography). The soil is slightly more oxidised than the flood-plain deposits. According to Morgan and McIntire (1959) the surface re-appears to the north at Habiganj, where it is limited on the north by a north-east to south-west fault trace. The semi-detailed survey by the Soil Survey units shows a more complicated topographical pattern than is suggested by Morgan and McIntire.[3]

3. See the Reconnaissance Soil Survey Reports for Noakhali District and Chandpur subdivision (1966) and Sadar North and South subdivisions Comilla District (1955) : Directorate o f Soil Survey, Dhaka.

(a) *Eastern Piedmont strip and Lalmai Range :* This is a narrow strip of land along the base of the Tripura hills, which are within India. This strip varies in width from two kilometers to about fifteen kilometers within Bangladesh. It is mainly composed of Pleistocene sediments, overlain by sandy clays washed down from the hills. This Piedmont strip, which is much broader in the Tripura State of India, is a Pleistocene terrace. The Lalmai range, a couple of miles west of Comilla town, is 15 km. in length and from half to one and a half km. wide. Its highest peaks are over 46m. It is bounded by faults on the western and eastern sides. The fault scarp on the east is up-thrown to the west and considerably dissected by drainage channels. On the west there are two parallel faults about a kilometer apart. Both are up-thrown on the east. The inner fault forms a well-defined valley. The outer (western-most) fault has a surface, throw in excess of 31m. at several places (Morgan & McIntire 1959). Structurally this range is a horst, tilted to the east. The upper part of this horst is composed of oxidised clays and sands of Pleistocene age, which rest upon beds of sandy shales, coarse ferruginous sandstones and mottled clays and sands, probably of the Tipam Series. Fragments of fossil wood are plentiful. The eastward dip of the upper deposits is slight, but of the lower deposits quite steep.

(b) *Low floodplain :* This long floodplain stretches from Nabinagar south to Maijdi. The relief is that of almost level broad ridges and basins, mainly deeply flooded by accumulated rainwater in the monsoon. Flooding is caused by the Meghna and also by the smaller river such as the Gumti and Dakatia. A long depression from Kachua to Maijdi marks an area of deeper flooding. There are extensive man-made raised land in the south-west, around Ramganj.

(c) *High floodplain :* This sub-region is mainly shallowly flooded, except in the extension in the north to Nabinagar, where half the land is deeply flooded. Most of the area has level, broad ridges and basins, with irregular narrow ridges and basins along the Gumti river. There is also a long, narrow depression along the Dakatia-Little Feni river which is seasonally deeply flooded. West of the Lalmai hills there is some man-made raised land flash floods occur, especially in the Gumti and Silonia rivers. The Comilla Basin between the Lalmai range and the Tripura hills is probably a garben.

XIX *Moribund Delta*

There are many different opinions as to how much of the Bengal Basin can be considered as the Ganges-Brahmaputra Delta. In fact it is even contended by some that there is not one delta but several deltas. Strickland's delimitation of the delta, as the area of transcendent

deposition' (Strickland 1940), is acceptable if only the upper floodplains of the rivers are not included and the Moribund Delta is included as an area with recent transcendent deposition. The delta of the Ganges-Brahmaputra rivers is here defined as that area included within the seaward distributaries of the Ganges and the Jamuna channel of the Brahmaputra (Map 2.3).

The Moribund part of this delta is characterised by rivers choked with sand and unable to carry much water except when the Ganges is in high flood ; a profusion of ox-bow lakes ; high plains well above normal flood-level, and interfluve depressions which are not falling up because of the absence of the annual spread of sediments (silt) which is of such great importance in the active part of the delta. This region can be conveniently classed as a high plain, with many crescent shaped basins (ox-bow lakes) which have water in them throughout the year. The rivers are slightly entrenched. They are almost dry most of the year; during the rainy season they drain the surface water primarily, and if their connection with the Ganges is not choked with san, they may also carry some of its flood water as a distributary. An exception to the rule is the Gorai, which takes off a good part of the Ganges water into the Pussur and Baleshwer rivers. The north-west and south-west of this sub-region are higher than the rest, and their soil is also sandier.

XX. *Central Delta Basins*

This extensive basin in the heart of the delta cannot be satisfactorily explained by Strickland's hypothesis of a seaward ledge and its blocking of inland deposition. These large basins (also known as the Faridpur Bil Area) are about 1931 sq. km. in area. The most satisfactory explanation to date has been advanced by Morgan and McIntire, whose hypothesis about the structural forces affecting the Bengal Basin has been referred to earlier. Their theory, that part of the delta is subsiding as a compensation to the elevation of the Tippera Surface and the Barind Tract, is plausible. The origin of the Central Delta Basins, with their extensive Bils, lies probably in the absence of rapid deposition by the active distributaries (which flow towards its east) couple with steady subsidence due to warping by torsional forces. The associated slightly higher land to the south of these Bils has been explained by Strickland (1940) as the zone where the rise of the tide (of 6m.) has led to rapid deposition of the silt carried by the once active rivers. The formation of this ledge has probably proceeded with compaction of the deposits, which made the depression along the east-west line to the north of it. The findings of Morgan and McIntire (1959) seem, however, to indicate a tectonic origin for these Bils.

XXI. *Immature Delta*

South of the Moribund Delta, there is a broad belt of land, barely above sea level. Whereas the height of the southern edge of the Moribund Delta is about 3m., a few kilometers to its south a land elevation only 0.91m. This very low land of some 4827 km. area, contains the Sunderban forest and the Sunderban reclaimed estates (cultivated land). There are two possible causes for the existence of such a large very low estuarine area - insufficient deposition by the Ganges distributaries or subsidence. Till the seventeenth century, the main Ganges distributary seems to have been the Hoogly-Bhagirathi. In the next century, the Ganges sent more and more water down its more eastern distributaries, till the 1787 flood and the break-through of the Jamuna forced it back and the Gorai distributary was enlarged.

The Ganges subsequently once again shifted east. Between the Hoogly-Bhagirathi and the Gorai (and its continuation - the Madhumati) the Ganges had two main distributaries, the Ichamati and the Bhairab, neither of which built up more than their own levees. The Jalangi and Mathabhanga rivers cut across the drainage lines of these rivers in the eighteenth century, but their work lasted only about a century. It seems, therefore, that the main distributaries of the Ganges never flowed through this region, and the small ones that did lasted a few centuries at most. The building up of this estuarine area is consequently not complete. The tides may have also contributed to the retardation by forcing the major part of the sediments to be deposited along the ledge, which extends from the levee of the Madhumati and Narail Upazila west-south-westwards to the Hoogly-Bhagirathi at Calcutta.

It is possible that subsidence has played a major part in depressing this area. There are many evidences of it, such as large ruins in the heart of the swampy estuarine areas such as at Shekertek and Bedkashi (Fawcus 1927), and the presence of human artifacts and tree stumps, buried in the alluvium many feet below the level of the sea. Hunter (1875) recorded the presence of large tree trunks buried in the ground at Khulna town, indicating a subsidence of 6 meters. During the foundation borings for the Khulna Shipyard Docks, decayed wood was found as far down as 31m. (Morgan & McIntire 1959). Possibly compression of the sediment forced them so far down. Morgan and McIntire (1959) made many borings and found maximum indications of subsidence to the extent of 7m. at Dhakikhal, 6.1m. at Dubla island, and 11m. at Shekertek ruins near the Shibsha river. Similar evidence has been found in the Central Delta Basin. Fawcus (1927) records that the cross section of a tank dug beside the Bils showed the following strata :

From ground level	to	1.5	m.	below	Dry sandy soil
1.5	to	3	m.	"	Wet sand
3	to	5	m.	"	Mud
5	to	6.1	m.	"	Caked mud with fissures (i.e. drier)
6.1	to	6.4	m.	"	Peaty debris
6.4	to	7	m.	"	Mud with tree remains
7	to	7.3	m.	"	Peaty debris
7.3	to	7.9	m.	"	Mud with tree remains
7.9	to	8.8	m.	"	Peaty debris
Below		8.8	m.		Clear sand

Most of the indications are that there has been subsidence to a maximum of 12.2m. both in this part of the Delta and in the Central Delta Basin. Quite likely the Mature Delta has also been affected but that it has not sunk so low because the tidal action precipitated most of the silt of the several Ganges distributaries of that area fast enough to counteract the sinking. It seems that both the absence of adequate deposition and subsidence are responsible for the incomplete build-up of this region. As is to be expected only along the rivers the higher levees afford places for settlements.

The sea-ward face of this region is a network of branching streams around roughly oblong shaped islands. When silt laden streams reach sea, their velocity is checked and their sediment load is flocculated. Bars form at the mouths, and the streams branch off to either side. In time these branches too form their bars and are also divided. As this process goes on the branches unite and redivide and the bars coalesce into islands, which are sometimes cut apart. This process forms a network of channels.

The high tide ponds back the estuarine rivers and force them to break their banks and open out cross-channels. These are a marked feature of the low areas much affected by tides, for 'as the delta is elevated out of tidal influence, the cross-channels disappear' (Strickland 1940). The sea-face is in places marked by old beach ridges, of a peculiar formation (Fawcus 1927). The sandy beach, usually facing south-west is backed by a ridge of sand dunes seven to ten meters high : behind. This is a grassy plain, of about two kilometers width and parallel to the beach this plain is bordered by a belt of mud, usually with a stream and forest trees. Behind this mud-flat there is again a succession of sandy shelf (an old beach), sand dunes, grassy plain and mud flat. Some beach-ridges are as much as three kilometers inland. Their mode of

formation depends upon the tide, which in this area, ebbs towards south-west. This makes the estuarine rivers build a south-west facing bar on the eastern side of their mouth since there the water is stiller. The summer tides and storms build up the sand dune ridges. The channel between the ridge and the mainland gradually fills up into a mud-flat and diverts the rivers silting further down.

There are extensive shoals, extending sixteen or more kilometers out to sea, between the larger rivers. At the mouth of the Raimangal river, the shoals extend 32 km. from the land. Between the Haringhata and Marjata estuaries, shoals cover more than 48 sq. km. A notable feature is that they are higher on their sea-ward sides than on their land-ward sides by two to three fathoms. This stretch of the coast contains the big islands of Patni and Dubla.

XXI. *Mature Delta*

(a) *Old Ganges floodplain* : This sub-region lies to the north of the present channel of the Podda and receives flood water from both the Jamuna and the Podda. This area does not receive extensive silt deposits any more, nor is it subject to much diluvion. There are extensive man-made raised land near Munshiganj and a large depression known as the Arial Bil.

(b) *Podda-Madhumati floodplain* : Land levels in this large sub-region varies considerably, from very shallowly flooded land in the north-west to deeply flooded basins in the south-west. There is some overland flooding, but the essential feature of this area is that there is neither extensive alluvion nor diluvion. Much of this plain was built up by the Madhumati when it was the main channel of the Ganges, but with the shifting of the main channel the land building process has ceased.

(c) *Non-saline tidal floodplain* : This sub-region differs from (b) because of the strong tidal effect. The relief is that of shallow basins, with ridges (levees) along the rivers. Most of the area is seasonally shallowly flooded, with the depth of flooding varying with the tide. In the dry season only the deeper basins continue to be tidally flooded.

(d) *Saline tidal floodplain* : Here the tidal effect is much stronger than in (c) and in the dry season the river water turns brackish. Tidal flow is strong and the scouring effect is quite noticeable. Cross-channels between the larger rivers exist, as in the Immature delta. Some basins in the interior are deeply flooded in the monsoons. Slow deposition is continuing at the mouth of the larger rivers.

XXIII. *Active Delta*

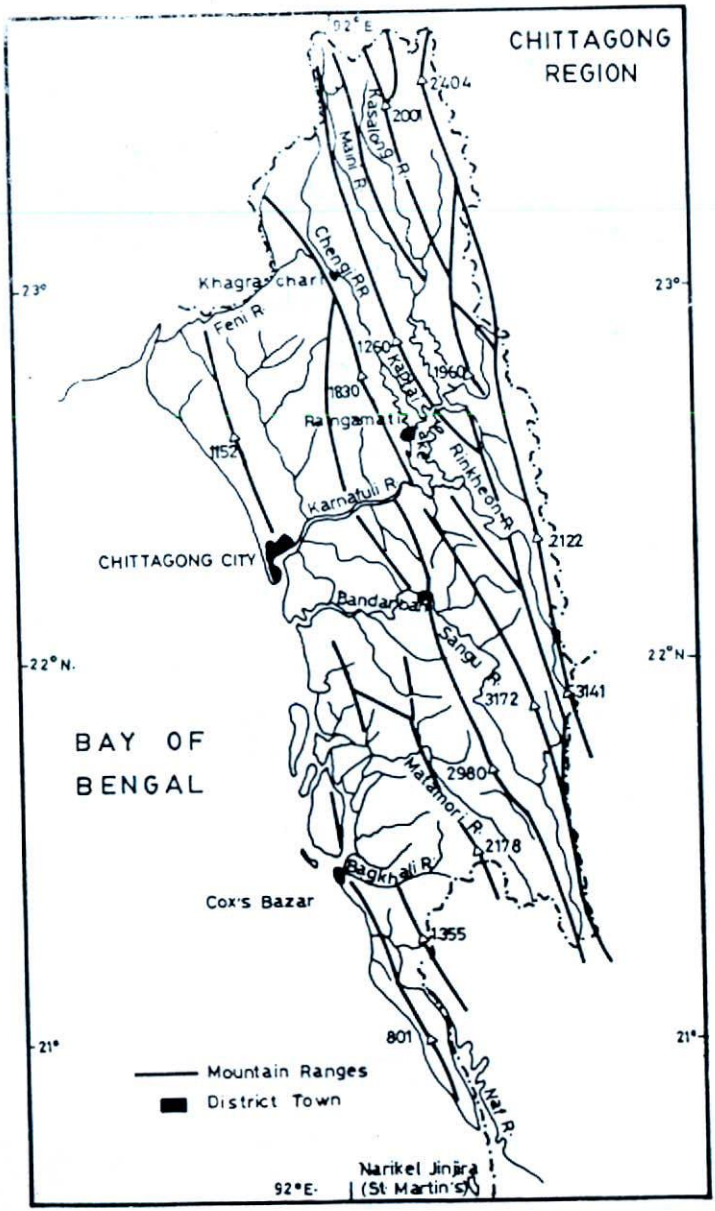
(a) *Active Podda floodplain :* This area is subject to flooding, alluvion and diluvion from the Podda. It includes Chars and Diaras in and on both banks of the river. Most of the chars are of calcareous silts and sands. The large diara along the right bank of the river is mainly calcareous loams and clays. Flooding varies with the river level and the land may be under one to 2m. of water at various times during the monsoons.

(b) *Mehendiganj islands :* This is a Char (island) area of accretion and erosion in the large mouth of the lower Meghna. The relief is that of low floodplain ridges and basins. The land is only shallowly flooded in the monsoon but the flood-level fluctuates tidally.

(c) *Meghna estuarine islands and Chars :* The rivers of this part of the delta form three main estuaries, the Haringhata, the Agunmukha and the Meghna. The Haringhata has only a few sandbanks. The Agunmukha encompasses the islands of Baisdia (Rabnabad) and Rangabali and the Chars of the Dhanmanik group. Boro Baisdia, 32.2 km. long by 6.5 km. broad, has the Rabnabad channel to its west and the Darchhira channel to its east, across which is Rangabali island, 23 km. long and 9.7 km. broad. To the north is Chhoto Baisdia. To the east and north-east of these two islands are large number of chars and sandbanks. The number of chars is not accurately known for new strips appear very frequently and some of the old ones are diluvated. On the whole the number and extent of the Chars is increasing. A fair guess is that there are some 120 Chars. From north to south, the main ones are Trailikya, Kalir, Shiber, Kajal, Kalmi, Manika, Kukuri-Mukuri and Andar. There used to be wild buffaloes in the dense forests of Kukuri-Mukuri at the turn of the century; both the forest and the wild buffaloes have vanished by now.

At the mouth of the Meghna are the really large islands of Bhola, Ramgati, Hatiya and Shondip. Around these are several Chars. Bhola is estimated to be 1331 sq. km. in area; its southern end is constantly being added to by new Chars and has grown over 250 sqkm. in the last quarter of a century. The Ilsa or Tetulia river separates Bhola from the mainland. Between it and Ramgati (till recently known as north Hatiya) is the main channel of the lower Meghna, locally also known as the Shahbazpur river or Ramgati has an area of 402 sq. km. Hatia (or south Hatiya) is to its south and separated by the Hatia channel. It has an area of 354 sq. km. (excluding Manpura). Between Bhola and Hatia is the fairly large island (365 sq. km.) of Manpura. Separated from Ramgati and Hatiya by the Hatiya channel, Shondip (Sandwip) is the eastern-most island (187 sq. miles). It is an old formation, but has been

Map 2.5


CHITTAGONG
REGION
92° E
2404
2001
Kaptai L.
Kasalong R.
Main R.
Chengi R.
Khagrachari
Feni R.
23°
1260
1960
1830
Rangamati
1152
Karnatuli R.
Rinkhiong R.
2122
CHITTAGONG CITY
Bandarban
Sangu R.
22°N.
3172
3141
BAY OF
BENGAL
2980
Matamori R.
2178
Baghkali R.
Cox's Bazar
1355
801
21°
Mountain Ranges
District Town
Naf R.
Narikel Jinjira
(St Martin's)
92°E.

eroded on one side or the other so often that very little of it has existed continually for more than a century. The earliest survey of the island is that of Major Rennel, which extended from 1764 to 1773. Next was Captain Hodges and Lieut. Siddon's survey from 1835 to 1840. The third important survey was that of the Revenue Department in 1864-65. There was a Diara Survey in 1881-82, and a Settlement Survey in 1911. All these show considerable changes in Ramgati, Hatia and Shondip islands.

The vast amount of sediment brought down by the Meghna has made the estuary shallow for a considerable distance. The 5 - fathom line is 64 km. south of these islands. There are several large shoals in this area; these may consolidate into large islands within this century.

(d) *Meghna estuarine floodplain* : This is an area of immediate level land, subject to only very shallow flooding through accumulated rain water. It consists of a ridge of high old land in the north and large areas of new accretion in the south. Tidal movements affect the area, but as there are few channels the land is not affected in the same manner as the non-saline tidal floodplain. Deposition by the Meghna and the Big *(Boro)* Feni rivers seems to be still enlarging the land area.

XXIV. *Chittagong Sub-region*

This part of Bangladesh, south of the Feni river, is so different from the rest of the country that it naturally forms a region. It is the most picturesque part of the country, with tangled hills and valleys, springs, lakes, islands, some mountainous ridges and many forests.

(a) *Northern coastal plains* : The plain along the coast extends from the Feni river to the Matamori delta, a distance of 121 km. Its breadth varies from one to fifteen km. From a wide plain at Zowarganj in the north, it narrows down to a little less than one km. at Foujdarhat. Further south it forms the Patenga peninsula on the northern bank of the Karnafuli river. Southwards the plain is narrowed down by the Jaldi hills. This plain is composed of saline clays and most of it is affected by the tides. The clay silt of the Meghna, Karnafuli, Sangu and Matamori is being deposited along this coast and around the offshore islands, resulting in their slow growth into the sea.

(b) *Central valley* : Between the coastal ranges of Sitakund and Jaldi and the hills of the Hill Tracts, there is a longitudinal valley 113 km. long and from 6 km. to 20 km. broad. It has within it the Halda river valley in the north, the Karnafuli-Sangu Doab and the Satkania valley, stretching 24 km. south of the Sangu river. The drainage lines in this valley are not uniform ; the Halda valley ora-

south to the Karnafuli river, the Doab drains north, south and west, whereas the Satkania valley drains north-west. The western lowland margin of this sub-region can be taken to be a line drawn from Chittagong city to Chandpur in the north of the low Jaldi range.

(c) *Matamori delta and Coastal islands* : The fast-flowing Matamori river debouches on the plains at Kakhara; fifteen km. further down it divides, thus forming the head of its delta. These two channels re-divide into numerous others, many of which turn back to join the main channel. Three main branches flow into the Moishkhal channel, two of which are known as Matamori Khal and one as Bura Matamori. The V-shaped lowland with its base between Mognama and Gomata and apex at Kakhara stands out clearly from the mountains to its east, the hills to its north and south and the coastal islands to its west. The tides are felt as far as Manikpur, near Kakhara. To complete its resemblance to the much larger delta to the north, there is even a small Chakaria Sunderban---a tidal forest with Keora, Baen, Gewa, Hargoza, and other coastal vegetation. There are six islands along this coast, in addition to which there are over a dozen Chars. Two of the islands, Ujantia and Koriardia, have not been fully raised above high water level and are still in the process of consolidation for which reason they are included in the Matamori delta. Kutabdia is the northern-most of these islands. It is separated from the mainland by the three km. wide, turbulent, Kutubdia channel. A swift and dangerous current flows along the middle of this channel (of 6 to 10 fathom depth) for most of the year. The island itself is 29 km. long and being tear-drop shaped, is four kilometer broad in the north and only one kilometer in the south. The total area is about 55 sq. km. The sea-ward side (west) has very good sandy beach over ten km. in length. To the south-east of Kutubdia across the channel, is Matarbari island. It is separated from Ujantia, Koriardia and Moishkhal islands by channels only a half km. broad. Its length is sixteen km. and average breadth is 3 km. Its area is about 31 sq. km. South-east of Matarbari , across the Kohalia channel, is the large island of Moishkhal (Moheshkali). It is the only island in Bangladesh with hills. With a maximum length of 32 km. and breadth averaging 10 km., its area is over 161 sq. km. The greater part of the eastern half is a mass of low tangled hills and ravines covered partly with tree forest and partly by scrub. In the south-east, these hills and abruptly on the Moishkhal channel in a row of reddish cliffs.

To the south-south-west of Moishkhal is the small sandy recurved, compound and complex spit known as Sonadia island. Since the 1930s it has grown three times in size by accretions to its east and north-east. At low tide Moishkhal and Sonadia are joined together by extensive mud-flats which now contains a small mangrove forest. Another

crescent-shaped island is forming south-east of Sonadia and threatens to push the Moishkhal channel towards Cox's Bazar town. There have been important accretions south of Kutubdia and Matarbari. During low tide, these show as large mud-flats. In a few decades they will probably form low grassy islands like Ujantia and Koriardia. The Moishkhal channel varies in breadth from one quarter to nearly 3.2 km. and in depth in mid-channel from 2 to 8 fathoms. The tides along the eastern coast are of considerable importance since they affect a far greater number of persons than along the Sunderbans coast. Here the settlements and fields come right down to the high-water edge a large number of streams carry flow tide water inalnd; and there is an appreciable amount of coastal traffic. The average daily rise in the tide is about two metres.

(d) *Western hills :* There are fairly marked differences in the land utilisation, soil characteristics, drainage pattern and even ecology of the hills and the mountain ranges of the Chittagong region. Topographically, of course, the two big hilly areas in the north and south of this region are clearly defined from the several mountain ranges to their east. Hilly areas have been taken to be those where the heights are generally below 300 meters the drainage pattern is not dominated by the trend of nearby mountain ranges. The Western hills sub- region includes the Sitakund and Mara Tong ranges and the complex of hills to the south and east of Ramgarh including the eastern part of the Middle Feni river valley. The Sitakund range has a 32 km. long ridge in the middle, which reaches 352m. at Sitakund peak. To the north, the high peaks on this range are Rajbari Tila (275m) and Sajidhala (244m). To the south, there is an abrupt fall and a Chittagong city heights are less than 92m. In the Mara Tong range a height of only 113m. is reached. Further north-east the hills are higher. The topography is deeply eroded and rounded ; the valleys are serpentine and almost isolated hillocks are common. As with most of the Chittagong region hills these are composed of Middle Miocene Tipam series mottled clays and sands and massive and soft ferruginous sandstone, with fossil wood and lignite in them. At Sitakund peak there are several hot springs. There are five broken ranges of hills between the Karnafuli river and the southern tip of Bangladesh. Just south of Chittagong city, across the Karnafuli, is an isolated hill mass. The Danga hill reaching a height of only 34m. at Ullu Tila. This may be the remnant of a Pleistocene terrace. A few miles to the south of it, the Jaldi range strikes south-east and reaches a height of 90 m. at Jaldi peak.

At Chunoti, this range joins with the foothills that extend along the eastern side of the central valley from the Karnafuli river southwards. Here a broad mass of tangled hills and ravines are formed. One arm extends for 36 km. between the Muranja and Tyambang (Chimbuk)

ranges, along the upper Matamori river valley. Southwards the hills break up into several small ranges and many isolated hillocks. There is a slight break where the Matamori river comes through. Continuing southwards the main line of hills throws out several discontinuous ridges, notably at Ringbhong, Khuntakhali, Chowfaldandi and Khurushkul. All these flat-topped ridges may be remnants of a Pleistocene terrace extending from Chhatak (Sylhet district) in the north to Teknaf in the south. The last two ridges of the main line face the hills on Moishkhal island. At one time the Moishkhal range was joined to these ridges, which were then, most likely, continuous and higher. The Moishkhal range is deeply eroded and the mass of hills and ravines is very complex. Its highest peak is Garamchhari 88m high. South of the Matamori river, the main range is known as the Garjania hills. The long Idgarh-Garjania valley lies wholly within it. South of the Bakkhali river the hills reach the sea at Cox's Bazar. Thereafter the main mass of hills goes down the Teknaf peninsula as the Teknaf range. The low uniform hills on the western side may be part of a pleistocene terrace. There is a slight break in the west along the Rejukhal valley. In its northern part, the Teknaf range is comparatively low (61 to 91m.). From Whykong a high ridge runs south ; its main peaks are Baragong (119m), Taunganga (268m), and Nytong (168m). The south-western end of this range ends at a village called Noakhali where there are a series of impressive cliffs, several 30m. in height. The range ends at Teknaf Bazar. South of Gorjania (north-east of Teknaf peninsula) these hills continue into Burma. The Rejukhal valley is an important component of this broken up landscape.

(e) *Middle Karnafuli system valleys :* Within the Hill Tracts District, the Karnafuli has several important tributaries, of which the Chengi, Kasalong and Rinkheong are the main ones. The Kasalong has a big tributary in the Maini river. The valleys of these rivers form a big, somewhat palmate, lowland between the mountain ranges (Map 2.5). The Kaptai Lake formed by the Kaptai Dam has drowned almost the whole of the middle-Karnafuli valley and the lower reaches of the other four rivers. The Mahalchari or Chengi valley is between the Phoromain and Dolajeri ranges, and has a length of 80 km. with an average breadth of less than 6.4 km. The Kassalong river has similarly a long longitudinal valley, between the Bhuacharimain and the Chipui Tlang ranges. A considerable portion of it is in the Kaptai Lake. The Maini valley is yet another long and narrow one . It branches off to the north-north-west from the Kasalong valley and so lies between the Dolajeri and Bhuacharimain ranges. The Rinkheong valley takes off to the south-east from the middle-Karnafuli valley ; it is very narrow and steep. The Kaptai Lake is one of the largest man-made lakes in the world. The official estimate is that it covers 476 sq. km. but unofficial estimates place it at 644 sq. km. when it swells in the

rainy season. In all these valleys, blue clay formed of weathered shale, and also thick bands of shale with layers of ill bedded sandstone are found.

(f) *Bakkhali river valley :* The Bakkhali valley is in two parts : the upper one forms part of the Idgarh-Gorjania valley and is just a small section of the southern hills. The lower valley is, however, a distinct break in the western part of these hills. It is 32 kilometers long and varies from one to sixteen kilometers in breadth. The Bakkhali river meanders through this low fertile valley in an extremely tortuous manner. Like the Feni, Karnafuli and Sangu rivers, it does not form a delta but its silt has badly affected navigation in the Moishkhal channel into which it falls.

(g) *Southern beach plain :* The beach plain is so called because its main feature is the continuous line of sandy beaches and sand dunes backed in places by narrow coastal plains and almost throughout by hills. It extends from the Bakkhali river mouth south to the Rengadumakhal, a distance of 105 km. It is cut across by several streams, of which the Rejukhal, Monkhali and Silkhali are the major ones. There is an almost continuous strip of cultivation south from Rejukhal. This coastal plain varies in width from a 100 m. at Patuartek (Elephant Point) to over a kilometer near Shilkhali. There are cliffs at Bhangamura, 11 km. south of Cox's Bazar, where the sea is eroding a part of the Teknaf range. Evidently the hills north and south of Bhangamura had been formerly eroded in like manner, for a line of cliffs (once known as the White Cliffs) can be made out for 24 km. from Cox's Bazar southwards. At Patuartek and Borodeil, the Teknaf range makes headlands, thus forming slight bays at Inoni and Shilkhali. This is evidently a coastline of submergence.

(h) *Nhila-Teknaf plain :* The hill wash brought down by the tributaries of the Naaf river (an arm of the sea) has formed two coastal plains. The northern one (Nhila Plain) is on the western side of the Naaf river, and is backed by the Teknaf range. The southern one (Teknaf plain) is near the mouth of the Naaf and has the open sea on the west. The two plains are separated only by a narrow spur of the Nytong peak. The similarity of both these long plains to sub-region (a) is obvious: the soil is heavy clay (except for a sandy central ridge in the Teknaf plain), the effects of the tides are of great importance to agriculture, and in the Nhila plain sudden floods from the hills streams are a hazard (as at Sitakund and Banskhali). The upper Naaf is silting rapidly (like the Moishkhal channel).

(i) *Jinjira islets and reefs :* Jinjira is the Bengali name for those islets often marked as St. Martins on maps. These islets are seven km. south-west of the tip of the Teknaf peninsula. There are three islets, joined together at low tide by sandy necks. The northern island is the main one, with an hour-glass shape and a length of 4.9 km. The narrow

waist is barely a couple of hundred meters wide. The two southern islets are very small. All of them are composed of limestone and corals with a thin mantle of sandy soil. Along the south and west shore are big coral reefs. Several kilometres to the west are the Jinjira reefs. To the north-west are the Cypress "sands", actually a large shoal of rocks.

(j) *Mountain ranges and eastern hills* : All the mountain ranges of the Hill Tracts are almost hogback ridges. They rise steeply, thus looking far more impressive than their height would imply, and extend in long narrow ridges, whose tops are barely thirty metres wide. Most of the ranges have scarps in the west, with cliffs and waterfalls. They form sharp water partings and have a trellis drainage system. In all these respects they are different from the low rounded foothills to the west. There are extensive stretches of hills and hillocks in between the ranges.

Four ranges, with an average elevation of over three hundred metres, strike in a north-south direction in the northern part of the Hill Tracts district. The western-most, the Phoromain range, reaches 463m. at Phoromain, 436m. at Rampahar and 417m. at Bhangamura. This range is a continuation of the hill complex south-east of Ramgarh. The next range eastwards is the Dolajeri. Its highest peak is Langtrai (429m). On the eastern side of this range are several high waterfalls : two of the highest have falls of 60 and 40m. Further east, across the Maini valley is the Bhuachari range, which rises to 611m. at Changpai peak. The eastern-most, within Bangladesh, is the Chipui - Lungsir range (also known as the Barkal range). It is bounded on the east by the Tuilianpui river. Its highest peaks, from north to south, are Khantlang (683m), Thangnang (735m), Lungtian (679m), Chipui (480m), Bara Toung (447m), and Barkal (572m). This range divides into two arms 65 km. north of Barkal. One arm reaching the Karnafuli river at Barkal, while the other passes into Indian territory of Mizoram.

South of the Karnafuli river there are seven main mountain ranges within Bangladesh. The Muranja range rises out of the Chunoti hills 5 km. east of Harbang, and strikes in a south-easterly direction. Its well-known peaks are Muranja (502m), Nashpo Taung (586m), and Basitaung (664m). This range can be clearly seen from Cox's Bazar. South of it, and somewhat parallel to it, is Wayla range, which reaches 414m. at Wayla Toung. Most of this range is in Burma. East of Muranja range and also roughly parallel to it are the Tyambang, Batimain and Politai ranges. The Tyambang or Chimbuk range rises south of the Sangu river and continues into Burma. Its main peaks are Lulaing (702m), Thainkhiang (894m), Kro (868m), Rungrang (849m), and Tindu (898m). On a branch of the

Lulaingkhal, near Lulaing peak, there is a waterfall of 107m. height. Near Uparampara further south, there is another high waterfall, with a drop of 45.75 meters.

These southern ranges have a good number of waterfalls of up to 21m. height. Batimain range is a continuation of the low Mara Taung range north of the Karnafuli. It reaches a height of 526m. at Batitaung. The long narrow Sangu river valley is contained by these ranges. The Politai range is the southern continuation of the Phoromain. Its main peaks are Sitapahar (433m), Ghilachari (477m), Ramiu Taung (921m), Politai (831m) and Keokradang (884m).[4] Near Ramiu Taung the Batimain range joins this one. A little further south, the joint ranges merge with the Saichal Mowdok range, which is the southward continuation of the Barkal range. The Saichal range is forked in the north ; the western ridge is the Bilaisari range with Bilaisari peak (669m). Where the fork joins is Saichal peak (648m). Further south the main ridge falls partly within Burma. The high peaks within Bangladesh are Waibung (808m), Rang Tlang (958m), Mowdok Tlang (905m), and Mowdok Mual (1004m), which is on the border with Burma.

4. Bengal Map. No 8 C/NWm, Survey of India (Surveyed 1936-37).

Chapter 3

Hydrography

WATER REGIME

A vast amount of water flows through Bangladesh. It is estimated that in an average year 870 million acrefeet[1] (MAF) of water flows into the country from India. The amount of rainfall received within the country is estimated at 203 MAF, with evaporation, evapotranspiration and deep percolation losses probably accounting for about 120 MAF. This means that about 953 MAF flows out to sea : 914 MAF through the Ganges-Brahmaputra delta within Bangladesh, and 39 MAF through the rivers of the Chittagong sub-region and Feni district.

Table 3.1

Average Annual Surface Water Inflow from India

Month	*MAF*
January	18.7
February	14.7
March	16.7
April	19.9
May	42.3
June	88.9
July	152.5
August	195.5
September	165.6
October	91.8
November	38.6
December	24.7
Annual Total	869.9

1. One million acrefeet equals 1233. 6448 cu. metre.

* The author wishes to thank Mr.S.A.Khan (ex- Dy. Director of the Hydrological Institute & Mr.M.Shahidullah (Dy.Dir. of MPO) for their assistance in updating some of the data in this Chapter.

This vast outflow is second only to that of the Amazon system and both in breadth and total annual volume the Podda-Lower Meghna is the third largest river in the world. The annual picture conceals important fluctuations in-flow during the year. As can be seen from the table of inflow from India, the amount coming in August is nearly seven times as much as in February. There is a close correlation between heavy monsoon rainfall and the flow through Bangladesh. Since nine-tenths of the flow is received from outside the country, the rise and fall of the rivers is governed principally by the amount of rainfall beyond its political boundaries : in Assam, Bhutan and Nepal Himalayas.

The Master Plan Organization (MPO) of the Ministry of Irrigation, Water Development & Flood Control has analyzed recent data and computed the average annual flow of all the rivers and streams to be about 37,590 cubic metres per second[2]. This is roughly equivalent to a total flow of 934 MAF per year (MPO 1984 Vol. II).

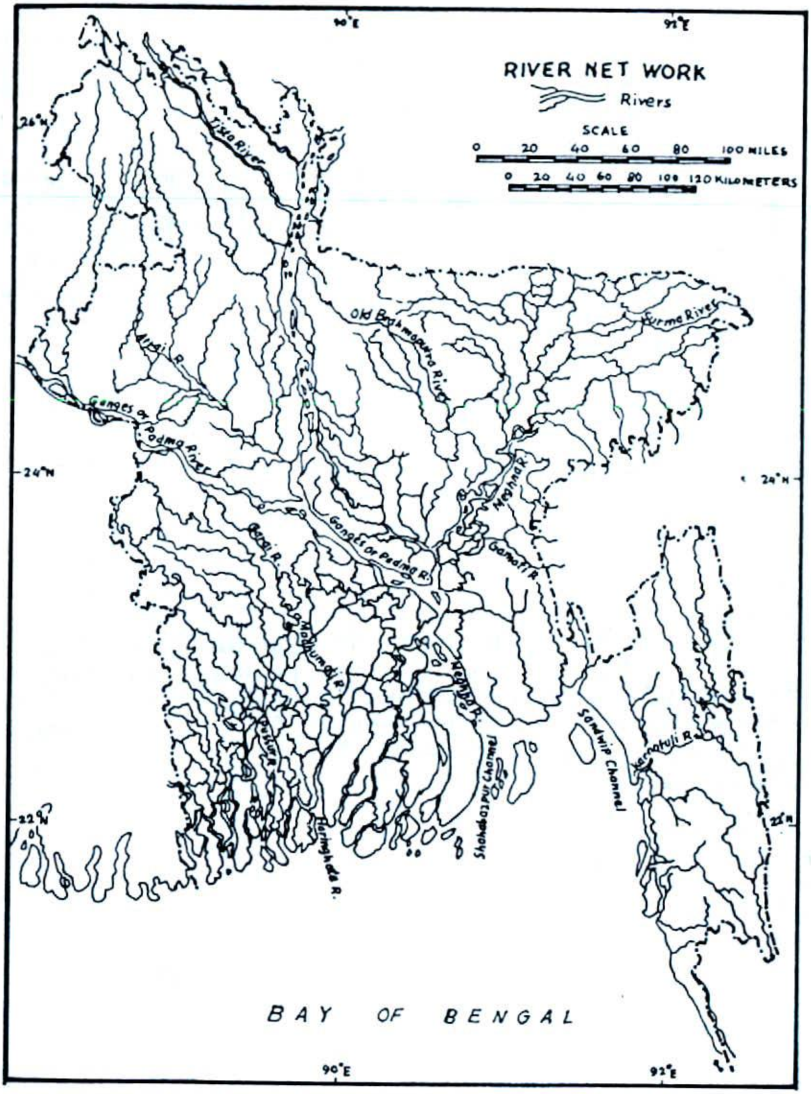
The average annual and low flow (February-April) figures of the major hydrologic areas and rivers are as shown in Table 3.2. The flows of the rivers and streams are particularly important. Since withdrawals for irrigation are mainly in the dry season (December-May). The average annual and average February-April flows for the important rivers in the south and east are given in Table 3.3 below. It should be noted that flows during the main irrigation period are usually a very small fraction of the average annual flows.

RIVER SYSTEM

The pride of Bangladesh is her waterways. The large network of rivers, streams and canals which total at least twenty four thousand kilometres in length. They consist of tiny mountain streams, winding seasonal creeks, muddy *khals* (canals), some truly magnificent rivers and their tributaries and distributaries[3]. In some places, such as Patuakhali and Barisal, the waterways are so plentiful that they form a veritable maze. The water courses are obviously not evenly distributed. They increase in numbers and size from the north-west of the Northern Region to the south east of the Southern Region. All of them, except those of the Chittagong sub-region belong to one or the other three major river systems, those of the Ganges, the Brahmaputra and the Meghna[4] (Map 3.1).

2. 35.31 cusecs is approkimately 1 cu. metre per second.
3. Many small rivers in Bangladesh have the same names. To avoid confusion these have been given the appellation of the Upazila or District in which they are of importance. All those joined together in the rainy season are hyphenated.
4. The Kaptai (lake) reservior may be counted as the fourth.

Map 3.1



RIVER NET WORK
Rivers
SCALE
0 20 40 60 80 100 MILES
0 20 40 60 80 100 120 KILOMETERS
90°E
92°E
26°N
24°N
22°N
Tista River
Old Brahmaputra River
Surma River
Atrai R.
Ganges or Padma River
Meghna R.
Gumti R.
Ganges or Padma R.
Garai R.
Madhumati R.
Meghna R.
Pusur R.
Haringhata R.
Shahbazpur Channel
Sandwip Channel
Karnafuli R.
BAY OF BENGAL

Tista (Teesta)

The Tista was the most important river of the Northern Region till 1787 and was the principal source of supply for the Karatoa, Atrai, Jobuneshwori and other rivers. Considerable structural changes in the Barind Region affected the Karatoa which rapidly dwindled. The Tista with a large amount of water left over, could not pass down the Atrai without causing floods. The excessive rains of 1787 suddenly brought down a vast flood of sand and choked the Atrai channel, with the result that the Tista burst into the very small Ghaghat river, and not finding sufficient outlet, overflowed and swept nearly the whole of Rangpur district. The flood, or rather deluge, happened in a single day, August 27th, 1787. Nearly a sixth of the population of Rangpur died in that year, mainly due to this flood (Vas 1911). The Tista found a new outlet for itself, and it has kept more or less to this channel since then. The frequent changes of its course has left a legacy in the shape of numerous stagnant cut-off channels in the west of Rangpur, most of which are known as *Mara* (dead) or *Buri* (old) Tista. The present channel within Bangladesh is about 177 kilometres long, and varies from nearly 300–550 metres in width. The Tista barrage, under construction since 1978 - 78, was completed in July 1990. It is located 16 km downstream from the Bangladesh border at Doani Point. The Barrage is 615 m. long and has 37 gates each 12 m. wide. The designed discharge is about 350,000 cusecs [9915 cum / sec] Further south, the river joins the mighty Brahmaputra just south of Chilmari. The danger level, rise of water beyond which leads to overflowing, and consequently floods, is at 50 metres above MSL at Dalia point. The minimum discharge is 4,000 cusecs and the maximum is around 35,000 cusecs (WSP 27). The name Tista, it may be mentioned, is derived from the Sanskrit word *Trisrota*, "three currents", and the river, in Hindu mythology, is said to flow from the breasts of the goddess Parvati.

Ghaghat and Bangali

West of the Tista are a number of rivers: the Ghaghat, Dhaljan, Jomuneshwori and Sarbamangla : the last three are tributary to the Brahmaputra-Jamuna. The Ghaghat is a distributary of the Tista. It flows past Rangpur and Gaibandha towns and joins the Brahmaputra a few miles north of Fulchari Ghat. A distributary known as the Bangali, flows south from Gaibandha. The Ghaghat is, for the most part, a sluggish stream, choked with weeds. Its flow varies from 50 to 2,500 cusecs (WSP 62). The Bangali has a larger flow, which varies from 400 to 21,000 cusecs (WSP 28).

Dharla and Dudhkumar

Flowing somewhat parallel to the Tista, and to the north-east, are the Dharla and the Dudhkumar. Both flow into the Brahmaputra.

The Dharla (White) is a swift river in the rainy season, but a braided clear stream in winter. In its upper course, it is known as the Jaldhaka or Singimari. In Rangpur district, it has a small tributary in the Nilkumar, formerly a larger river. The Dharla (known as Dhola in Rangpur) has low and shelving banks and is particularly liable to change its course. In 1947 it completely diluvated the old site of Kurigram town. The Dudhkumar, known in its upper course as Sankosh, is a small river. It also flows in a south-easterly direction and into the Brahmaputra. Right on the eastern border is the Sankosh river of the Bhutan Duars. Major part of this river is in India.

Table 3.2

Average Annual Flow of Water.

Stream Flows Source : MPO 1984 Vol.II.	Annual Flow (m^3/sec)	Feb-April Flow (m^3/sec)
Brahmaputra (Bahadurabad)	19,500	5,400
Old Brahmaputra (inflow only)	2,320	113
North-west, Northern Region (outflow)	3,100	423
North-east Central Region & Sylhet (outflow)	6,710	293 (Jun-Mar)
South-west (Southern Region)	1,990	146
South-east (Comilla, Feni, Chittagong)	1,010	183

Note : The average annual flow for the South-east has been increased by 11 m^3/sec because the MPO calculation did not include a large number of small rivers, notab ly Idgong, Reju and Naaf. (MPO 1984 ; Vol.II)

Karatoa (Deonai-Jamuneswani-Karatoa-Bangali-Phulyhore System)

The Karatoa is an intriguing river. It was formerly the main channel of the Tista, and possibly was also a distributary of the Brahmaputra. In the Siyar-al-Mu'takhkhirin it is recorded that this river was three times the size of the Ganges when Bakhtiar Khilji invaded the Northern Region (c.1115 A.D.). It is now broken up into four distinct parts. The tectonic disturbances which led to this have been mentioned earlier. The northern part, hereafter called the Dinajpur Karatoa, is the main source of the Atrai. It rises in a marsh in Baikanthapur in Jalpaiguri (India), but also receives water from underground streams. From Khansama Upazila its name changes to Atrai. The Dinajpur Karatoa was connected with the Rangpur Karatoa north of Khansama, but very little water passes down that channel at present. The upper part of Rangpur Karatoa originates in the Jalpaiguri district of India and is known as Deonai-Jamuneswani upto Gobindaganj.

The Jamuneswani-Karatoa flows in slight meanders south-south-eastwards to Gobindoganj Upazila where the main stream turns east-wards through the Katakhali and falls into the Bangali. The portion of the former river through Shibaganj Upazila is dry most of the year it effectively separates the Rangpur Karatoa from the Bogra Karatoa. The latter river flows past Bogra town and southwards, till it joins the Bangali to make the Phuljhor river, which falls into the Hurasagar. The maximum discharge of the Bogra-Karatoa is below 3,000 cusecs (WSP 52) and it has declined rapidly since the construction of the Brahmaputra Right Embankment. The fourth part, the Pabna-Karatoa is a moribund river bed near Handial. Various other channels are also pointed out as those of the old Karatoa. The ancient Karatoa must have been a large river. In Ven den Broucks map of Bengal, prepared in 1660, it is shown as a large channel, and in Major Rennell's map, prepared in 1776, it is still a major river. As late as 1810, Buchanan-Hamilton writes of it as 'a very considerable river.' The decline, however, came so rapidly after the 1820 flood that the old banks of the river are distinctly traceable nearly 1.609 km. apart (Gupta 1910). The river was formerly sacred to the Hindus, as the derivation of the name shows. Kar (Hand) and Toa (Writer) signified that the river was formed by the water which was poured on the hands of Siva, when he married the mountain goddess Parvati.

Little Jamuna

West of the Rangpur and Bogra Karatoas is the Jamuna hereafter called the Little Jamuna, to distinguish it from its giant namesake. The Little Jamuna rises in Jalpaiguri district (India) and flows more or less southwards through eastern Dinajpur district and drains western Bogra district and falls into the Atrai in Naogaon district. The Tulshiganga and Chhiri Nadi, both of which drain the Eastern Barind, are its principal tributaries. The Little Jamuna, as has been mentioned earlier, has carved out its own valley in the Barind, which separates the Eastern from the East-Central Barind.

Atrai (Karatoa-Atrai-Gur-Gumani-Harasager)

The Karatoa-Atrai is west of the Little Jamuna. It is the western most tributary of the Brahmaputra. Its main source is the Dinajpur Karatoa, which changes its name in Khansama Upazila to Atrai; this channel bifurcates north-west of Chirirbandar and reunites south-west of it. The western are is called Gabura and the eastern is called Kankra. The re-united river is once again the Atrai, which flows almost due south to Manda Upazila separating the East-Central and West-Central Barinds. It receives many small streams while passing through

the Barind, but its flood-plain between the Barind tracts is only a couple of kilometres wide. From the Manda Upazila, the river flows south-east. At Shutigachha, Little Jamuna joins it. A few kilometres further down, near Atrai railway station, the river bifurcates into the Gur and the old Atrai channels. The old Atrai, the southern channel, flows south and then east. The Baranoi, which drains the southern part of the Lower Atrai Basin, joins it at this second bend. The course of the river is henceforth difficult to follow since in the very low-land of the low Bhar, rivers bifurcate and re-unite a number of times. The Narad and the Nandakuya join the old Atrai from the south by a number of channels. The northern channel, known as the Gur, receives the main flow of the Nagar, which drains the southern part of the Eastern Barind near Singra. The Gur too bifurcates and each of its arms bifurcates in turn. The old Atrai is called the Gumani after it is joined by the Nandakuya. The Gur joins it at Chanchkoir, near the eastern end of the Chalan Bil. The confluence in the rainy season is a very large sheet of water, known as *Eailam*. The joint river is known as Gumani till the Baral joins it east of Chatmohar, from where it is known by the latter name. Then 48.27 km. down-stream, the Atrai-Baral is joined by the Phuljhor (Bangali-Karatoa): the combined stream is known as the Hurasagar, which in turn falls into the Brahmaputra-Jamuna. The whole course of the Atrai-Gumani-Baral-Hurasagar will be referred to as Atrai for simplicity's sake, unless a specific reference to one of the component parts is made. This river formerly flowed into the Podda near Ratanganj in Bera Upazila, but after the changes of 1787 no water flows down that way. The Atrai is said to be identifiable with one of the sacred rivers of the Mahabharata.

Purnabhaba - Mahananda

The rivers west of the Atrai are all tributary to Ganges, but since they also drain the Ganges-Brahmaputra paradelta, they may be described here. The upper course of the Purnabhaba is just a few kilometres west of the Atrai. The main source of the former river is the Brahmanpur Barind. It is joined by the Dhepa which is a distributory of Atrai. Just south of Dinajpur town this river flows between the Western and West-central Barinds, and drains the west of the West-central part. Its valley, as has been earlier mentioned, is from 3 to 8 kilometres broad. It joins the Mahananda just south of Kohanpur. Between the Purnabhaba and the Mahananda river are three other tributaries of the latter river, the Tangon, Kulik and Nagar. The Tangon has an entrenched valley, even in the Piedmont Plain. Along the Kulik the land is markedly undulating. The Nagar forms the western border of Dinajpur district for many kilometres. The Mahananda, a major tributary of the Ganges, rises near Mahaldiram in Darjeeling district (India). It forms the western

boundary of Bangladesh at Tetulia Upazila and then again at Ranishankoil Upazila. Flowing through India, it again forms the boundary of Bangladesh near Bholahat, then flows through Chapai Nawabganj district and joins the Ganges south of Nawabganj town. The banks of the last portions of the Mahananda are alternately sheer and sloping, and the river is 275 to 550 metre (330 to 600 yards) wide, and deep. Rise of water can be 6 metre or more within a short time during the rainy season. The average maximum flow is about 1830 m^3/s (65,000 cusecs) flood discharge can be over 2150 m^3/s (80,000 cusecs) at Chapai Nawabgonj. The winter flow, as can be expected, is only a few hundred cusecs.

Bangali

Before coming to the Brahmaputra itself, a mention of the Bangali river is necessary. This river is a continuation of the Ghaghat river of Rangpur. It has a connection with the Jamuna in the east, and with the Karatoa (through the Katakhali) from the west at Ramnagar. Flowing south, it receives the Belai distributary from the Brahmaputra and further on bifurcates, the western arm being called Halhalia, while the eastern retains the original name. The Bangali arm receives the manash Madhukhali distributary of the Brahmaputra north of Dhunot and within a few kilometres bifurcates to send an arm due south, known as the Ichhamati (Sirajganj). The Bangali flows south-west from this point ; and receives the Halhalia west of Dhunot and the Bogra Karatoa further south near Khanpur. The united Bangali-Karatoa, as has been mentioned earlier, is the Phuljhor, which joins the Atrai-Baral to form Hurasagar. The Sirajganj-Ichhamati is joined by the Kazipur distributary of the Brahmaputra in Kazipur Upazila. The combined stream falls into the Phuljhor at Nalka.

The Simla Khal, an offshoot of the Jamuna, flows east of Sirajganj town and joins the Dhanbandi, another Jamuna offshoot, which flows through that town. The Dhanbandi falls into the Hurasagar at Manpur. The Hurasagar itself is an offshoot of the Jamuna. It flows south-west, then south, and finally south-east to rejoin the Jamuna north of Bera. Its mean discharge from June to September is about 100,000 cusecs.

Brahmaputra - Jamuna

The Brahmaputra-Jamuna is the second largest river in Bangladesh. In size it is gigantic. In the rainy season the river is nowhere less than five kilometre broad, and often ten kilometres or more. It is, through

Table 3.3

Available Streamflow

Southwest

River and Station	Period of Record Used in Analysis (water year)	Average annual flow (m^3/sec.)	Average February-April flow (m^3/sec)
Mathabhanga River at Hatboalia	1957-62, 1967-77-88	36.0	7.0
Kumar River (Jessore) at Garaganj	1961-62, 1965-76-76	16.5	3.7
Gorai River at Gorai Railway Bridge	1975-88	1360.0	70.0
Kumar River (Faridpur) at Mazurdia	1965-76	36.3	1.0
Arial Khan River at Chowdhury char	1975-88	492.0	57.0
Kobadak River at Jhikargacha	1965-78	13.6	4.2
Begabati River at Arpara	1967-69, 1974-75	20.7	2.1
Chandana-Arkandi Khal River at Ramdia	1965-74	11.0	0.43
Chitra River at Kaliganj	1959-62, 1969-75	3.06	0.14
	Total	1,990	146

Southeast

(Post-Farakka flow is often zero in some years.)

Gumti River at Comilla	1965-70, 1972-88	72.5	18.6
Little Feni River at Gunabati Railroad Bridge	1966, 1974-78	40.4	10.9
Muhuri River at Parsuram	1965-81	23.6	4.56
Feni River at Kaliachari	1975-82	57.5	9.97
Halda River at Panchpukuria	1965-69, 1974-82	36.9	4.94
Ichamati River at Thandachari	1965-82	8.89	1.32
Sangu River at Bandarban	1965-67, 1970-88	86.7	7.0
Matamuhuri River at Lama	1965-88	72.0	10.63
Bagkhali River at Ramu	1965-88	30.5	2.05
{Karnafuli River at Kaptai Dam	1962-69	570.0	1,113.0}
	Total	999	183
	Grand Total	2,989	329

Source : MPO June 1984, Vol. II

most of its course within Bangladesh, studded with islands (Chars) many of which go under water during the rainy season. One such braided portion is to the east of Kurigram Upazila, where the 4 main channels and three islands are together 11 km (seven miles) in breadth. Thus, by breadth alone, this river qualifies as one of the largest in the world. The discharge during the rainy season is enormous, averaging 40,000 m^3/s, by which measure too, it ranks with the Amazon, Congo, La Plata, Yangtse, Mississippi and Meghna as one of the seven largest rivers.

The name Brahmaputra-Jamuna is used here, because in popular parlance the Brahmaputra continues south-east (as the Old Brahmaputra), and the river between Bahadurabad and Aricha is the Jamuna and not Brahmaputra. The origin of this Jamuna channel has been explained earlier. Since the layman and most of the official agencies recognise the Jamuna as a river with some sort of difference from the Brahmaputra, the latter name is given to the stretch from Nunkhawa to Bahadurabad and the stretch whole south to Aricha is referred to as the Brahmaputra-Jamuna. The Hydrology Directorate of the Water Development Board refers to the whole stretch as the Brahmaputra-Jamuna.

The total length of the Tsangpo-Brahmaputra-Jamuna river is about 2700 kilometres. The total drainage area down to Aricha is 580,000 sqkm of which 293,000 sqkm are in Tibet, 241,000 sqkm in India and only 47,000 sqkm in Bangladesh (WSP 18). There are guage and discharge records for this river at Bahadurabad, where flow represents the flow entering Bangladesh plus those of the Dudhkumar, Dharla, and Tista, and minus those of the Old Brahmaputra and Bangali. The drainage area above Bahadurabad is 536,000 sqkm (WSP 18). The highest recorded flood has been 98,600 m^3/s (Ang/88) or 3.48 m/cs (MPO, NWP-II). In comparison, the maximum measured flood on the Mississippi river carried about 2.4 m/cs (Morgan & McIntire 1959). It is estimated that the maximum discharge of the Brahmaputra-Jamuna is likely to exceed 3.5 m/cs. During the rainy season it brings down something like 1.2 million tons of sediment daily, and the annual silt run-off at Bahadurabad is estimated at 735 million metric tons. Average annual flow at Bahadurabad is estimated to be 501 million acre-feet.

August has always been the month when widespread flooding has been most likely. Floods from May to July are usually due to the Brahmaputra-Jamuna and Meghna. From August to October due to the combined flows of those river and the Ganges. As a rule, the flow of the Brahmaputra-Jamuna is more erratic than that of the Ganges. The gradient of the Jamuna averages 1 : 11,850 which is slightly more than that of the Ganges.

Old Brahmaputra

The Old Brahmaputra takes off from the left bank of the Brahmaputra to the north of Bahadurabad. Flowing more or less to the south-east it passes by Jamalpur and Mymensingh towns and falls into the Meghna at Bhairab Bazaar. Its average gradient is 4.7 cm. per km. Over most of its course, the right (southern) bank is higher than the left. Before the 1787 changes, the river was a kilometre and a half wide. The left side levee can still be traced, more than three quarter of a kilometre from the present left bank. The flow in a river of that size and with the given gradient could have reached a maximum of two million cusecs.

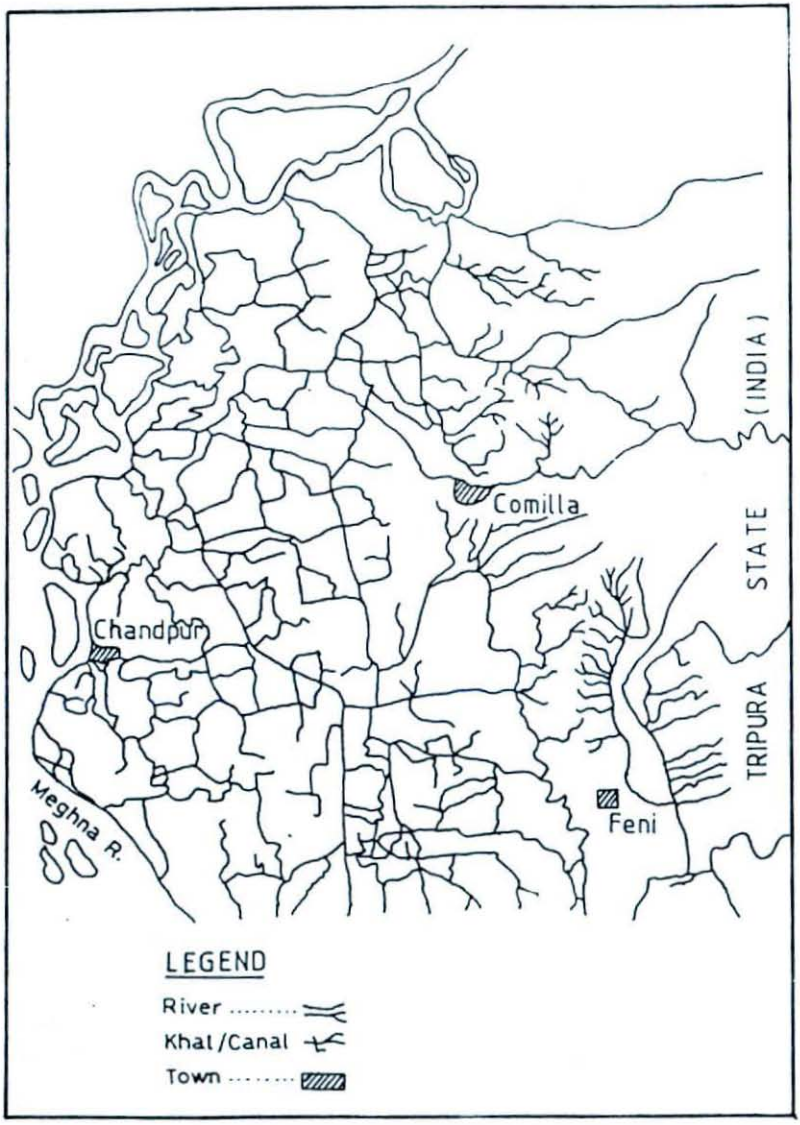
The mean discharge from the middle of May to the middle of October at Mymensingh is about 50,000 cusecs (WSP 69). The river is nearly half a kilometre wide at Mymensingh town. It has two main off-shoots, the Jhinai and Banar. The Jinai takes off north-west of Jamalpur town, joins the Chatlai channel of the Jamuna and falls into that river just north of Sharishbari. The Banar is joined to the Old Brahmaputra at Nandina, and receives quite a lot of water from it in the rainy season. After passing the main volume of its water down the Lakha river, the Banar falls into the Old Brahmaputra at Egaro Shindur and the latter river joins the Meghna at Bhairab Bazaar. Formerly the Kangsha was an important left bank distributary of the latter river, but its head has silted up leaving it an attenuated seasonal stream. It flows north-east, east and then east-southeast to join the Dhanu. Its discharge varies from 500 to over 40,000 cusecs (WSP 61). The Nitai and Bhogai are tributary to the Kangsha. The Someshori comes down from the Garo Hills and joins the Surma south-east of Kalmakanda. A large number of streams come down from the Garo Hills, of which the western Someshwori, Malijhi, Tharua, Tolongs, Bhogai and Dursha are the main ones. They drain into the Kangsha.

Dhaleswari

The Lohajang river branches off from the Jamuna north-west of Tangail town and the Dhaleswari branches off seven kilometres to the south-west. These two join near Elashin and flow south-east as the Dhaleswari. The Dhaleswari bifurcates and the southern arm flows south of Manikganj and joins the main stream, which flows north of Manikganj 48 km to the south-east. This southern arm, the Kaliganga river, now carries more water than the Dhaleswari. Just north of their confluence the river again bifurcates, the southern arm retaining the name, while the northern is called Buriganga (Old Ganges). It flows past Dhaka and joins the Dhaleswari at Fatulla. The Dhaleswari is joined by the Laklya at Narayanganj.

Map 3.2

TIPPERA SURFACE DRAINAGE PATTERN



The river is then very large. It, in its turn, joins the Meghna at Shaitnol, and loses its separate identity. The mean discharge of the Dhaleswari in the rainy season, at Manikganj, is about 200,000 cusecs.

Bangshi

The Bangshi is an important tributory of the Dhaleswari river. It originates from the foot of the terrace area of the Madhupur and receives spills from the Brahmaputra, travels southwards to fall into the Dhaleswari river at Savar. Its peak flow is 1000 m^3/s and minimum flow is only 5 m^3/s at Mirzapur.

Surma - Meghna

East of the Brahmaputra system of rivers is that of the Surma-Meghna. The Surma river rises as the Barak, on the southern slopes of the Naga-Manipur watershed. The Barak divides into two branches within the Cachar district of Assam (India). The northern branch, Surma, or more correctly Surma, flows west and then south-west to Sylhet town. Beyond there, it flows north-west and west to Sunamganj town, from where it maintains a course south-west and then south to Madna, where it meets the Kushiara branch. It receives several rivers and streamsfrom the Meghalaya Plateau from the north. From east to west they are the Lubha, Hari (Kushia), Goyain Gong (Chengar Khal), Piyain, Bogapani, Jadukata, Someswori, and Kangsha. The flood period is generally from the last week of May to the middle of October, the mean discharge in this period being about 30,000 cusecs. Between 1950 and 1958 the maximum and minimum discharge recorded were 53,008 cusecs (15th August, 1958) and 487 cusecs (21st March, 1954) (WSP 10). The Surma bifurcates south of Mohanganj, soon after it receives the Kangsha and, further south, the Mogra. The western channel is known as Dhanu in its upper course, Boulai in the middle and Ghorautra lower down. It joins the Meghna near Kuliarchar. The southern branch of the Barak, the Kushiara, receives the Manu (with flood discharge of about 15,000 cusecs) (WSP 31), north of Moulvi Bazaar town and bifurcates into a northern channel, the Bibiyana, and a southern one, which resumes the name of the original river, the Barak. The Bibiyana changes its name to Kalni, lower down its course and joins the Surma near Ajmiriganj. The Barak (western) receives the Gopla and Khowai from the Tripura hills, and falls into the Surma at Madna. The way these rivers change their names is indeed confusing. To make matters worse, there is no general agreement as to where one name should begin and the other end. The Surma from Ajmiriganj down-stream, is often referred to as the Meghna. The matter would be

simple but for the fact that from Madna downstream for about 26 km (in a straight line) one of the two channels of the Surma-Meghna is known as the Dhaleswari. Unfortunately, this northern Dhaleswari has the habit of changing sides, so that east of the Surma-Meghna channel, but west of that place it is west of that channel. The switch takes place south of Oshtogram, where both channels meet and is known as the Dhaleswari. To avoid confusion the main channel from Ajmiriganj down to the confluence with the Dhanu-Ghorautra will be referred to as Surma. This confluence five kilometres is east of Kuliarchar. Downstream from there, the river will be referred to as Meghna. Most of the Surma system falls in the Haor Basin, where the line of drainage is not clear and well defined. In the Piedmont tract from Durgapur to Jaintapur, most of the network of streams and channels overflow in the rainy season and create vast sheets of water which connect the Haors with the rivers. In the Haor Basin too, the rivers overflow and fill the Haors in the early part of the rainy season, and receive back much of the water soon as the monsoon rains slacken.

The Meghna has two distinct parts. The upper Meghna from Kuliarchar to Shaitnol is a comparatively small river. The lower Meghna below Shaitnol is one of the largest rivers in the world, because it is the mouth of the Ganges and Brahmaputra rivers. The lower Meghna is here treated as a separate river. The Meghna receives the Old Brahmaputra on its right bank at Bhairab Bazaar. A little above the confluence the Meghna has a railway bridge over it. The width of the river there is three quarter of a kilometre. The mean discharge at that point, from late May to mid October, is about 7,100 m^3/s with a recorded max. of 14,000 m^3/s (MPO NWP-II). Average annual discharge is estimated to be 92 million acre-feet. Several small channels separate from the Meghna and meandering through the lowland bordering the Tippera Surface, receive the flow of a number of hill streams and re-join the main river down-stream. The most important of these offshoots is the Titas, which takes off south of Ghatalpar and after meandering through two long-bends, extending over 240 km re-joins the Meghna through two channels, in Nabinagar Upazila. It receives the Howrah hill stream near Akhaura. Brahmanbaria and Akhaura are both on the banks of this river. Other offshoots of the Meghna are Pagli, Katalia, Dhonagoda, Matlab and Udhamdi. The Meghna and these off shoots receive the waters of a number of hill streams from the Tripura hills. The important hill streams are the Gumti, Howrah, Kagni, Senai Buri, Hari Mangal, Kakrai, Pagli, Kurulia, Balujuri, Sonaichari, Handachora, Jangalia and Durduria. All of these are liable to flash floods. The Gumti, Kakri and Howrah are the main culprits. They have silted their beds to the extent that they now flow above the mean level of the land when brimful. Embankments have

been built to contain them. Most of these are looked after by the farmers and are, therefore not sufficiently strong. Every other year one or the other of these streams overflow and cause considerable damage to crops, live-stock and houses.

The Meghna receives the Tippera Surface streams from the east, and the enlarged Dhaleswari from the west. At the confluence, just north of Shaitnol, the Meghna is about five kilometres broad. The Dhaleswari comes down in a brown stream and the Meghna is a clear blue-green. For many kilometres the waters do not seem to mix, for half the river remains brown and the other half is blue-green. The boatmen are fond of pointing out this peculiarity.

Sixteen kilometres from Shaitnol, the combined Ganges and Brahmaputra-Jamuna, as the Podda (Padma) river, meets the Meghna in a large confluence 11 km wide in the rainy season. From this point southwards the Meghna becomes one the largest rivers in the world.

Gumti, Dakatia, Little Feni:

The Gumti falls into the Meghna at Daudkandi. Its flow varies from 100 to 20,000 cusecs at Comilla. Another tributary from the Tippera Surface is the Dakatia. The main source of this river was the Kakrai, but the Little Feni cut back and captured this upper portion. The Dakatia now has its source in the Chauddagram Khal (canal), which connects it with the Little Feni. The Dakatia sends out a channel southwards, which forms the Noakhali (new canal) Khal. The main channel, meanders westward to Shekherhat, from where the old course goes south to join the Meghna at Raipur, and the new and more strong channel passes through the Chandpur Khal to join west of Chandpur town. For three-fourths of the year the Dakatia is fed by tidal currents from the Meghna. The Little Feni follows a very tortuous course south-wards, and falls into the Meghna estuary, south-east of Companyganj and a few kilometres from the Big Feni estuary. The Little Feni is a tidal river; in the rainy season its flow is around 15,000 cusecs. At flow tide there is a reversal of flow of the same volume (WSP 25).

The Tippera Surface (Map 3.2) shows a well marked rectangular drainage pattern. Its cause has been ascribed to the excavation of ditches for earth to build dikes (Morgan and McIntire 1959). This is only part of the reason. To drain off surplus rain water and to avoid the tight meanders of the hill streams as water-ways, large numbers of canals have been dug in this region. Some of them are very ancient in origin. These canals are sufficiently numerous to give a rectangular pattern to the drainage system. Among the most important of them are Chandpur, Boaljuri Trimani, Chauddagram, Bijoypur and

Gokarana Khals. All of these canals are joined to the numerous channels which drain off the surplus water of the tanks. A typical drainage channel cuts past several homesteads, every tank of which has an outlet into it. The main canals have a large number of such channels flowing into them. The canals (Khals), drainage channels and tank outlets together form the grid pattern which is typical of this area.

Table 3.4

Average Monthly Discharge of the Major Rivers

(a) Pre Farakka : MAF (b) Post Farakka : m^3/s

Month	Ganges (Hardinge Bridge)		Brahmaputra (Bahadurabad)		Meghna (Bhairab Bazar)	
	a	b	a	b	a	b
January	6.76	1750	11.28	4930	1.29	435
February	5.32	1350	8.45	4230	0.97	290
March	5.02	1080	10.23	4800	1.38	380
April	4.32	1150	14.34	7510	1.97	1130
May	4.28	1500	34.41	15290	4.20	3270
June	9.06	3370	68.28	30350	8.03	5910
July	38.81	19800	95.73	46180	16.97	10280
August	81.54	40120	97.96	43190	17.98	11450
September	77.70	39500	76.28	38050	17.28	10290
October	37.45	16550	47.68	23640	13.55	7570
November	14.94	5730	22.02	10740	6.47	3660
December	9.11	2900	14.63	6880	2.15	1035
Annual	294.31	---	501.27	--	92.24	--

Ganges

The Ganges, the most sacred of all river to the Hindus, rises west of the Nanda Devi Range, and quite close to the sources of the Indus and the Tsangpo (Brahmaputra). It has a length of 2200 km (1370 miles) upto Goalundo, and 2526 km (1570 miles) to the mouth of the Meghna, and a drainage area of 977,500 sqkm (377,400 sq.miles) upto Goalundo. Its average pre-diversion, (ie. before the commissioning of the Farakka Barrage in India (1975), about 40 km upstream from the Bangladesh border) the discharge in winter was 2265 m^3/s (80,000 cusecs) and in the rainy season 18,150 m^3/s (640,800 cusecs).

The average annual discharge at Hardinge (Sara) bridge (1934-62) is 11,611 m^3/s (410,000 cusecs), as compared to 19,201 m^3/s (678,000 cusecs) of the Brahmaputra at Bahadurabad (1956-62). Total flow per year is estimated to be 294 million acre-feet (Table 3.6). In the middle Ganges valley, nine large tributaries join it. From Patna downstream it is as large as when it first forms the border of Bangladesh at Shibganj. Just west of that place it sends south its first distributary, the Bhagirathi, which becomes the Hoogly further down. Just west of Godagari town the Mahnanda, a large river in the rainy season, falls into the Ganges. The Baral, a left bank distirbutary, takes off at Charghat while the Bhairab and Mathabhanga, take off from the right bank, south-east of that place. The Baral joins the Atrai-Gamani system. The Jalangi channel of the Bhairab and the Bhagirathi - Hoogly are entirely in the Western Region.

Bhairab.

The Bhairab is an important river in the Moribund Delta. Its name means 'the terrible', and attests to the size it had reached when the main volume of the Ganges was carried by it. At present the main stream is not navigable beyond Bagherpara Upazila. It has two main branches, the Khulna-Ichhamati and the Kobadak. The Khulna-Ichhamati has part of its course in India and part in Satkhira district, and forms the boundary between the two countries. This river too is prone to change names. Down to Kaliganj, it is Kalindi till Kaikhali, from which place it is the large estuarine river, the Raimangal, which splits up into two, the western named the Hariabhanga, and the eastern retaining the original name. Down to Kaikhali, the river will be referred to as Khulna Ichhamati, while south of it. it is the Raimangal - Hariabhanga.

Kobadak

The Kobadak, a corruption of Kapotakshi (the 'pigeon-eyed'), flows south to the forest outpost of Kobadak at the edge of the Sunderbans, and there joins the Kholpetna to form the large estuarine river, the Arpangasia. The Bhairab flows south-south-east, to Khulna town, where it joins the Khulna-Atai and becomes the Rupsha. Just south of the town the Rupsha branches into two, the eastern one of which resumes the name Bhairab and flowing southwards loses itself in the estuarine rivers, Keora and Bhola.

Between the Mathabhanga (the 'Broken Head') and the Gorai, a large right bank Ganges distributary taking off near Kusthtia town, there are a large number of rivers and Khals (canals). The Mathabhanga

splits up into four main channels, the Churni, Chitra, Nabagonga and Kumar, within Kushtia district. The Churni joins the Bhairab, and is an important source of its Khulna-Ichhamati branch. The Chitra flows south-south-east to Uzirhat, where it divides into two branches, the Khulna-Atai and the Chitra: the former joins the Bhairab north of Khulna town, while the latter joins it to the south. The Nabagonga (New Ganges) is another decayed channel, navigable in the rainy season and only up to Magura. The lower Nabagonga channel takes much of the Gorai's flow into the Pussur river. The Kumar, also called Pangasi, branches from the Mathabhanga, 16 km from Alamdanga town and flows in a south-easterly direction to a point eight kilometres north of Magura town, where it divides into two channels, one of which falls into the Gorai, the other joins the Nabagonga through the Muchikhali at that town.

Gorai (Gorai-Madhumati-Baleswar)

The Gorai is formed of three large offshoots of the Ganges just north of Kushtia town. South of Kushtia its first offshoot, the Kaliganga, branches off to join the Kumar near Sailkopa. This river has been completely dammed by one of the primary canals of the Ganges-Kobadak project and the lower half of the course is now almost a dry bed. The main river bifurcates and re-joins several times as it flows south-east to Muhammadpur Upazila from there flowing south-south-west. It changes its name to Madhumati. The Kumar, Nabagonga, and Chitra join it through several channels south of Mollahat Upazila. There the name changes to Baleswor (the 'Young Lord') which in turn changes to Haringhata (the 'Deer Ford') from the Bogi forest outpost of the Sunderbans. The Gorai-Madhumati has a flood discharge of nearly 7,000 m^3/s, but in winter its flow has gone as low as five cusecs (MPO-NWP-II).

All the rivers between the Khulna-Ichhamati, Ganges, Gorai-Madhumati and the sea are connected by cross-channels, which are especially numerous in the Sunderbans. They are of great importance to inland navigation in the delta, for though the rivers flow in a north-south direction, the traffic is mainly east to west.

The drainage pattern is very complicated in the Immature and Mature deltas. The main grid is based upon four rivers the Raimangal-Hariabhanga, Kobadak-Arpangasia-Malancha, Shibsha-Pussur-Marjata and Madhumati-Haringhata all of which flow from north to south. Between the Raimangal and Kobadak rivers are the Khulna-Jamuna, Galghashia and Dholpetua rivers. The Galghashia joins the Dholpetua, which joins the Kobadak to form the Arpangasia.

This river divides into three. The western most, Araibaki is joined by the Firingi cross-channel from the Khulna-Jamuna and under the name of Malancha flows into the estuary of the same name. The eastern-most, the Bol, joins the main stream to form the large Barn Panga, which widens cut into the estuary, after the much smaller Malancha, which also flows into it.

Cross-channels such as the Sakbaria, Bajharia, Bajbata and Koyra connect the Kobadat-Arpangasia with the Shibsha. This latter river is formed of the Balta, Ghansrail, Bhadra, Deluti, Henus Badurgachha and Dhaki rivers, which drain the Boyra swamps and bring some of the Pussur's flow. The Shibsha joins Pussur near the sea to form the Morzal river, which flows into the Marjata estuary. A branch of the Shibsha, the Hansraj - Kaga bifurcates from that river and also joins the Morzal.

Rupsha - Pussur

The Pussur (also called the Pusur or Pushur) is the continuation of the Rupsha, which as mentioned earlier, is formed of the union of the Bhairab and the Atrai. At present much of its water is from the Gorai diverted through the Nabaganga. From near Baitaghata the Rupsha changes its name of Kazibacha, which is given up near Chalna for the name Pussur. Near the Mongla port, the Pussur receives the Mongla river, and near the forest outpost at Chandpai it receives the Mirgamari cross-channel from the Bhola, both on the left bank. On the right bank the Manki, Dhaki and Bhodra are connected with the Shibsha System. In the lower delta, the Pussur is second only to the Meghna in size. Formerly it was third, after the Madhumati, but with the considerable diversion of the Gorai flow through the Nabaganga, it is now bigger than that river. From its junction with the Mongla, it is nowhere less than a kilometre and a half wide. Thirty two kilometres from the open sea, it joins the Shibsha to form the five to eight kilometres wide Morzal river, which empties into the Bay by the Marjata and the Pussur estuaries.

The land between the Pussur and Bhola is drained by the Sela, which lies wholly within the Sunderbans. Many cross-channels connect it with the systems on either side. A large cross-channel connects with the Morzal, at the head of its estuary which is the Bangara.

East of the Sela the next big river is the Bhola, which begins as a small channel where the Bhairab becomes the Keora tributary of the Baleswor. The Bhola falls into the Haringhata estuary of the

Baleswor. The Baleswor, which is the continuation of the Gorai-Madhumati has played a very important role in building up the Mature Delta. The rich Bagherhat and Pirojpur districts depend upon it for the annual deposit of silt. Formerly the flood waters kept the sea-water from reaching beyond Bogi at the edge of the Sunderbans but with the diversion of the Gorai into the Pussur, the river is decaying. The flow was sufficient to make the forests of freshwater nature to grow within sixteen kilometres of the sea. At the point of it junction with the Bhola it widens out to 6 km to form one of the sources of the huge Haringhata estuary, which also receives the flows of the Bishkhali and the Buriswar (Burishor) and so reaches a maximum width of nineteen kilometres.

Podda (Padma)

The Gorai-Madhumati Baleswar (Baleshor) is the eastern-most distributary of the Ganges proper, which does not throw out any more major off-shoot down to its confluence with Brahmaputra-Jamuna at Goalundo. From Goalundo downstream the combined Jamuna and Ganges forms the Podda. This name (Podda or Padma) is applied to the Ganges as far up as the point at which the Bhagirathi leaves the left bank, and according to the Hindus, takes the sanctity of the Ganges with itself. It is hydrographically more correct to call the river Ganges down to its confluence with the Jamuna. The Podda is sometimes referred to as the Ganges but this is incorrect, not only because this channel was opened out due to the diverted flow of the Brahmaputra, but also because for most of the year, the Brahmaputra-Jamuna contributes more to the flow of the Podda than to that of the Ganges. The river between Aricha and Sureshwor is therefore, best called the Podda for it has every right to be regarded as a separate river. The Podda is 120 kilometres long and from 4 to 6 kilometres wide. The very important Goalundo-Chandpur steamer route is mostly on this river near Tepakhola, 14 km from Goalundo, the small Faridpur Khal distributary takes off from the right bank. Fifty kilometres further down the Arial Khan river also takes off from the right bank. Fourteen kilometres further downstream the Lohajang Khal falls in at Lohajang on the left bank, and the Kristanagar river branches off from the opposite side. A few kilometres below that place, the Shosha Khal and Naria Khal, take off from the right bank, join up and as one stream fall into the Arial Khan south of Madaripur. The Podda joins the Meghna five kilometres from Sureshwor in a maze of shifting shoals and Chars. The Lower Meghna is actually a continuation of the Podda.

Arial Khan and the rivers of Barisal-Patuakhali

The Faridpur Khal joins the Kumar, which meanders across the north of Faridpur district and falls into the Arial Khan at Shibchar. The Arial Khan was, in the second half of the nineteenth century, one of the main outlets of the Podda. It has silted up at its head. It bifurcates below Madaripur, but receives back it offshoot, the Turki, below Gaurnadi, and reinforced by the large Safipur offhoot of the Meghna near Muladi, joins that river as a large stream eleven kilometres north-east of Barisal town. The lower Arial Khan and the Madhumati are two of the three main sources for the large network of rivers and Khals in Barisal. The third source is the Bil area of the Central Delta. The Darika Don and the Shworupkhathi and Kaliganj rivers join the Arial Khan and the Madhumati across the north of Barisal district. The Baldia and Uzirpur Khals drain some of the Bils into them. The Kaliganj and Shworupkhathi join and fall into the Baleshwor as the Kacha. The Barisal river takes off from the Arial Khan north of Barisal town and meanders towards the south-west. It receives the Kalijira river, Gabkhan Khal and the Rajapur Don on the right bank, and sends out the Bukhinagar Don and the Bakerganj and Pandab rivers from the left bank. From Betagi the name of the Barisal river changes to the Bishkhali, which falls into the Haringhata estuary. On most maps the Paira river is marked as Burishwar. The main offshoots of the Bakerganj river are the Boga Don (a cross-channel with the Ilsa branch of the Meghna), the Patuakhali river and the Kukua Bharani. The Patuakhali (also known as Galachipa Khal) joins the Rabnabad channel (more commonly known as the Agunmukha : the mouth of fire'). The southern-most part of Barguna district (Amtali and Kalapara Upazilas) is cut up by many cross-channels between the Paira and the Agunmukha. The Andharmanik river is the main channel in that network. There are many tidally flushed streams carrying surface drainage, known as Dona.

Lower Meghna

The Lower Meghna, the largest river in Bangladesh, is the joint stream of the Podda and the Meghna, reinforced by the Dhaleswari. All the three rivers are large. The Dhaleswari-Meghna and the Podda are each 5 km wide at the confluence. The lower Meghna has several Chars in it, which create two main channels, of which the large eastern one is five to eight kilometres wide. The western channel is only about two kilometers in width. Near Muladi the one and a half kilometre wide Safipur river is an offshoot from the right bank. Further south the Lower Meghna divides into three channels, which are, west to east, the Ilsa (or Tetulia), the Shahbazpur and the Bamni. The Ilsa is the

five to six and a half kilometre wide channel separating Bhola island from the Barisal mainland. On the western side of the mouth of the Ilsa are the Rabnabad islands. The Shahbazpur Channel, 5 to 8 km wide, separates Bhola from Ramgati and Hatia islands. At its mouth are the Manpura islands. The Bamni can now be said not to exist. It formerly flowed between the islands of Ramgati and Char Lakkhi and the Noakhali mainland, and was at times the main outlet for the Meghna. The tides and their bores always affected it considerably, and this channel dwindled or widened in an unpredictable manner. After breaking down a considerable part of the mainland in the 1940s, it suddenly shoaled to such an extent just west of Noakhali town, that in winter there was a land bridge from the mainland to Ramgati island. To make this a permanent feature, a large earthen dam was built. To accelerate the accretion of Chars, a second cross-dam was built near Noakhali, which rapidly 'built up' nearly 260 square kilometres of land.

The estuary of the Lower Meghna is usually taken to stretch from the Rabnabad islands to the Kumira coast, a distance of 153 km. The water is, however, saline for half the year as for north as a line drawn from the middle of Bhola to the north of Shondip. The estuary of the Lower Meghna may be considered to be the Ilsa and Shahbazpur rivers which together have a width of thirty two kilometres at the sea-face. The estuarine discharge is not known, but at Chandpur the mean discharge from June to October is around 2.5 million cusecs. The mean maximum in this period of the year is about 4 million cusecs. In winter the flow is about one-eighth as much, but the river is even then several kilometres wide the low flow figure is due to the sluggishness of the flow. In maximum flood, the Lower Meghna's flow is no less than five million cusecs. It is also estimated that from May to October, its daily load of sediments is nearly four million tons. The annual load of sediments carried by it is about 1,500 million tons and annual water discharge about 875 million acre-feet. In comparison the Congo, the La Plata and the Yangtse have total annual flows of 1,022,636 million acre-feet (MAF) respectively. The Lower Meghna, as the major outlet of the combined Ganges and Brahmaputra, has therefore somewhat less outflow than the Congo, which is second only to the Amazon. Table 3.5 gives a comparative picture.

The Lower Meghna is measured from Chandpur south, and includes the main Meghna Channel and the Tetulia. The flow is estimated for a point mid-way between Chandpur and Mehendiganj. The length of the Upper Meghna is measured down to Chandpur, but the discharge measurement is at Bhairab Bazar. The Brahmaputra flow is measured at Bhadurabad and the length down to Aricha. The Ganges flow is measured at Hardinge (Sara) bridge and the length down to Goalundo. The Podda is measured from Aricha-Goalundo to Chandpur and flow is estimated for the mid-point.

Table 3.5

Estimated Average Annual Discharge of the Worlds' Major Rivers

Rivers	Length (kilometers)	Drainage Area (million acres)	Average Discharge (MAF/Year)
Amazon	6275.1	1.428	5.475
Congo	4666.1	992	1.022
Lower Meghna	160.9	416	875
Podda	-	386	790
La Plata	3942	570	636
Yangtse	5470.6	479	559
Brahmaputra	2735.3	142	501
Orinoco	2735.3	217	436
Mississippi	6275.1	796	330
Mekong	4344.3	198	378
Irrawaddy	2011.15	106	349
Ganges	4064.5	244	294
Indus	3137.6	240	168
Niger	4183.3	275	157
Upper Meghna	949.3	20	92

Chittagong Sub-region

The rivers of the Chittagong Sub-Region remain to be considered. They are swifter than those of the other parts of Bangladesh, being for most of their course mountain streams. Large numbers of hill torrents can increase their flow suddenly after a good thunderstorm, which often leads to flash floods.

Karnafuli

The Karnafuli ('flower of the ear') rises in the higher Arakan Yomas and cutting across the main ranges of the Hill Tracts falls into the sea a few kilometers from Chittagong city. It is known as the Kynsa Khyong to the Marma. There were rapids at Demagri (in India) and Barkal (this has now been submerged by the Kaptai lake) and gorges at Chilerdak where it cuts through the Subalong Range, and at Silchari where it cuts through the Sitapahar Range. The Jamaimoroni Peak, place of one of the Hill Tracts most popular legends, is besides

this latter gorge. The main tributaries of the Karnafuli are Thega, Subalong, Rinkheong, Kaptai and Ichhamati on the left side and Sajjak, Horina, Kasalong, Chengi and Halda on the right. Dhurung and Sarta are tributaries of the Halda, a river as prone to overflooding as the Gumti. The Karnafuli falls into the sea after executing a large S - bend along the Chittagong harbour. In ebb tide, the channel going out into the sea, can be traced through mud banks, which are spreading further every year. Its estimated annual flow is 25 million acre-feet.

Sangu

The Sangu or Sankha rises in the Sangu Reserve Forest in the south-east of the Hill Tracts. It flows north-west for most of its course and falls into the sea just sixteen kilometres from the mouth of the Karnafuli. The Marma call its upper course Sabok Khyong and its middle course Rigre Khyong (Hutchinson 1906). In its upper course there are two small waterfalls and several rapids. Dolu, Hungor and Tankawati are its main tributaries. Its estimated annual flow is 4.5 million acre-feet.

Matamuhuri

South of the Sangu is the Matamori (Matamuhuri), or Moree Khyong, as it is known to the Marma. In the mountains it is navigable only by Shallow boats. Small motor boats can ascend as far as Alikadam 64 kilometres from Chiringa, in the rainy season. In its lower reaches, it fans out into the fairly big Chakaria delta. Its estimated annual flow is 3 million acre-feet. South of this river the main ones are the Bogkhali, Rejukhal and Naaf. The first two are small. The Naaf has a short mountaineous course before falling into the, 56 kilometres long and 3.2 kilometres, broad Naaf estuary.

Lakes, Beels (Bils), Baors and Haors

In between the rivers and canals there are a large number of water bodies, mostly connected to them by numerous channels. Of lakes, strictly speaking, there are only three : the Rinkhyongkine, Bogakine and the Ahshula Bil. The Rinkhyongkine is on the watershed of the Rinkhyong river in south-east Hill Tracts district. It is a kilometre and a half long and 400 metres broad and well stocked with fish. The Bogakine is west of Keokradang Peak, at a height of 372 metres it is parallelogram in shape and quite deep. There used to be no fish in its waters till someone released a few *Magur* (cat fish), and it is reported that they have multiplied exceedingly well. This lake is

venerated by the local Khumi tribesmen. The Ahshula Bil, though so called, is more properly a lake, or *rawd*, as they are called in Bengali. It is at the northern end of the Eastern Barind. The banks slope steeply to the water and the lake is deep. Its alignment along the north-west-south-east direction of the Karatoa fault suggests strongly that it is due to block faulting at the same time as the land to the south was raised.

Bils (Beels), as has been explained previously, are usually saucer - like depressions, of a marshy character. In the rainy season they are full of water and resemble lakes. In other seasons the water-level goes down and sedges make them look like marshes. Some Bils dry up completely and are cultivated. A few look like lakes throughout the year. They are all fed by surface run-off and by small channels that connect them with the rivers. The former source is the more important. There are far more Bils (probably over a thousand) than can be described adequately. The important ones are mentioned here.

In the Northern Region there are a large number of Bils, a legacy of the much changed river system. There are no big Bils in Dinajpur district. Rangpur district has three : Tagrai, west of Kurigram town; Lunipukur, west of Rangpur town and Bara Bil in Pirganj Upazila. In Bogra district there are two large Bils : just to the east of the Bogra Karatoa, the Nurail and the Keshpathar. Further east, in Shariakandi Upazila are the smaller Sat and Gobarchapa Bils. In the south-west is the Raktadaha Bil, connected with the Parul in Rajshahi district. Along the Mahananda river are several Bils of which Baitia in Bholahat Upazila is the largest. In the West-central Barind the main Bils are Boro Mirzapur in Porsha Upazila (probably in a block fault) and Paticola in Godagari Upazila. Along the eastern edge of the west-central part of the Barind are a number of Bils, probably marking an old course of the Atrai river. From north to south the big Bils in this line are Chakchaki, Sabul, Ghuri, Kanchon, Manda, Utrail, Siddheshwor, Ghona, Hilna, Kumari, Shona and Bagsimli. Between these Bils and the Chalan Bil System are a number of others, such as Ajum, Malshi, Angra, Podda, Shewti, Gondi, Parul and Shonaikanda.

The Chalan Bil System is large, It consists of all those Bils which join through various channels to form, more or less, one continuous sheet of water in the rainy season. They are, from west to east, Purba Madhanagar, Piprul, Dangapara, Laror, Tajpur, Niala, Chalan Majhgaon, Briasho, Choumohon, Satail, Khardaha, Darikushi, Kajipara, Gajna, Bara, Sonapatila, Ghugudaha, Kuralia, Chiral, Dikshi and Gurka. These Bils are the lower spots in the low-lying Bhar area, most of which is inundated in the rainy season. The Chalan Bill was formed when the Jamuna branch of the Brahmaputra expanded and dammed back the Ganges, causing the latter to deposit sediments at the mouth of the Karatoa and Atrai, which then

flowed into the Ganges. It was probably a back-swamp before it was greatly expanded by the pent up flow of the Atrai and Karatoa, and became a lake of some 1090 sqkm. With the gradual silting up of its southern side by the annual deposits of the Ganges it has moved 19 km inland in the last century and a half. By 1909, the area of the Bill is said to have been reduced to an area of 368 sqkm of which only 85 sqkm were under water throughout the year (0 Malley 1923). It was then estimated that 6.3 million cubic metres of 'silt' was brought into it by feeder rivers, of which 1.5 million cubic metres were carried off by those draining it. The remaining 4.8 million cubic metres were deposited, which if distributed equally would raise the level of the Bils 1.3 cm a year. In 1913, however, it has found that the perennial water body was less than half of what it was four years back. In the 1950s various reclamation works have reduced the Bil to about 26 sq. km.

In South Bengal there are far more Bils than in North Bengal and also a number of Baors. These latter are cut off arms of decayed river channels, principally of the oxbow type. All the Baors are in the Moribund Delta. They are more stagnant than the Bils and generally have water throughout the year. The Principal Baors are Sagarkhali, Jaleshwor, Bokor Thampar, Khedapara, Rampur, Pathanpapra, Katgarar, Jogini Bhagini, Ichhamati, Baluhorer, Joydia, Marjat, Bukbhona, Harina and Arol. They range in size from half a kilometre to thirteen sq. kilometres. The larger Bils in this area are Kamladaha, Chakli, Taleria, Jhenja, Boalia, Malar and Jaleshwor. The line of Bils across the north of Khulna district and into the Central Delta Basin contain the following large ones, from west to east Dantbhanga, Boyra, Shahapur, Dakatia, Pabla, Bakar, Boro, Kolo, Patla, Barnal and Srirampur. They cover parts of the Satkhira, Asasuni, Debhata, Kaliganj, Tala, Dumuria, Daulatpur, Terokheda, Mollahat and Bagherhat Upazila.The main Bils in the Central Delta Basin are Katli, Nalua, Chatal, Moura, Nagarkanda, Kazlidanga, Baghila, Atadanga, Chanda, Pathram (two of them), Ujan, Digra, Ishwordi, Rathnoranga, Harhora, Ghazoria, Soladanga, Patnidanga, Kasmira, Pabnia, Gopalpur, Bashor, Kajalia, Ramshil dighi, Boghia, Janihjauia, Tungi, Douura, Deulbari, Poddo, Dumaria, Satla, Ashkar, Suga, Baldia and Harta. Of these, Katli, Nalua, Kasmira, Pabania, Soladanga and both Pathrams dry up in March and April, before they begin to fill up again from May onwards. The other Bils have some water all year round.

Over most of Central Bengal large Bils are comparatively few. There are many small basins in the Recent and the Pleistocene deposits, but they are slight depressions. Outside the Haor Basin the large Bils are Arial, Belai and Howda. Arial Bil is a dominant feature in the Kaliganga-Podda interfluve. Belai is in the southern part of the Madhupur Tract, and Howda is in the northern part. In the Haor Basin

there are no less than 400 Haors and Bils. The majority of these are, however, small appendages of the larger water bodies. In the deep centre the main water bodies are Baram-Banka-Habibpur-Maka-Makalkandi[6] and Ghulduba Haors and the Panga and Bandha Bils. In the deep basin, at the foot of the Meghalaya Plateau, are the large Tangua, Sanir and Matian Haors. Close by to the east are the Dakhar, Jhilkar-Jhinkar and Pathar-chauli Haors. In the eastern part of the Haor Basin Rim are the Jamaikata-Mahai-Nalua-Parua Haors. Between the Tarpa (Satgaon and Bhanugach ranges there is the large Hail Haor. In the Central Sylhet lowland there are a number of Haors such as the Hakaluki group of Haors and Bils and the Chatal, Bar and Hailka Haors. There are seasonal Bils, with water only in the rainy seasons all along the foot of the Meghalaya Plateau. In the south of the Basin the major Haors are Dingapata, Ganeshar, Talar, Anganer, Bara and Humaipur.

South of the Haor Basin, on the Tippera Surface plain and the Titas plain there are a number of comparatively small Bils, of which the major ones are Buroli, Hatia, Kahla, Fada, Horkhai, Gogra, Sandipa, Bayeshakaha, Shafla, Belanga, Shahzadpur, Hugli Langula and Satbaria.

In the Chittagong Sub-Region Bils are even fewer they are small and usually contain water only in the rainy season. The well-known Gumai bil has been drained, but occassionally floods quite deeply. There are however, big marshes, overgrown with large grasses and reeds, along many of the rivers of the Hill Tracts. The largest of these marshes is along the lower course of the Sajjak river.

WATER-TABLE

The water-table is generally high, becaue of the soil and topography, over most of the country. The highest level varies from less than one metre below the surface in the delta areas in the rainy months to fifteen metres or more below in the Barind in the dry months. Over the greater part of the country, however, the water-table is between one and three metres during the rainy season. In view of the necessity for providing good drinking water in the rural areas, there is a program to sink one hand-pump for every 200 persons. The stagnant, exposed water drawn from tanks, is an ever-present danger to health and is very often responsible for spreading typhoid, cholera and other diseases. It is noticeable that with the implementation of this drinking water scheme the incidence of these diseases has gone down. Though the water-table is as high as two metres or less in large parts

6 All those joined together in the rainy (monsoon) season are hyphenated.

of the country, good aquifers are found mainly between 18 and 46 metres. In the Barind and Madhupur Tracts and the Chittagong sub-region good aquifers are often lower. In the coastal belt, aquifers with potable water are usually at depth below 100 metres and often as low as 300 metres (1000 feet). The natural fluctuation of the water-table varies from one and a half to over seven metres. On the eastern side of the Brahmaputra-Jammuna, deep-tube well irrigation causes lowering of the water table by as much as 10 meters during the dry seasons. This causes drying of thousands of domestic hand tube-wells which in turn creates serious drinking water problems.

Salinity

For continuous application of irrigation water the threshold level is 750 micro-mho/cm at 25°c (Haskonigs report vide MPO 1984 Vol. II). The permissible limit for supplemental irrigation with slight reduction in yield for rice crops in the coastal areas is 2000 micro-mhos (1968 Leedshill-Deleuw report, ibid.). Since the diversion of Ganges water at Farakka from the early part of 1975, salinity levels have increased dramtically in the western part of the Southern Region. The dry season 2000 micro-mhos saline front has penetrated as far as Magura (241 km from the sea) in the Nabaganga river, and the 6000 micro-mhos front has come up as much as 173 km from the sea (MPO 1984 Vol. II page 31). This has had a serious impact on the agriculture of this area and is affecting the Sundarbans forest ecology. Table 3.6 shows how salinity levels have been increasing at Khulna.

Table 3.6

Instantaneous Maximum Salinity at Khulna
(Rupsa River)

Year	mmhos/cm	Year	mmhos/cm
1966	3000	1982	14000
1967	2000	1983	17000
1968	1000	1984	63000
1969	9000	1985	8000
1970	4000	1986	16000
1979	6000	1987	12600
1980	12000	1988	16240
1981	6000	1989	28000

Source : Vol. I, National Water Plan, MPO, Dhaka, 1986. & MPO, NW P-II, 1990.

Floods

Destructive floods are one of the most serious handicaps in this riverine country. There are few areas which are not liable to serious flooding once every two or three years. The situation has become aggravated by the silting-up of most of the rivers. Execessive destruction of the natural vegetation in all the head-waters of the major rivers (Garhwal, Nepal, Assam, Tripura, Mizoram, Chittagong Hill Tracts) has led to extensive erosion and consequently the river beds have been silting up rapidly in the last three decades. This has reduced their water-carrying capacity and every spell of rainy weather is now viwed with alarm. Spells of rain which in former years only filled the rivers, now cause damaging floods. The heavy rains need not be in Bangladesh. If it rains heavily anywhere in the large basins of the several river systems, its effects will, sooner or later, be felt in Bangladesh. Apart from flash floods along the northern borders, which can happen in any of the rainy months, the period most prone to floods are the two months from the middle of August to the middle of October, when both the Ganges and the Brahmaputra are in full spate.

Two of the largest rivers of the world, draining monsoon rainfall and snowmelt from the vast Himalayan catchment, join in Bangladesh. Synchronisation of flood in the rivers always causes havoc in Bangladesh. There is a flooding of another sort which is always welcome : the slow rise of water into the jute and paddy fields. This not only gives them the large amount of water they need, but also fertilises them by depositing a layer of silt, which contain organic matter. Of course, this happens only in the lower areas (e.g., Mature and Active Deltas, Bhar and Titas Basins etc.) Recently there have been severe floods in 1987 and 1988. With progressive deforestation in the Himalayas and possible increase in the Greenhouse effect, the probability of very large and damaging floods may have increased.

Table 3.7

Spring Tidal Range

Tiger Point	---	2.40 m
Jefford Point	---	2.40 m
Pussur Entrance	---	2.60 m
Jinjira (St. Martins) Island	---	2.80 m
Mutlah Sand Heads	---	2.80 m
Cox's Bazar	---	2.83 m
Kutubdia Island	---	3.17 m
Jaldi (Norman) Channel	---	5.49 m
Shondip (Sandwip) Channel	---	5.49 m

Tides

The mean rise at High Water during Springs varies from two to more than five metres, while the mean rise at High Water during Neaps varies from one to four and a half metres. The Spring range for various places is given below :

Along the Bangladesh coast the tide has the nature of a progressive wave, but comes up the middle of the Bay faster than along the east coast. It reaches 21' 43' N. at 89'34'E. fully forty-six minutes earlier than it reaches 21' 26' N. at 91' 59' E. Time difference in the progress of the tide has been calculated with reference to an arbitrary point (latitude 21' 24' N, longitude 89' 34' E) at the head of 'Swatch of No 'Ground', and is given in Table 3.9 (Rizvi 1960) for several places in and along the Bay.

According to S.Z.H. Rizvi the tide produced in the Bay of Bengal is due to "a standing oscillation with node at about 6'30' N latitude in resonance with the tidal impulses in the Indian Ocean." He, however, qualifies that this is true mainly south of 20'20 N (i.e. head of the Bay).

Table 3.8

Time Difference in Tide

Location	Latitude	Time Difference	
		H.	M.
Passur Entrance	21° 48'N	+ 01	15
Mutlah Sand Heads	20° 58'N	+ 00	48
Jefford Point	21° 43 N	+ 00	45
Jaldia (Norman) Point	22° 11'N	+ 04	21
D'Apres Shoals	21° 57'N	+ 05	40
Kutubdia Island	21° 52'N	+ 02	29
Tiger Point	21° 51'N	+ 01	23
Cox's Bazar	21° 26'N	+ 01	31
Meghna Flats	21° 23'N	+ 01	20
Jinjira (St. Martins) Island	20° 37'N	+ 00	20

The tide reaches the Sunderban coast earlier than the Chittagong coast of the same latitude. As a result, a west to east secondary wave travels till it meets the slower Chittagong tide. This produces the lightly

circular motion noted by many observers. The funnel shaped Meghna estuary used to create several bores, varying in height from two to four and a half metre which travel at twenty four to thirty two kilometre per hour. For reasons not yet known these bores have been reduced since the mid-1970's.

Table 3.9

Tidal Range

(in metre)

Location	Mean Heights (Springs)			Mean Heights (Neaps)			Mean Level
	HWS	LWS	Range	HWN	LWN	Range	
Passur Entrance	3.35	0.80	2.56	2.56	1.55	1.0	1.77
Mutlah Sand Heads	2.83	-	2.80	2.04	-	-	1.83
Jefford Point	3.08	0.70	2.40	2.34	1.37	0.97	1.68
Tiger Point	2.10	0.60	2.40	2.22	1.34	0.88	1.64
Meghna Flats	3.20	-	-	-	-	-	-
D' Apres Shoals	2.90	-	-	-	-	-	-
Chittagong port	4.14	0.33	3.81	2.10	0.91	2.07	2.10
Jaldia (Norman Pt)	4.6	0.80	3.78	3.50	1.86	1.64	2.31
Kutubdia Island	3.70	0.40	3.29	2.68	1.40	1.28	2.04
Cox's Bazar	3.41	0.36	3.05	2.50	1.28	1.22	1.90
Jinjira (St. Martins) Island	3.17	0.49	2.68	2.31	1.34	0.97	1.83